Lectures to Plumbers.

J. WRIGHT CLARKE.

Presented by
J. Wright Clarke Esq
March 1893

Presented to
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By the Author.

16 March 1893.

LECTURES TO PLUMBERS.

J. WRIGHT CLARKE.

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LECTURES

TO

PLUMBERS.

BY

J. WRIGHT CLARKE,

PLUMBER,

Lecturer on Technical and Instructor in Practical Plumbing at the Polytechnic, London.
First National Honors Medalist for Plumbers' Work, 1881.

AUTHOR OF "PLUMBING PRACTICE" AND "CLARKE'S TABLES."

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PREFACE.

THE reception accorded previous efforts, and the letters of encouragement received by the Author from correspondents in all parts of the world, encourages him to hope for a similar reception for this, his latest work.

These "Lectures" were originally delivered to the Students of various Plumbing and Building Construction Classes, also to Architectural and Engineering Students, at the Polytechnic (Regent Street, London), and elsewhere, and to Sanitary Officers at the Sanitary Institute.

Published subsequently in the "PLUMBER AND DECORATOR," they are now collated and re-published in book form to meet queries constantly addressed to the Author. For them no claim is made to literary merit, but the great aim throughout has been to deal with the simplest, as with the most intricate questions, in a practical manner, and in language that could be understood by Students of every grade, whether connected with the Plumbing or the allied professions, at school or in practice.

There are, of course, many details of Plumbing Work which are not treated in the present book. These will, however, be fully dealt with in a Second Volume, some two years hence.

Experience in the past shows that practitioners of standing and repute are still "students," and to such, whether Plumbers or Sanitary Engineers, who do not believe they already "know it all," this book is dedicated by

THE AUTHOR.

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ON METALS.

A PURE metal is a simple body, or element which cannot be divided into any number of substances different from its original nature. For instance, nothing but gold can be extracted from gold, tin from tin, lead from lead, and so on. But there are compounds of metals which can be divided into their component parts. Ores are metallic compounds which have to be divided to separate the pure metal from other matters which, although useful from a chemical point of view for other purposes, would be considered impurities where a metal is required to be free from them.

On looking through the list of metals found in, or on, the earth's crust, we find only five that are of much interest to the plumber. These are lead, tin, zinc, copper and iron. With the exception of copper, none of these ores are found in a metallic condition, but in combination with other substances which have to be separated from the metals. Below is a table of the principal ores and their compounds :—

Metal.	Symbol.	Ore.	Composition.
Lead	Pb	Galena	Lead and Sulphur.
Tin	Sn	Tinstone	Tin and oxygen.
Zinc	Zn	Blende	Zinc and Sulphur.
Copper	Cu	Copper Glance	Copper and Sulphur.
		Copper Pyrites	Copper, Iron, and Sulphur.
Iron	Fe	Magnetite	Iron and Oxygen.
		Hæmatite	Iron and Oxygen.

The above is only a very brief list of the various ores. The reader is urged to buy Mr. Bloxam's book—"Metals," which contains a very good description of the principal metals, and their extraction from ores, besides giving other useful information.

It is the physical properties of the various metals which lead us to choose those most suitable for various purposes in the building. As an instance, lead would not do for girders, or any use where hardness and tenacity are necessary. Iron possesses these properties to a much higher degree than any of the metals under discussion. By a peculiar treatment of the iron, by which it is converted into steel, the above properties can be nearly doubled. But by no known means can lead be hardened to such an extent as to be useful in the same way as iron. But lead can be hardened by adding another metal—antimony—but this would be called an alloy, a name given to a mixture of two or more metals. And then again, the specific gravity of iron is so much less than lead, that the iron has an advantage where lightness is necessary. Below is a table of tenacity and malleability of the five metals under discussion :—

Tenacity.		Malleability.
Iron	27½	Copper.
Copper	18	Tin.
Zinc	2	Lead.
Tin	1½	Zinc.
Lead	1	Iron.

The table of tenacity is intended to show the relative power of resistance the metals have to being torn asunder. If an iron wire of a certain size will sustain a weight of 27½ lbs. before breaking, one made of lead and the same thickness would support only 1 lb. Tin is a very little stronger than, and zinc is about twice as tenacious as lead. The malleability of a metal depends a great deal on its tenacity, coupled with softness. The list shows the iron to be the least malleable, although the most tenacious. Lead is about mid-way in the list, and copper is shown to be the most malleable, that is, the copper has such softness and tenacity as to be capable of being rolled into thinner sheets without breaking than any of the other metals. Gold and silver are still more malleable, and can be rolled or hammered into sheets so thin that a slight puff of air will blow them away. Gold is used in this state for gilding objects such as mouldings, figures, picture frames, and for sign-writing. Another comparative table is given below showing the relative ductility of the five metals :—

Iron.
Copper.
Zinc.
Tin.
Lead.

Here we have a table which will be found to agree with that of tenacity, thus showing that those metals, the atoms of which present the greatest resistance to being torn asunder, can be drawn to a finer or thinner wire than the others.

In addition to the three physical properties that have been mentioned there is lustre or the power of reflecting rays of light. All the metals under discussion have this power to a greater or lesser degree, but they are so readily affected by the oxygen in the air that they soon become covered with an oxide of the metal, and lose their brightness. Of all the metals, gold has the greatest power of resistance to being tarnished by oxygen.

A table is given below of specific gravity (another physical property of metals). This is intended to show the weights of the metals in comparison with an equal bulk or body of distilled water at a temperature of 60 degs. F.

Lead	11⅓	... 11·36
Copper	9	... 8·95
Iron	7 4-5	... 7·84
Tin	7⅛	... 7·29
Zinc	7 1-7	... 7·14

Plumbers are interested in this table, as it teaches them a lesson worth knowing. When a plumber is using a pot of solder, he will see from the table the necessity of keeping the contents well stirred and mixed. If this is not done, every time a ladleful is taken out of the pot the metal will become poorer in tin, and more difficult to work. The tin will swim (so to speak) on the top and get used first, leaving a too great percentage of lead. Zinc will swim on the top of the solder, and if care is exercised it can be skimmed off, but as its specific gravity is very little less than tin, the tin would be skimmed off at the same time. A better way for extracting zinc from solder will be given at a future time.

Fusibility is considered a physical property of metals. Below a table is given :—

Tin	melts at ...	442 degs. F
Lead	" ...	617 "
Zinc	" ...	773 "
*Copper	" ...	1990 "
Iron (cast)	" ...	2780 "

* Above zinc it is difficult to ascertain the fusing point of metals.

Fusibility, or the property of becoming liquid when sufficiently heated, plays an important part in the use of the various metals.

Zinc, lead, and tin can be melted over an ordinary fire, but the other metals require a much greater heat. Some of the above metals, when alloyed in certain proportions, fuse at a lesser degree of heat than the metals by themselves.

At a degree of heat less than melting point some of the metals are very brittle, but at a lesser degree still they are rendered more malleable, and that is why plumbers will heat lead pipes when making bends in them. Metals become less tenacious when heated, but to a certain degree they become tougher, so that they will sometimes stretch before breaking, when a pulling power is exerted. Nearly all metals expand when heated.

In addition to physical or natural properties, metals can combine with other matter, and this constitutes what is commonly called chemical properties.

Oxygen has a chemical affinity for nearly all the metals. Expose any of them to a damp atmosphere, or immerse them in water, and their surfaces will oxidize; that is, enter into combination with oxygen, and become what we commonly call tarnished. Of the grosser metals, tin will resist this action of oxygen the most; hence its value for coating some of the other metals.

Tin-plate is sheet-iron coated with tin. Galvanised-iron is iron coated with zinc. But for this protection iron will sometimes entirely lose its metallic properties and become nothing but a red dust or powder.

Oxygen attacks lead very slowly. After the surface has become covered with oxide the action is retarded, so that a piece of lead exposed to the air will last hundreds of years, provided the oxidised surface is not removed. Those metals which oxidise by exposure to the air will more readily combine with oxygen when exposed to heat. As an example, iron furnace bars soon become what is called burnt out. Lead heated to redness will be converted into dross, that is, oxide of lead. This is known by the name of litharge. The yellow form of litharge is sometimes called massicot. Still further heating of the litharge, it is converted into minium, or red-lead, used as a driers for paint, or as a cement, when mixed with white-lead and oil, for joints to iron-pipes.

Ceruse, or white lead, is another chemical compound of lead, oxygen, and carbonic acid. Lead-pipes that have been in contact with lime *in a damp situation* will be found to be much affected by carbonic acid. Lead coffins sometimes have holes eaten through the lead by the same gas. Holes are frequently found in unventilated soil-pipes and traps, arising from the same cause. The white lead of commerce is carbonate of lead, ground and mixed with oil to a stiff paste. White lead is manufactured by exposing thin sheets of the metal to the fumes of acetic acid formed by weak vinegar, contained in vessels surrounded by tan in a state of fermentation. This raises the temperature of the chamber and its contents, and accelerates the formation of the gas and carbonisation of the lead. There is a more modern way of making white lead, which is reported to be not so dangerous to the health of the workers, but up to now this is a trade secret. There is a chemical action takes place between some of the metals, which is sometimes known as a galvanic, and sometimes as voltaic action. Moisture is necessary for this action to set up. Lead and iron form a galvanic couple in which one of the metals will, in time, gradually disappear. Let my reader look at the base of any old iron railings that have been fixed to stone with metallic lead. In a great many cases the iron will be found to have entirely disappeared near the lead. Expose a piece of tin plate (which is iron coated with tin) that has been scratched, to a moist atmosphere, and in time the iron will entirely disappear. In the case of a piece of galvanised iron similarly treated, it is the zinc that will be, what is commonly called, eaten away. The soldered seam of a soil-pipe will often be eaten through, and the lead itself scarcely affected. The edges of the soldered angles in a lead-lined wooden cistern will often be found to be full of holes, and very probably by the galvanic action set up between the metals. In the case of lead-cisterns, some waters are found to act on the lead more than others. Waters that are very pure and highly aerated, or those containing an excess of carbonic acid, are very injurious to lead. Water from sewage readily attacks lead, but hard waters generally do not affect it to any serious extent. Although lime will readily attack lead a solution has the opposite effect, and to a certain extent protects the lead from corrosion. Lead will resist the action of sulphuric acid (oil of vitriol) more than any of the other grosser metals, hence it is much used for lining vitriol chambers.

Muriatic acid (spirits of salts) has very little effect upon metallic lead. Strong nitric acid attacks lead to a limited degree, but when the acid is diluted it will readily dissolve the lead. Because of its power of resisting the action of acids, lead is much used for vessels in chemical manufactories. Where of necessity these vessels must be large, the pieces of lead are *burned* together. If soldered together the acid would destroy the soldering. Sometimes this burning is called *autogenous soldering*, and consists of uniting the edges of the sheets of lead by melting them together. This is done by means of a machine for generating hydrogen gas, and an air bellows with the necessary tubing, &c., so arranged that air and gas mixed in proper proportions, and aided by a blast, will burn with sufficient heat to melt the lead. Advantage is taken of the chemical action of diluted sulphuric acid upon zinc, for making the hydrogen gas. The dilute acid consists of hydrogen, sulphur, and oxygen. Zinc being added to this compound, takes the place of the hydrogen, which is set free and collected in a chamber, whence it is conveyed to the flame-jet by indiarubber tubes, the escape of the gas being regulated by a cock. The chemical formula of the above chemical action is $H^2SO^4+Zn=ZnSO^4+H^2$. Iron wire can be used instead of zinc. $Fe+H^2SO^4=FeSO^4+H_2$. The student plumber may perhaps have noticed when *killing spirits* that the escaping gas will burn if a light is applied to it. This is also hydrogen gas. The spirits of salt is called hydrochloric acid by the chemist. In this case the zinc and chlorine combine, and set the hydrogen free. Nitric and hydrochloric acid when mixed are called *aqua regia*, and will dissolve gold. Neither of these acids will do this alone.

The principal metal used by plumbers is lead, the Latin name for which is "Plumbum," hence we get the title of "plumber," a worker in or of lead.

There are several ores containing lead, but there are only two which contain it in sufficient quantity to extract the metal in large quantities, *viz.*, "Galena," or sulphide of lead, and "Cerussite," or white lead ore, or carbonate of lead. The Galena is composed principally of lead and sulphur, and the Cerussite of lead, oxygen, and carbonic acid. These are the chief impurities which have to be removed from the lead ores, so as to get the metal in a pure state. Antimony is sometimes, and silver nearly always, found in lead ores. The principal lead mines in England are in Cornwall, Derbyshire, and Cumberland. Lead is also found in Flintshire, Scotland, and the Isle of Man. The ores are first sorted by hand, then broken or crushed to small pieces. They are then washed to remove any earth and to dissolve some of the other impurities, As sulphur will not dissolve in water, it has to be expelled from the lead by heat. This operation is conducted in different ways in different localities, but the principle is nearly the same in all cases, and consists of roasting the prepared ores in a kind of oven, called a reverberatory furnace. The ores are spread over the hearth, and flames from a fire at one end of the furnace pass over the ores. A quantity of unconsumed air passes through, with the flames, the oxygen of which combines partly with the lead forming oxide of lead, and partly with the sulphur, forming sulphurous acid, which passes away as a vapour. The whole operation of smelting lasts about five hours. For the first hour and-a-half the heat is kept very low. For the second hour and a half, the temperature is brought to a bright red heat, and sometimes a little quicklime is added to assist the fluxing, so as to convert the slag into a liquid state, and thus allow the lead to more readily drain away. For the next hour the heat is raised to a higher temperature, and more lime thrown in, and for the next hour it is raised to its highest temperature. The molten metal is then allowed to flow out of the "taphole" into an outer basin, where logs of wet wood are sometimes let down into it, which causes the lead to appear as if it was boiling. This operation assists the lead to separate itself from any impurities, which being of lighter specific gravity than lead, rise to the surface and can be skimmed off. The lead is then cast into pigs.

When lead contains much antimony, which renders it very hard, it has to be softened in the calcining or improving furnace. This is a reverberatory furnace with a low arch, and with a cast-iron pan fixed on the hearth. The hard lead is first melted in a separate pot, and then ladled into the cast-iron pan, which is first heated to a dull redness, where it is exposed to the action of the oxygen brought in with the flames, thus causing the impurities to be converted into oxides. These collecting on the surface are skimmed off at intervals.

At a white heat lead evaporates, and the fumes, which are oxide of lead, are caught in the flues from the furnace, the flues being specially constructed, and of great length, for that purpose. Lead expands very much when heated, but does not always contract, on cooling, to its original bulk.

Lead is sent into the market in the form of pigs or ingots weighing about 1 to 1½ cwt. each. These pigs are bought by the manufacturers who make them into sheets and pipes in the forms required for the plumber to use.

Tin is much used by the plumber, but is generally alloyed with some other metal. For example, with lead as solder, with copper in the form of cocks and valves. Tin is also much used for coating sheet-iron to protect it from the action of the oxygen in the air, tin not being affected in the same manner as iron in a damp atmosphere. Copper cooking utensils should have a coating of tin to prevent any of the copper being dissolved and mixed with the food. Composition tubing, used by gasfitters, is an alloy of tin, lead, and antimony. Sheet-lead is sometimes coated with tin for lining drinking water cisterns, but some authorities state this not to be a good plan. Pure tin pipes are sometimes —but rarely on account of cost—used for drinking water—but lead pipes, lined with tin, have been much used these last few years for conveying drinking water.

Zinc is a metal which may be said to be of modern origin—not that it really is so, but its use as a substitute for lead, for covering roofs, &c., dates back only about a third of a century. Zinc is now much used for roofs on account of its lightness when rolled into thin sheets. It is also used for eaves-gutters of houses and rain-water pipes. For lining cisterns, for ornaments, ventilators, slating nails, bell-wire tubing, and also for chimney pots. This last is a very unsuitable use to put it to, as any-one may judge for himself, if he would look upwards when passing through almost any street in London, and note their dilapidated appearance.

Zinc white, an oxide of zinc, is used as a base for some paints. Iron is often coated with zinc, called galvanising it, to protect it from rusting. Some authorities state that moist air causes a film of oxide to form on zinc, which protects the metal from further action; but this is open to question, for in cisterns the zinc only lasts a few years, and on roofs, where no injury could happen to it, zinc is soon destroyed by the atmosphere. On close examination it will often be found that scarcely a bit of metallic zinc is left, it having become so highly oxidised, or, as we call it, "perished." If in contact with soot, the zinc loses its metallic properties much more quickly, they, in the presence of moisture, forming a galvanic couple. There are metals which, when brought into contact with zinc, form a voltaic action, when water is present, aud which soon destroys the zinc. Some architects, acting on this knowledge, specify that when lead gutters are laid and zinc flats to discharge into them, that a strip of felt shall be placed to prevent the metals coming into contact. Lime is destructive to zinc, so is also some woods, such as oak, which contains a strong acid.

In a very varied experience I have found zinc used for soil-pipes and, I need scarcely add, full of holes. Urine and the gases emanating from sewage will soon corrode zinc. In the Parkes Museum of Hygiene, there is a zinc trap that was taken from beneath a W.C. and its state, apart from its unsanitary shape, is proof that zinc is a very unsuitable metal to use for that purpose. There are a great number of people at the present time who are using this metal for ventilation-pipes to drains and soil-pipes. This is to be regretted. Zinc is a very brittle metal, but is rendered malleable by being heated to about 200 degrees to 250 degrees Fahr., but on raising the temperature to about 400 degrees Fahr. it is again made brittle. At a red heat zinc takes fire and burns furiously, but at a slightly less heat this metal passes away as vapour.

When two or more metals are melted together, the mixture is called an alloy. An alloy of metals often presents entirely different properties to either of the constituents. For example, two parts of copper and one of tin melted together and allowed to cool form a very hard and brittle mass, much harder than either the copper or the tin by themselves. Although the quantity of copper, which has a reddish colour, exceeds that of tin, the alloy is white in colour. This alloy, known as speculum metal, can be so highly polished as to be useful as a reflector. Gun metal, which is an alloy of about nine parts of copper and one of tin, is very tough and hard, but is not so malleable or ductile as either of the metals by themselves. Tin is much softer than copper, but it has the peculiar property of hardening copper. As tin melts at a less degree of heat than copper, it is necessary when making an alloy to melt the copper first, and then add the tin. If the tin and copper were melted together, the tin would be converted into dross some time before the copper began to melt. As copper and tin have different specific gravities, it is necessary before making a casting with an alloy to thoroughly mix them by stirring.

Brass is an alloy of copper with zinc. The crucible in which the mixture is melted has to be kept covered with charcoal, otherwise the zinc will escape in the form of vapour. Good brass is tough when cold, but if heated it is rendered brittle. Zinc and copper alloyed in certain proportions is sometimes called spelter, and is used as a solder for joining hard metals together. If the metals to be united by this solder, commonly called brazing, melt at a low temperature, an excess of zinc must be used. This is necessary, as zinc melts at a lower heat than copper, and the alloy which has a greater proportion of zinc melts at a lower heat than one in which the copper is in excess. It is important that all solders should melt at a less degree of heat than the metals to be united; at the same time the solder should, as nearly as possible, be equal to the metals in their physical properties of tenacity and malleability, &c.

The above-named solder, commonly called spelter (which is the commercial name also applied to zinc in the form of cakes or ingots), would not do for joining pieces of lead together, for the reason that lead melts at a less degree of heat than the spelter, and the spelter would not nearly approach the lead in its physical properties. For joining lead together a solder must be used which is as nearly as possible like the lead. Plumbers' solder is composed of two parts, by weight, of lead and one of tin, and melts at from 385 degrees Fahr., to 442 degrees Fahr. Lead melt at 608 degrees Fahr. to 620 degrees Fahr., and tin at 442 degrees Fahr. to 446 degrees Fahr. From this it will be seen that an alloy of two parts of lead with one of tin, melts at a lesser degree of heat than either of those metals by themselves.

A coarse solder of one of tin with three of lead melts at 482 degrees Fahr. Fine solder for use with copper-bit composed of two of tin with three of lead, melts at 340 degrees Fahr. A solder composed of four of tin and one of lead melts at 320 degrees Fahr.

Bismuth is a metal which melts at 507 degrees Fahr., but by adding it, in certain proportions, to any of the above alloys, they are rendered still more fusible. The solder used for joining pewter together must of necessity melt at a lesser degree of heat than the pewter, which is an alloy of four parts of tin with one of lead. To render the solder very fusible, bismuth is added to lead and tin in the following proportions :—lead one; tin, one; bismuth, two. This is called "Newton's" fusible alloy, and melts at 203 degrees Fahr. Water boils at 212 degrees Fahr., so that the above solder can be melted in boilingwater

Oxygen is an element, very widely distributed. Water is composed of two volumes of hydrogen and one of oxygen. The air is composed principally of oxygen and nitrogen. In 10,000 parts by volume of air, 7,900 are nitrogen, 2,096 oxygen, and four carbonic acid. Most of the metals are found in combination with oxygen, and it is this gas which is so destructive to metals. Not that the metals are destroyed, they have undergone a chemical change, they have entered into combination with oxygen, and we then know them as oxides of the metals. Chemists can separate oxygen from metals, and so reduce them again to a metallic condition. Take a piece of iron and leave it exposed to moist atmosphere, it will become rusty, as commonly spoken, and the surface reduced to a red dust, or scales. This dust is rubbed off, perhaps only by the passing wind, and a fresh surface of the iron is exposed, and is again oxidised ; this again is removed, until at last not a bit of the metallic iron is left. But nothing is wasted by this process ; there is just as much iron in the world now as there was a thousand years ago. And so of oxygen ; the only difference is in the degree of combination. As stated in an earlier paper, oxygen attacks lead very slowly. If a plumber wishes to join two pieces of sheet-lead, or lead-pipe, together with solder, he first of all has to remove the oxidised surface. The lead or pipe may not have left the manufacturing machine more than a few hours, but yet the lead has tarnished, as we generally call it, not sufficiently to be very injurious to it, but enough to prevent the solder from alloying with the surface. The plumber shaves off the tarnished surface where he is going to apply the solder, but he finds the solder will not adhere to the prepared parts, for the reason that in applying the solder he causes a thin film of oxide to form on the lead. To avoid this the plumber uses what is commonly called a flux. This is a composition applied to the parts to be joined to prevent the air being in actual contact with and so cause oxidation of them. The flux used by plumbers is tallow (commonly called "touch"), which is rubbed over the edges of the sheet-lead, or ends of the pipes, and so acts as a kind of varnish to protect them from tarnishing. The lead can be shaved, and if touch is then rubbed over the clean parts no great injury would occur, even if a few hours elapsed before the soldereing was done, although if left for a day or two it would be necessary to reshave the work arising probably from the oxygen and other gases retained in the touch itself. When a joint has been touched, this flux will often spread beyond the prepared parts, and the solder will tin, as it is generally spoken of, on the pipe. To prevent this the lead or pipe ends are soiled (called "smudged" by north-country plumbers) a few inches each side of the intended joint. Composite candles act as a good flux for lead, but an objection is, the cloth used for making the joint gets so saturated with the composition that some time has generally to be spent in warming the cloth to make it flexible, so as to bend to the shape of the intended joint. Resin is generally used for copper bit work, but touch should also be used, so that the spare rosin can be wiped off the work while still hot from the soldering tool. If this is not done the work looks dirty when finished. Resin is generally used for tinning brass-work ready for soldering. Killed spirits is sometimes used for this purpose, but it is not a good plan, as when making the wiped joint zinc gets into the solder and spoils it for working. For this reason when brass-work is bought with the ends ready-tinned the tinning should be filed off, and the parts retinned, using resin as a flux.

Gallipoli oil is the flux used when soldering pewter. Borax for brazing iron or copper. Chloride of zinc (killed spirits) is used when soldering zinc. In this case it is not necessary to scrape or shape the metal, as the acid removes the film of oxide.

Sometimes the hydrochloric acid (spirits of salts) is used pure, instead of being saturated with zinc, but the result is the same, as immediately the acid is applied it combines with a portion of the zinc and becomes chloride of zinc.

ON ALLOYS.

IN last month's issue were given the proportions and melting points of the alloys used by plumbers for joining lead-pipes and sheets together. These alloys being known as soft solders for the reason that they are used for joining soft metals, such as lead, &c, together, and also because they melt at a very low temperature. I wish here to add that plumbers' solder, composed of two parts by weight of lead and one of tin, is generally known by plumbers as "metal." Some years ago the Plumbers' Company used to assay all solder made in the City of London to prove its quality, and then when it was cast into bars each bar was marked with the company's stamp, as a guarantee of its quality. This solder was then known as "sealed solder," and was in great demand both for exportation and use in other parts of the country besides London. The writer has assisted to cast and stamp several tons of solder after it had been assayed and tested by the late master of the Plumbers' Company, Mr. George Shaw.

Hard Solders are used for joining some of the hard metals together. This solder was referred to in my last paper under the name of "spelter." A soft spelter used for brazing, or hard soldering, ordinary brass work together is composed of one part of zinc and one part of copper, but for joining copper or iron together a harder spelter is used, composed of two parts of zinc and three of copper. These proportions may be slightly varied to suit when brass is being joined together. Some kinds of brass have a greater proportion of zinc than others, and it follows that when the zinc is in the greatest proportion the spelter must also have an excess of zinc so as to melt at a lesser degree of heat than the brass to be joined. As an example, ordinary brass is composed of two parts of copper and one of zinc. If this alloy is made very hot, but short of redness, it becomes very brittle and almost at melting point. If spelter, composed of the same proportions of zinc and copper, was used for joining this brass together, the whole would melt together into an unshapely mass when the necessary heat was applied to melt the spelter. Another kind of brass sometimes called "pot metal" is composed of about five parts of copper and two of lead. This metal is sometimes used for very common taps. The melting point of this metal is very low, indeed, some years ago the writer was making an underhand joint on to a stop-cock made of pot metal, when he melted a hole in the cock by pouring on plumbers' solder. All alloys of copper and zinc are known by the name of "brass," but alloys of copper, zinc, and tin are generally called "bronze." The bronze coin of the realm is composed of copper ninety-five, zinc one, and tin four parts. Bronze for stop-cocks and valves, copper eighty-eight, zinc two, and tin ten parts.

Gun Metal is an alloy of copper and tin. As stated in an earlier chapter, tin has the property of hardening copper. A very hard gun metal is composed of copper five and tin one part, and a soft gun metal is composed of sixteen parts copper and one of tin. The proportions of the constituents of an alloy have to be varied according to the purposes to which it is to be put. In some cases a hard, and in others, a soft alloy is wanted—or an alloy is required hard but not brittle, or it may be wanted to resist wearing by friction—or for rolling into sheets. Some alloys have to withstand a tensile strain. And again, some alloys are required to be a particular colour, and the constituents have to be varied accordingly. By adding a small proportion of phosphorous to gun metal, the alloy is called "phosphor bronze," and is used for special parts in some kinds of machinery. It is reported that phosphorous is a preservative against the effects of the atmosphere.

Bell Metal is a hard alloy of about four parts copper and one of tin. Sheet copper is sometimes used for sheathing ships bottoms, but an alloy of three parts copper, two zinc, and 1-100th of lead is now often used instead of copper. This alloy is known as "Muntz's metal" and is so malleable as to be easily rolled when hot, into thin sheets. An alloy of copper, 60, zinc 38·2, and iron 1·8 is malleable when red hot, and is known as "Gedges" metal.

Babbits Metal is an alloy of copper four, zinc eight, and tin ninety-six parts. It is used for bearings in machinery. If the bearings get hot the alloy melts.

Arguzoid is a very hard white alloy, composed of the following metals :—Copper 56, zinc 23, nickel 12·5, tin 4, iron 3·5. The writer has used lavatory cocks and fittings, made of this alloy, which has a very white, silvery appearance.

All metals expand when heated, and contract on cooling, but not always to the original dimensions. This applies also to most, but not all, of the alloys. The following alloy will expand on cooling :—Lead nine, antimony two, and bismuth one part.

Good type metal should not contract on cooling. This metal is composed of three or four parts of lead, and one of antimony. The antimony being used to harden the lead. Some kinds of type metal have the above proportions varied, and have a small addition of tin.

ON LEAD PIPES.

DURING this last half-century great improvements have been made in the machinery for manufacturing lead into the forms in which plumbers use it. In olden times both sheet lead and pipes were cast. For pipes the lead was sometimes cast in the form of a sheet which was then cut to the necessary sizes, folded on a mandril, and then burnt together by pouring melted lead on the seam until the parts to be joined were fused together. These pipes were not always made round, sometimes they were oval, in other cases square or oblong in cross section. Small pipes were sometimes cast in short pieces, and the ends burnt together afterwards, or after one piece was made another length was cast on to the end of it in such a way that on casting the second length, the end ot the first was melted and joined to it. This process being repeated until a pipe of the required length was made. Another way was to cast a short length, the bore being the size of the intended pipe, but the substance much thicker. This was then put on a hard metal mandril and drawn through perforations each one smaller than the preceding one, until the lead pipe was drawn out much longer, and the substance reduced. Another way was to pass the thick lead-pipe, when cast, between groved or fluted rollers until it was reduced to the required substance. In each case the bore of the pipe was kept the same size by the metal core or mandril placed inside.

Bramah, the designer of the W.C. which bears his name, was the first to invent a machine for making lead-pipes to any length. The modern machine for making drawn lead-pipe is founded on Bramah's principles, and simply consists of a gigantic squirt. Lead in a semi-molten condition being forced through a die, with a core in the centre, and issuing in the form of a hollow tube. Different dies and cores have to be used for making the pipes of different sizes and thicknesses. Soil-pipes are generally made in 10 ft. lengths, but most manufacturers will make them 12, 14, or 16 ft. long when they are required to do so. But these are awkward lengths to move about, they are very liable to bend or buckle and get out of shape. Soil-pipes are made 3 in., 3½ in., 4 in., 4½ in., 5 in., and 6 in. in diameter. The substance of the lead for soil-pipes can be had equal to sheet lead weighing 6, 7, 8, 9, and 10 lbs. per square foot. Soil-pipe is described as those number of pounds, according to the class of work to be done. The weights are intended to represent the lead as being that weight each superficial foot, and not that the pipe should weigh that number of pounds each foot in length.

Lead ventilation-pipes are generally used about a pound less in substance than the soil-pipes. As an example, where 7 lb. soil-pipe is used, the vent-pipe would be 6 lb., and so on for the other weights.

2 in., 1¾ in., 1½ in., and 1¼ in. pipes are usually made in 12 ft. lengths, but can be had in coils from 30 to 60 ft. The 2 in. is rarely made longer than 25 to 30 ft.

1 in. ¾ in. ⅝ in., ½ in., ⅜ in., and ¼ in. pipes are made in lengths of 15 ft. and coils from 60 to 90 ft. long. The substance and weight of lead-pipes should be governed by the purpose for which they are intended to be used.

Service-pipes should be stronger than waste-pipes, and waste-pipes thicker in substance than air or vent-pipes.

The following weights are according to the Metropolis Water Company's Act 1871, for branch-pipes connected to the Water Co.'s, mains, and are generally spoken of as rising main-pipes. *

Internal diameter of pipes in inches.	Weight of pipe in lbs. per lineal yard.
⅜ in.	5 lbs.
½ ,,	6 ,,
⅝ ,,	7½ ,,
¾ ,,	9 ,,
1 ,,	12 ,,
1¼ ,,	16 ,,
1½ ,,	21 ,,
2 ,,	30 ,,

Warning or overflow-pipes are as follows :—

½ in bore	3 lbs. per yard
¾ ,,	5 ,,
1 ,,	7 ,,

Main service-pipes are usually described according to the number of pounds a certain length will weigh.

⅜ inch pipe is called	⅜ inch 25's
½ ,, ,, ,,	½ ,, 30's
⅝ ,, ,, ,,	⅝ ,, 38's
¾ ,, ,, ,,	¾ ,, 45's
1 ,, ,, ,,	1 ,, 60's

The above figures represent the number of lbs. a 15 ft. length will weigh.

1¼ inch pipe is called	1¼ inch 64's
1½ ,, ,, ,,	1½ ,, 84's
2 ,, ,, ,,	2 ,, 120's

The above figures represent the number of lbs. a 12 ft. length will weigh.

From Mr. Kirkaldy's experiments we find that—

½ in. 34's burst with a pressure of	1,579 lbs. sq. in.
⅝ ,, 41's ,, ,, ,,	1,349 ,,
¾ ,, 57's ,, ,, ,,	1,191 ,,
1 ,, 61's ,, ,, ,,	911 ,,
1¼ ,, 63's ,, ,, ,,	683 ,,
1½ ,, 85's ,, ,, ,,	734 ,,
2 ,, 110's ,, ,, ,,	498 ,,

The thickness of the pipes in last table averages a little over 1-5th of an inch, and the experiments prove that pipes for conveying water under pressure should be thicker in substance when made to a larger size. As an example, ½ in. pipe made of lead ·2 in. thick burst with a pressure of 1,579 lbs. per square inch. 2 in. lead-pipe ·21 thick burst at a pressure of 498 lbs. Although the 2 in. pipe was of thicker substance than the ½ in., the 2 in. burst at less than one-third of the internal pressure that was required to burst the ½ in.

As some waters have an injurious effect on lead-pipes, it has been found necessary to use another metal than lead for conveying water, especially when to be used for domestic or drinking purposes. Pure tin has been found to be better than lead for this purpose, but the cost is so great that it is very rarely used. As a substitute lead encased tin-pipes have been recommended. These pipes are drawn in the same manner as lead-pipes, the pipe machine being charged with lead and tin in such a way that the two metals issue from the die in the proper proportions, and so that a lead-pipe surrounds the inner one of tin. Although the inner and outer pipes can be seen to be distinct yet they are so made that the two metals cannot be separated by any amount of bending or twisting. Professor Frankland a short time ago —when speaking on this subject—said, "The public should be warned against the use of tin-lined pipes, unless they knew how they were manufactured. In some cases the way in which they were manufactured produced an alloy of lead and tin, which acted more on the water than lead-pipes alone. He had suggested a plan to some manufacturers by which pipes could be made which were not in the slightest degree affected by water, but whether all the pipes were of that kind or not he could not say; but certainly where this alloy was produced there was danger."

On the other hand, we have heard Mr. Maguire, sanitary engineer, Dublin, state that "A very slight proportion of tin alloyed with the lead also prevents an injurious action. The pipes and sheets used in the Dublin waterworks are required by the authorities to be made from such alloy. Strong wood tanks lined with this alloy in sheets 7 lbs. to the square foot form durable and safe storage tanks."

The following table, based on Mr. Kirkaldy's experiments, shows that lead-encased tin-pipes will resist a greater bursting pressure than pure lead-pipes :—

½ inch 19's ·14 thick burst at	1,859 lbs. per sq. in.
⅝ ,, 21's ·13 ,, ,,	1,454 ,,
¾ ,, 28's ·15 ,, ,,	1,416 ,,
1 ,, 36's ·14 ,, ,,	1,265 ,,
1¼ ,, 32's ·13 ,, ,,	835 ,,
1½ ,, 43's ·15 ,, ,,	849 ,,
2 ,, 65's ·17 ,, ,,	642 ,,

This table shows that ½ in. encased pipe, about 1-7th of an in. in thickness, will resist a greater bursting pressure than a 2 in. pipe about 1-6th of an inch thick. The student should compare this table with the one for lead-pipes, and mark that the lead-encased-tin pipe is much stronger than the lead-pipe.

* The New River Company insist upon all down service-pipes from cisterns being of the same weights as the rising main-pipes.

ON CASTING SHEET LEAD.

BEFORE the invention of the lead mill, sheet lead used to be cast. The following brief description will give the student some idea how it was done.

A good-sized shop, well lighted, and free from draughts, is necessary. The floor should be kept clean, so that any spilt lead could be swept up. Stone floors are better than wood. In a convenient position a large cast-iron pot with a broad rim, to support the weight of the lead, is set in brickwork, with a fireplace beneath, and a flue encircling the pot for heating the contents.

A large wooden bench, with raised sides (generally called the casting frame, or mould), should be fixed so that the workers can walk all round it. The bed of the frame is covered with clean, but loamy sand slightly moistened, to make it bind together. This sand is carefully levelled on the surface, and is beat down into a close and compact condition, to prevent it being washed into holes when the molten lead is poured on to it. A piece of board cut to fit inside the sides of the frame, and with strips to project beyond as handles, is used to level the sand. This tool, called a "strike," is used by two men, one at each end, who push it up and down the frame, and sometimes give it a kind of chopping motion, until the sand is made moderately smooth and even. The surface of the sand is then "planed." The plane is like a large plasterer's trowel, but made of copper, the edges being slightly curled upwards. A piece of touch is rubbed on the face of the plane, which is then passed backwards and forwards, varied by circular motions all over the sand until it is perfectly smooth. When well planed the sand will look bright when seen in certain positions.

At the end of the casting-frame, nearest the pot, is the "head pan." This is generally of cast-iron, and the same length as the width of the frame. The lip of the head pan rests on the end of the frame, and it is supported on legs, or trestles. At the bottom end of the frame is the "foot pan" which is a long trough made of wood, and lined with sheet copper, placed to receive the superfluous lead removed by the strike. At the lowest end of the foot pan is the waggon, this being a large cast-iron bowl on wheels placed to receive the lead caught in the foot pan. When all is ready, the operation of casting proceeds as follows :—

The strike used for levelling the bed is wiped clean, and "muffles" put on the handles, the thickness of the muffles being regulated according to the substance it is intended to cast the lead.

The lead is ladled out of the pot into the head pan. The heat of the lead must be such that it does not set in a solid mass, or congeal and adhere to the sides of the head pan. An allowance should be made for the absorption of heat by the cast-iron pan. When the necessary quantity of lead is ladled into the pan, it should be well stirred and kept in motion, so that it is of uniform heat throughout. As soon as the lead has cooled sufficiently (generally found by dipping in a piece of clean dry wood and noticing the smoke, or charring of the wood, or by dipping in a piece of sheet lead and noticing if it melts, or if some of the melted lead congeals around it), the strikers take up their positions near the frame, and, at a given signal, the third hand (man) tilts the head pan and upsets the lead into the frame, the strikers then quickly push the strike before them, and remove the superfluous lead before it has time to set. This lead runs onto the foot pan, thence into the wagon, when it is immediately dragged to and emptied into the pot. As soon as the strike has passed the end of the frame, a man stands ready with a drawing knife and cuts off the bottom selvage. If this is not done the sheet will sometimes spoil by cracking right across. As the lead cools it contracts, so it is important that the ends of the sheet are not tied so as to prevent this contraction.

After the sheet is cast it is rolled up and hoisted off the frame. The sand is then sifted and moistened, and the whole process repeated for the next sheet. Some casting frames are 18 ft. long, by 6½ ft. wide, and it follows that is the size of the sheets. Smaller frames are used, about 10 ft. long by 4 ft. wide. It is very difficult to cast large sheets less than 7 or 8 lbs. each square foot. When cast lighter, the thickness of the sheet will vary very much. Old lead can be used for casting into sheets, but it is advisable to cut out all old solder, &c., and to add some new pig lead.

It is much to be regretted that cast sheet lead is now very rarely used. On looking at some of our old Cathedrals, and other ancient buildings with lead roofs, they will be found to be generally in better condition than a great many modern ones with milled lead roofs. There is little doubt that in cast lead all the molecules are in a natural position towards each other, whilst in milled lead they are squeezed into unnatural positions during the process of milling, and are so compressed that they cannot move over each other when exposed to influences causing expansion and contraction of the metal.

ON MILLED LEAD.

MILLED lead is never made by plumbers, for the reason that large, special made and expensive machinery is necessary. But as the operation of milling is interesting, a very brief description of the process is given. The lead mill consists of a large iron frame in some cases about sixty, in others about ninety feet long, by, from 7 to 10 ft. wide. The bed of the mill has a series of cross rollers its whole length about 3 or 4 in. in diameter, for the sheet-lead to move freely on as it leaves the large milling rollers. Across the centre of the frame are placed two large rollers, arranged similar to some of the patent wringing machines used in laundries. These rollers are made of iron or steel, are very strong and have smooth faces. In some cases steam is passed through these rollers so as to make them very hot, and so soften the lead as it passes between that it rolls out much easier. The large rollers are placed one over the other, the distance apart being regulated by screws, according to the thickness the lead is to be rolled. A large cake of lead is cast, and then, while still hot, passed between the rollers which reduces the thickness, but makes it much longer. After the cake of lead has passed through and become reduced in thickness, the adjusting screws are tightened, so as to bring the rollers closer together, when the lead is again passed between them, this further reducing the thickness of the lead. This operation is repeated until the sheet of lead has become reduced to the required substance. When very thin sheet lead is required it is found necessary, in some cases, to pass two sheets between the rollers at the same time. As lead is very wanting in tenacity, it breaks into holes when rolled out very thin, and passed in single sheets between the rollers.

Milled lead can be bought in sheets up to 40 ft. long, and from 6 ft. 9 in. to 9 ft. wide, and weighing from 3 lbs. up to 20 lbs. each superficial foot. Sheet-lead is described according to the number of pounds one square foot weighs. Milled lead, when ½ in. thick and upwards, is generally described as "plate lead."

When the thickness of sheet-lead is known, the weight of each square foot can be found by dividing the thickness by ·017, that being the thickness, in inches, of one square foot weighing one pound. As an example, suppose a piece of lead is ½ in. (or ·5 in. thick). Divide ·5 by ·017, and we get 29 and a small remainder. One square foot of milled lead ½ in. thick weighs a little over 29 lbs. Or, supposing the weight is known, and the thickness is required we can find that by multiplying the weight in pounds by ·017, when the answer will be in inches. To make this clear, supposing it is required to know the thickness of a piece of 8 lb. lead. Multiply 8 by ·017 and we get ·136, or nearly ⅛ in. Another example is given. A piece of lead is 1 in. thick, what will one square foot weigh? Divide 1 in. by ·017, and we get 59 nearly, which is within a point of the actual weight. If the student remembers that ·017 is the thickness of a piece of sheet-lead when spread out, so as to cover a square foot of surface, he will then be able to calculate thickness, or weight, as the case may be, and so save the necessity of remembering a long table of thicknesses and weights. A final example is given. What is the external diameter of 4 in. 10 lb. lead soil-pipe? Multiply ·017 by 10, double the product and add four, the internal diameter of the pipe, and we get 4·340, or a little over 4⅓ in.

ON RED AND WHITE LEAD AND CEMENTS.

MENTION has already been made of the action of oxygen, and carbonic acid on lead, and the resultant oxides and carbonate. Plumbers use these compounds when mixed together, and with linseed oil, as cement for making joints to iron pipes, bedding W.C. basins, and at the junction of lead-pipes to W.C.'s, also when making screwed connections to boilers, iron and slate cisterns and similar purposes. A cement made of red and white lead absorbs more oxygen when exposed to the air, and eventually becomes very hard and brittle. For this reason, this cement is often improperly used where a softer and more elastic cement would have been better. For instance, when this cement is used for bedding W.C.'s, the joint often cracks by the vibration of the apparatus caused by the flush of the incoming water when used. A better cement for bedding W.C.'s is common putty, made of whiting, and an oil that does not absorb oxygen to the same extent as linseed oil. Neither is lead cement good for making connections to slate and iron cisterns, especially when intended to hold drinking water, as the cement is slightly soluble in some kinds of waters. For the same reason joints to iron pipes for conveying drinking water should not be made with red and white lead cement. Quite recently an analysis was made of water, drawn from iron pipes, with red-leaded joints, when lead was found in solution in the water. The pipes were taken out and beeswax used for the joints. A second analysis showed no signs of lead. The same observations apply to slate cisterns when put together with lead cemented joints, especially when the cisterns are intended to hold drinking water which is of a soft and solvent nature. In some cases where lead cement has been used for making the connection to an iron cistern, the iron inside the cistern where in contact with the lead has been found to oxidise considerably more than the other parts. This arises, no doubt, from a voltaic action setting up between the iron and the lead compounds. This voltaic action has also been noticed round the manholes of kitchen boilers, when a small leakage has been taking place, the escaping water causing the voltaic couple to be complete. In the absence of water or moisture no action would have taken place.

Iron Cements.—In some cases where iron has to be connected with iron a cement made of the iron oxides answers very well.

Another cement, known as "rust cement," is sometimes used by plumbers for joining cast iron socket pipes together. It is also used by engineers for caulking the joints of cast-iron tanks. Rust cement is composed of cast-iron turnings or borings. These turnings are sometimes mixed with dirt and shop sweepings, and so oily, that it is necessary to make them red hot, to burn out the dirt and oil before rising, otherwise they would not rust when required. When the borings are quite clean and free from oil they are pounded small and mixed with sal ammoniac and a small quantity of flour of sulphur. The proportions vary, according to the ideas of the workman, but one of the commonest is 1 cwt. of borings, and 1 lb. of sal ammoniac. The proportions are also varied, according as the cement is required to set quickly or slowly. For a quick setting cement Mr. Molesworth gives—

1 sal ammoniac by weight
2 flour of sulphur "
80 iron borings "

and for a slow setting cement.

2 sal ammoniac by weight
1 flour of sulphur "
200 iron borings "

The slow setting cement is the strongest, if the necessary time can be allowed for it to set. For making the cement, the ingredients should be mixed dry, and then slightly moistened. Soon afterwards they begin to rust, and become warm when they should be again thoroughly mixed and covered with water until ready for use.

Some workmen use urine, instead of the sal ammoniac, as the rusting agent. When the cement is properly made, and the joints in the pipes packed with it, the borings rust and expand very much, with the result that after a time the joint is almost a solid mass, and will stand a very great hydraulic pressure. It is important that the pipes to be joined should have their spickets and sockets free from grease, tar, or anything of a similar nature. Rust joints have been made to cast-iron pipes coated with a bituminous material, such as Dr. Angus Smith's solution, but after an interval of several weeks the cement was found to be as green as when first used, not the least oxidation having taken place.

Mastic Cement is a combination of bitumen with limestone, or other calcareous matter and sand. Some years ago it was used for making good or pointing lead flashings to the stone gables or parapets of houses, and was a substitution for "burning in" the flashings. *Burning in* is the term used when the chase, into which the edge of the lead flashing is turned, is filled up with molten lead instead of with cement of any kind.

Brimstone or Sulphur has sometimes been used as a cement for fixing iron work to stone. Most engineers have now abandoned lead for that purpose, more especially in situations exposed to the elements. In damp situations a galvanic action takes place between lead and iron, and the iron is eventually destroyed.

Portland Cement is now very much used for various purposes. Plumbers make good earthenware W.C. traps to drains with this cement. It is also used for making the joints of stoneware drain-pipes, but for this purpose great care must be taken when selecting the cement. A great deal of Lias lime is mixed with the cheaper cements, so as to make them set quickly, but it is very difficult to make joints to drain-pipes so that they will stand a hydraulic pressure when the cement is of an inferior quality. Portland cement expands when setting, so that in some cases it has been found necessary to add a little clean, sharp, washed sand. It is not at all an uncommon occurrence for the Portland cement to swell with such force as to burst all the sockets of stoneware drain-pipes. The writer once had to relay the whole of the drains three times, in a house at Chelsea, before they would stand a hydraulic pressure of about 1 lb. on the square inch, and each time it was because of the pipe sockets splitting by the force of the expansion of the Portland cement.

A wash of Portland cement has been applied with good results to the insides of iron cisterns to prevent oxidation. The joints of iron drains have been made with Portland cement, and have answered fairly well, but these joints should always be made with metallic lead, as not being so brittle. The lead is also of a more yielding nature, and allows for a slight motion of the pipes without causing them to break or the joints to leak. This is of great importance where alternate discharges of hot and cold water pass through the drains, causing them to expand and contract, thus putting a violent strain on the joints.

Plaster of Paris is often used by plumbers for bedding wash-hand basins, and the marble tops over them. This cement is very unsuitable for the above purpose, as it soon breaks away, thus allowing water to splash over the rim of the basin. A nasty faint odour can generally be found round the joint between the washhand basin and the marble or slate top, arising from an accumulation of stale, dirty soap curds. A ring made of a piece of soft india-rubber tubing makes a good packing to use instead of plaster of Paris.

THEORY AND PRACTICE ON SOLDERING.

IN the May issue was given the constituents and melting points of various solders, and also the various fluxes used when soldering metals together. It remains now to describe the various ways plumbers apply the solder and prepare the work for joining. In selecting the proper solder to use, the plumber must be guided by the nature of the metals he is going to join together. The solder must as nearly as possible approach the metals in their physical properties, for reasons it is not necessary to repeat. When the ends of pipes are to be joined by a "wiped" joint, the first thing the plumber has to do is to prepare them, so that they fit so tightly that no solder will run through when the joint is being made. Student plumbers treat this matter too lightly, as if it was of no importance, and it is only after a solid joint or two has been made that they take more pains when preparing a joint. The ends of the pipes should first of all be made quite true and round. A tan-pin should be used for rounding the ends of the pipes, and not as is so often done, the end of a bolt, or handle of a tool pushed in and twisted round. Both ends of the pipes should be opened, one slightly more than the other, so that one sockets into the other, and then the outer arrisses rasped off, so that the inner pipe end is reduced to a feather edge, and the outer, or socket-pipe end, treated in a similar way, so that should a joint be wiped rather bare, the edge of the lead-pipe will not show through the soldering. After the pipe ends have been prepared as described, they should be covered for about 4 to 9 in., according to the size of the pipe, with a compound of size, lampblack, and a little powdered chalk, commonly called "soil." This soil, sometimes called "smudge," is to prevent the solder tinning to the pipe beyond the part intended for the joint. When the lead-pipe is very greasy, the ends have to be wiped clean and rubbed over with dry chalk to "kill the grease," or otherwise the soil would peel off, or be wiped off with the cloth when the joint is being made. After soiling the pipe ends they should be shaved, that is the part to which the solder is to alloy is to be scraped clean to remove the soil and oxidised or tarnished surface. In some country towns the plumbers shave the pipe ends first and soil them afterwards; but this is not a good plan. They will shave the pipe perhaps 2 in. long, and then soil over about one inch of the shaved part, the pipe being thus reduced in substance equal to the thickness of the shaving, and consequently that much weaker.

Plumbers have different ideas as to what length the joints should be shaved, and some make all joints the same length, irrespective of the size of the pipes. But a difference should be made. For a ½ in. pipe joint 2½ in. long is sufficient, and so on to a graduated scale to 3½ in. for a 4 in. pipe joint. The inside of the socket end should also be shaved so that solder may run into it and round the entering end, and thus make the joint water-tight, even if the whole of the solder should be wiped off the outside. Some plumbers will close the feather edge of the socket round the spicket end. When this is done, and the joint wiped rather bare, it will often leak, or water will ooze through the thin film of solder over the point of connection. When shaving the pipe ends care should be taken not to leave any parts unshaved, and at the same time not to take off more than necessary, so as to reduce the substance of the pipe more than can be avoided. Neither should the shave-hook be dug in too deep at the ends of the joints, so as to nick the pipe. Lead-pipes are often found to break at the joint ends because of this. When making the joint care should be taken not to wipe the ends too bare, but to leave enough solder on to strengthen the pipe, and entirely cover the part which is reduced in substance by the shave-hook. Figs. 1 and 2 will illustrate what is meant, Fig. 1 being badly shaved and wiped, and Fig. 2 a joint properly prepared and finished. When preparing the angles of cisterns and sinks for soldering, the point of the shave-hook is often

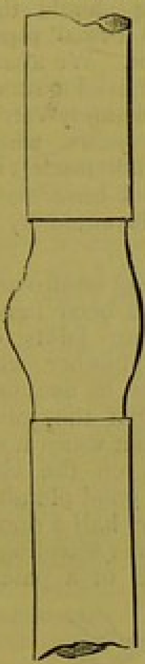


FIG. 1.

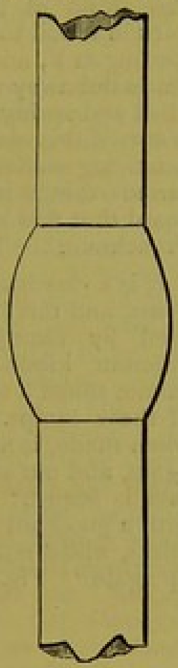


FIG. 2

used in such a way as to reduce the thickness of the lead very much, and then when wiping, the solder is left too thin at the edges, thus making those parts very weak where they should have been the strongest.

It is difficult to describe the process of wiping a joint, and if I was to lecture for two or three hours upon it you would not then know so much about it as if you had ten minutes practice at the bench. You could watch twenty men making joints and, even if they were all first-class wipers, no two would proceed in exactly the same way, and yet all would turn out equally good work.

When preparing branch joints the same care has to be taken as pointed out for straight joints, and in addition the branch-pipe should be well supported so that, especially when the joint is being made on the bench, the weight will not cause it to enter too far into the main-pipe. It is also a good plan to enlarge the end of the branch-pipe both for waste, service, or soil-pipes. Now that sanitary engineers are using soil-pipes much smaller than they used to do it is important that the branch soil-pipes should be bent as shown at Fig. 3.

I have known straight branch-pipes to be filled with a solid plug of paper, &c., which projected across the vertical soil-pipe and thus cause a stoppage, but never knew such a stoppage to occur when the branch was bent as shown. Service-pipes should be treated in the same manner, the bend being turned so as to meet the current of water. I may here say that when water has to turn round sharp bends in pipes the velocity is much retarded, and a less quantity passes through in a given time than when the bends are easy or more gradual.

I have already said the process of joint wiping is difficult to describe without demonstra-

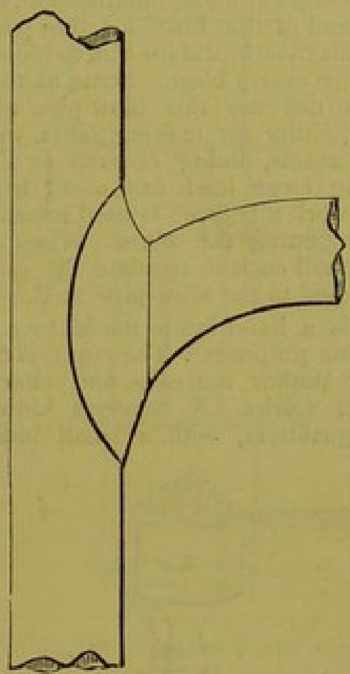


FIG. 3.

tion, but the various methods for heating and applying solder may be of interest. The old-fashioned way of heating the solder in an iron pot, taking a ladleful of solder, and pouring or splashing it on the joint until sufficient has been put on "to get up a heat" when it is wiped with or without the aid of an iron, is the one most commonly practiced at the present day. For large jobs it is the most convenient, and preferred by all good tradesmen to any other method. But there are times when it is difficult to get a fire for heating the solder. When gas is at hand that can sometimes be made available for melting the pot of solder, and then when wiping the joint use a gas blow-pipe instead of an ordinary plumbers'-iron. Or the solder can be run into strips and melted on to the joint by means of the gas blow-pipe, and when sufficiently heated wiped with a cloth in the ordinary way. A good many plumbers make their own blow-pipes, as shown by Fig. 4.

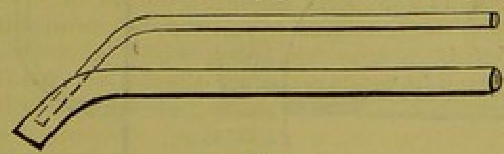


FIG. 4.

A piece of flexible india-rubber hose $\frac{1}{4}$ in. or $\frac{3}{8}$ in. in diameter is attached to the pipe, and connected with a gas-pipe, or the burner can be unscrewed from the nearest gas bracket and the hose attached to that. It is sometimes advisable to have a cock at A to regulate the gas supply, this cock to have a by-pass so that a small light is kept burning ready for use. A piece of hose similar to the other, but about 18 in. long, is attached to the pipe B. A small wooden, ebonite, or other suitable mouthpiece is fixed on the loose end of the hose for the plumber to grip with his mouth, and for him to blow through to get the necessary blast. Some of the men I work with can use this blow-pipe with great advantage, either for making joints, wiping flat or raised seams, lining cisterns or sinks, and for making large lead rain-water heads, &c. For large work a bellows is used instead of the mouth for getting the blast. When a bellows is used a small cock to regulate the quantity of air is attached to the blow-pipe at B.

Fig. 5 is a hand-lamp made by a plumber for soldering purposes. The cup C is filled with cotton, or similar material, and charged with methylated spirits. A common blow-pipe, as used by gasfitters, with a small india-rubber

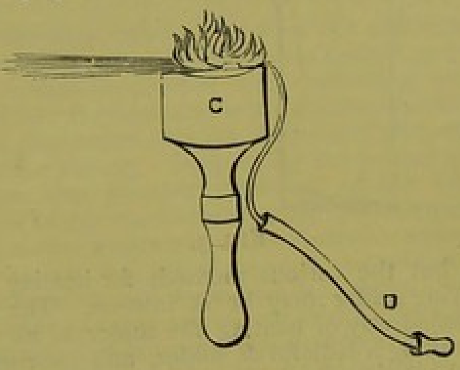


FIG. 5.

tube and mouthpiece, is fixed as shown at D. This lamp has been found very useful when wiping joints on to small work.

About twenty-six years ago a fellow apprentice, and with whom I lodged, made a self-acting blow-lamp, as shown at Fig. 6. The materials used were two old oil lamps, as used for fixing

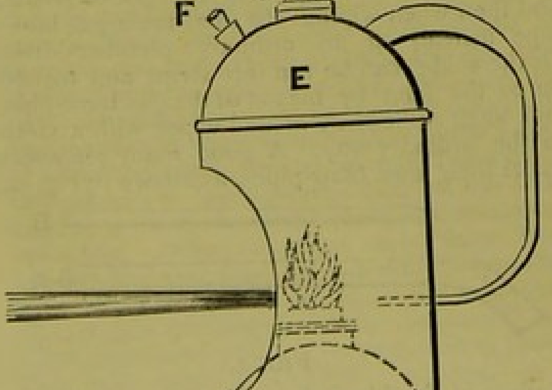


FIG. 6.

into candlesticks. an old coffee canister, and a 6d. blow-pipe. The burner of one lamp E was taken out and a screw soldered in, but as we were afraid of this lamp bursting should the spirit in it boil too much, we added a small pipe, opening at F, and fixed a cork in it. We afterwards did away with the cork, and fixed a small valve and spring, so as to act as a safety-valve. We used this old lamp for several years, when practicing soldering or making small models of various things in our lodgings. I have since heard that this kind of lamp was invented by a Frenchman.

It is a very handy lamp for making small-sized joints, and this last few years it has been much used by plumbers when making joints of different kinds. I know one plumber who cannot make a wiped joint without he uses one of these lamps. He says that "if the joint, when made, is not quite true he can warm it up again, and put some more metal on the side that is barest." I would back a good plumber with a good pot of solder to make half a dozen joints, whilst our friend above "was warming it up again." Fig. 7 is an illustration of a patent

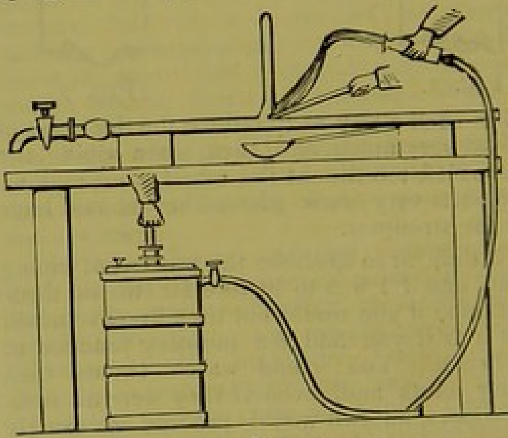


FIG. 7.

soldering machine that is no doubt very useful. I have not seen it in general work, but have tried it with good results. Another man who had never seen the machine before was told to make a 2 in. upright joint by its aid. He prepared his joint by soiling, shaving and fixing it. He then melted a small bar of solder, weighing about four pounds, into a ladle held over the flame, and splashed it onto the joint in the usual way. He then took the jet in one hand, and his wiping cloth in the other, and wiped a very good joint. The whole of the time from start to finish was under half-an-hour. He was then asked to take a fresh piece of 2 in. pipe and make an underhand joint on the bench. After preparing and fixing the joint he collected the spare solder, left from the other joint, added sufficient from a bar to fill his 4 lb. ladle, and then poured it on the joint, heated it up by means of the flame from the machine, and wiped a first-class joint, this being done under half-an-hour. I purposely omit giving the name of the proprietors of this machine, as it would be very unfair for me to praise any one person's things to the disadvantage of other people's, of which I may know nothing, and which might be equally good.

When I was a young man and learning the trade of a plumber it was very unusual to find a copper bit in a plumber's kit, excepting a small one for tinning brasswork. If a man was found making a copper bit joint he was laughed and sneered at, and called all sorts of hard names. Now a copper bit is a very handy tool in its right place and properly used, but unfortunately it is a tool very much abused by a class of men who usurp the title of plumbers, and who, by their tinkering way of doing work, bring the whole trade into disrepute. Making wiped joints is not the only criterion of a plumber, but if he cannot wipe a joint it is doubtful if he can properly do anything else that comes under the heading of plumbing. I have just been making an examination of a large building where some talented experts had been at work with copper bits, and, to sum up my opinions, the work they had done was simply disgraceful. The pipes were not straight, were not firmly fixed, and there were about six or seven joints that had to be tied up with red lead cement and string. Some of the joints had as much resin as solder round them. The bends in the pipes were all so crippled that they were only about half bore. In some cases the mahogany W.C. seats had to be cut and fitted round the branch service pipes to the valves, where they lay horizontally, the plumbers (?) not having the good sense to fix them beneath the seats and out of sight. In these men's hands the copper bit was a dangerous tool, as it gave them a colourable claim to be called plumbers. In the hands of a good plumber a copper bit is a useful tool, and there are places were a copper bit joint is the right one to make. For instance, to small brass unions and other fittings that are too small for making a wiped joint to, but in those cases I prefer an overcast joint, that is, a joint made with a body of solder melted on it as shown at Fig. 8 so as to strengthen it and render it less liable to be broken when screwing up the union. These joints can only be made with the pipe, &c., laying horizontally. When of necessity a copper bit joint must be made in its position, and upright, the ordinary cup joint must be made.

When inspecting country mansions, and I have to go to all parts of the United Kingdom, I find a great deal of copper bit plumbing, more especially in the north and west. Lead soil, waste, and air pipes are made with copper bit seams, bends are made with two pieces of sheet

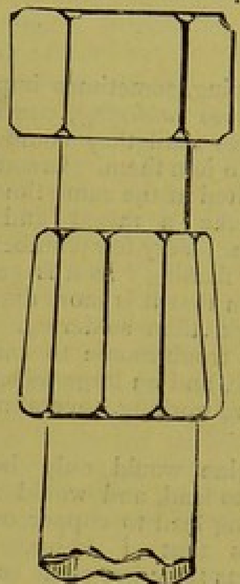


FIG. 8.

lead worked to the required shape and copper-bitted together. Sometimes elbows are made instead of bends, and soldered by the same means. Tacks soldered to the soil, &c. pipes, the joints made, including branch joints, traps made, and in fact the whole of the soldering done by the aid of the copper bit. A wiped joint being the exception and not the rule. In some places it can be seen that the work was well done, and by good plumbers, but the best copper-bit work looks poor and weak when compared with a good wiped metal job. The greater portion of the work that I have seen has been wretchedly done, and I cannot help but think that in a great many cases the plumber has been dispensed with and the village blacksmith employed instead. In dismissing the subject of soldering let me impress upon you the importance of making good wiped joints. A great many may not agree with me on this matter, and will maintain that a good copper bit joint is equal to a wiped one. To those I would say, do your work so well and in such a way that village blacksmiths and tinkers are at a discount. Those men may be highly respectable and very good at their own trades, but they cannot do good plumbing, and a plumber lowers himself very much when he copies their way of doing work.

ON LEAD BURNING.

LEAD burning, sometimes improperly called *Autogenous soldering*, consists of melting the lead edges until they combine, instead of using solder to join them. In some cases a strip of lead is melted at the same time as the edges so as to make a raised and consequently stronger seam. Very few plumbers practice lead burning, or "flaming" as it is generally called, for the reason that it is more difficult to do, on all round work, than soldering. The machine too would be troublesome to carry about from place to place, and on large jobs, where several plumbers were working, several machines would be required.

The machine would only be useful when joining lead to lead, and would not answer so well for joining lead to copper or brass. Some lead burners that I know, complain that burning affects their eye-sight so that they cannot read ordinary printed matter without the aid of glasses. But these are men who are always working at lead burning.

There is no reason why the ordinary plumber should not know how to do "flaming," as there are times when it is necessary to join lead by that means. Vitriol chambers, and vessels for containing acids, should be burned together. If they were soldered in the ordinary way the acids would attack the solder and eventually destroy its metallic nature, and the chambers or vessels would leak. Sometimes an intricate piece of lead-work on a roof cannot be bossed or worked to fit its position, in which case the lead could be burned together, and would look much better than if soldered. I always think that soldering, on a roof, looks patchy, no matter how nicely it is done, or how highly decorated with soil. When covering floors or large staircase landings it sometimes occurs that sheet-lead cannot be had in pieces large enough. Small pieces can be used, and if burned together the seam can be cleaned oft, leaving a smooth surface, the seam being invisible. A soldered seam could be cleaned off too, but a white silvery-looking streak would be left to show where the pieces of lead joined together.

The machine generally used for burning lead consists of a chamber for generating hydrogen gas, a bellows for supplying the necessary amount of atmospheric air; india-rubber tubes for conveying the air and gas, and the jet, burner, or nipple at which the mixture is ignited and applied to the parts to be joined. There is a difference of opinion as to who first invented this machine, but there is no necessity for us to trouble ourselves about that matter so we will pass on and consider the machine as we find it.

Fig. 9, represents in section the one most commonly used. There are other patterns used by some Americans as well as Englishmen, but although they may vary in shape, there is little or no difference in their action. Some are made of sheet-lead without any enclosure, but those for ordinary use, and that have to be moved about from place to place, are best when made in the old-fashioned way, by having a wooden box made and lined with lead. Although they look clumsy when compared with those not enclosed, they are no heavier, as they can be lined with light lead, whereas, the others have to be made of heavy lead or they would collapse through not being strong enough to support their own weight and that of the charging

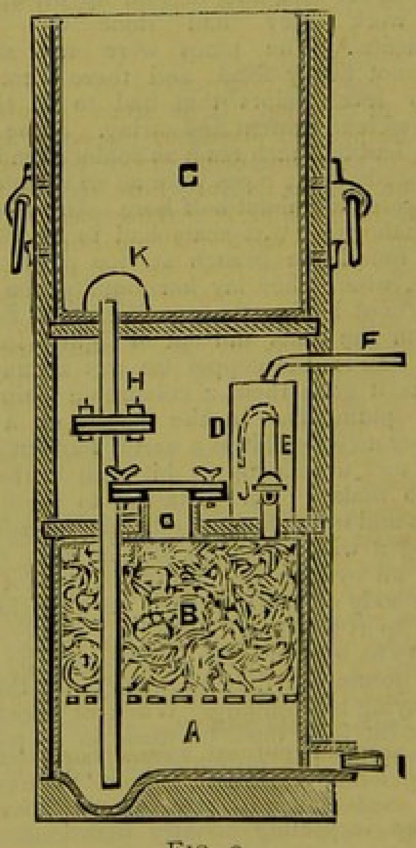


FIG. 9.

materials. And neither do the enclosed ones get bruised and distorted by being knocked against. Again, the wooden enclosure keeps the acid chamber warm and prevents the sulphate of zinc, which is formed by the materials used for charging the machine, from crystalising and eventually blocking up the pipes and machine.

To desribe the machine; A is a small space covered with a false bottom made of a piece of perforated sheet lead, and supported on pieces of pipe. B is a chamber usually filled with scrap zinc, although sometimes small bars of spelter, which is the commercial name for zinc, are used instead. The zinc is put into the chamber B through the small manhole C and rests on the piece of perforated lead over A. D is a pipe from the top of the gas generating chamber, leading into the wash bottle E, and F is a pipe from the bottle E, to which is connected the india-rubber tubing for conveying the gas to the burner, which will be described further on. G is the acid chamber, and H a pipe to convey the dilute acid down to the bottom of the well of the gas generating chamber. I is a small pipe from the well for emptying the machine when out of use. The wash bottle E is also intended to cut off direct communication between the generating chamber and the flame or jet, but as a matter of fact the bottle rarely gets properly charged with water, but after using for some time a considerable quantity of water taken up in suspension by the gas drains into the bottle and so it gets charged in that way. J is a stop-cock for turning off the gas which should always be done immediately the plumber leaves off burning. If he stops for only a few seconds this cock should be turned off as there is risk of the flame being drawn back into the machine. There is very little risk of this so long as the machine is making gas, but should it become spent and a small quantity of atmospheric air enter the machine and mix with the hydrogen gas, the compound at once becomes highly explosive. While writing on the causes of explosion I may here say that in some cases air can be driven by the bellows so as to force back the gas into the machine in which case there is some little risk of an explosion.

The bellows will sometimes, when improperly used, draw gas back into its inside, and should the burning flame at the nipple be drawn back or burn its way back into the bellows, an explosion is almost certain to occur. I never had this happen but once, and that was when a student, who was assisting at a demonstration of lead burning, did not keep the bellows going fast enough, the bellows at the same time having a defective clack valve so that it sucked a lighted flame back into its interior.

If a light was put into a vessel containing pure hydrogen the light would go out, hydrogen not being explosive unless mixed with oxygen or atmospheric air.

To charge the machine, zinc has to be put into the generating chamber as before described Iron wire could be substituted for the zinc, but it is not quite so good, and the gas from iron smells more offensive. After charging with zinc, dilute sulphuric acid in the proportion of one of acid to seven or eight of clean water, is poured into the acid chamber G.

On opening the stop-cock J to let out the air in the bottom chamber, the dilute acid runs down the pipe H and comes into contact with the zinc. The sulphur in the acid and the oxygen, which is one of the constituents of water, enters into chemical combination with the zinc, evolving heat and setting the hydrogen free. The chemical formula for this change was given in an earlier chapter when describing the action of acids on metals.

Soon after the dilute acid is let down the bottom chamber will begin to get warm and hydrogen gas released. If very little or no gas is being used it will generate with sufficient power to force all or nearly all, of the dilute acid back into the top or acid chamber. When the solution is all forced out of the bottom chamber the gas will escape up the pipe H through the contents of the chamber G, causing some to splash over the sides.

For this reason it is never safe to stand over an open acid chamber as injury might occur to the eyes or face. A heavy perforated lead cap K will break the violence of the escaping gas. The machine should never be charged until the plumber is ready to begin burning, otherwise the gas blows off and is wasted. After a time the machine will cease to generate gas, in which case it is sometimes necessary to add more water, or sulphuric acid. Or perhaps the zinc may have become entirely dissolved, and the machine want recharging. Or if the machine is placed in a cold situation the contents may have become cold and crystalised. All these points have to be attended to, and it is only by experience the plumber can tell what is required to be done to again get up a gas charge.

The machine should always be worked down before being left at meal times, and kept in a warm situation to prevent the sulphate of zinc solidifying, but at night or other times when the machine is going to be left for some time before using again, the dilute acid should be emptied out, and the generating chamber well rinsed with warm water and left to drain empty. The zinc need not be removed. If the machine is left charged the contents will solidify in crystals and it will sometimes take an hour or two and several pails of hot water to dissolve them, so that the machine can again be got into working order.

The bellows next claims our attention. It is important that the air should be driven at a moderate and equal speed as it is very difficult to burn well if the air is supplied in puffs or at varying pressures. Fig. 10 is a sketch of the bellows generally used for lead burning, which consists of a sheet iron cylinder, enclosing the bellows A worked by a treadle B. The upper portion C is a leather chamber, into which the air from A is forced through the valve shown by dotted lines at D. The spiral spring E is fixed to exercise a gentle pressure on the top of the air chamber to expel the air through the pipe F, to which is attached an India-rubber tubing for conveying the air to the breeches pieces of the flam jet. Although fitted with a treadle to work the bellows, as a fact, the foot is rarely used for the purpose. The plumber's mate generally sits on the top of the blowing machine and works the bellows by means of a strip of

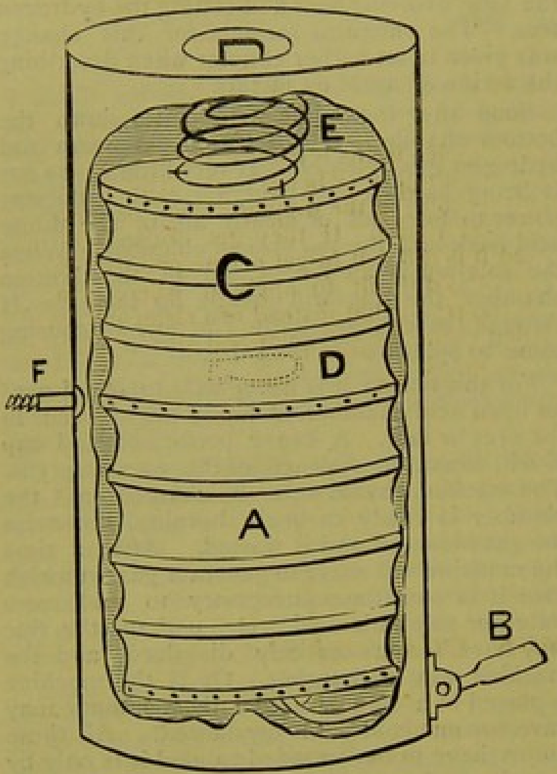


FIG. 10.

wood held in the hands, and with which he works the treadle; not giving long strokes, but keeping up what may be called a gentle and regular jog so as to keep the air chamber in an equal state of distension and thus ensuring a regular and constant stream of air to mix with the hydrogen near the point of ignition at the nipple or jet. The plumber's mate has to acquire a certain amount of skill, and he is generally labouring under the displeasure of the plumber until he succeeds in blowing properly. Nothing annoys a lead burner more than to have a bad blower for a mate.

For large work it is convenient to have a special air chamber as shown at Fig. 11. This consists of a vessel to hold water and another vessel inverted as shown in the figure. Air is driven by a bellows through the pipe G, which causes the inverted vessel to rise. The pipe H is connected with the India-rubber tubing leading to the flam jet breeches piece. A stop should be fixed to the floating chamber to prevent its being lifted out of the water if the bellows should be worked too hard. This air chamber is constructed on the same principles as a common gas holder. Or the upper chamber can be fixed if a strong blast is required. In this case it is not usual to put so much water into the lower chamber. If too much water is put in, it will overflow when air is forced into the holder, the pressure on the surface of the water inside forcing it down with a corresponding rise of water on the outside of the inner or

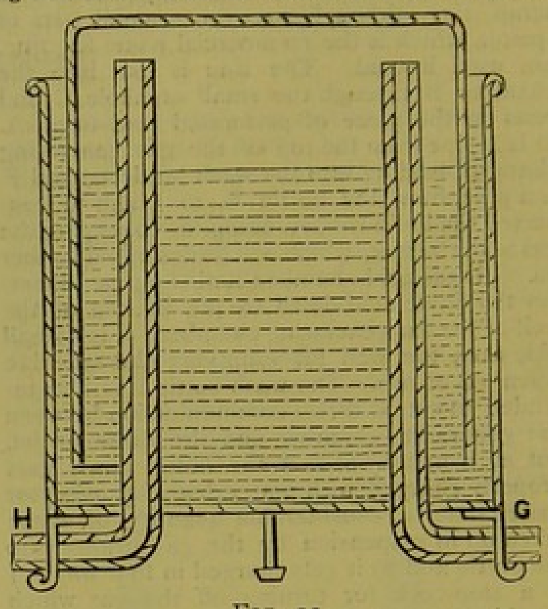


FIG. 11.

top chamber. The India-rubber tubing should be of vulcanised, or mineralised rubber, and should be of a good substance to prevent kinking at the bends, which would obstruct the free flow of the air and hydrogen gas. The tube should be about ⅜ in. to ½ in. in diameter. It is not advisable to use wire lined rubber, as the acid acts on the wire and eventually destroys it.

The breeches piece is shown at Fig. 12, and

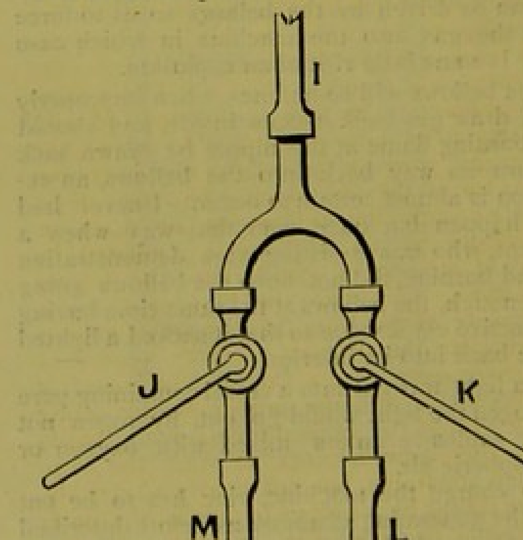


FIG. 12.

consists of a brass U-shaped tube, with a branch I, to which is attached a piece of India-rubber tube about 2 ft. or 3 ft. long, so that the plumber can freely move his flam jet about without having to drag the breeches piece at every motion of his hand. The cocks J, K are for regulating the supply of atmospheric air and hydrogen gas in the proper proportions. These proportions can only be learned by practice. The India-rubber tubes L and M are connected with the gas machine and air bellows respectively, and are of a length governed by the position of the work to be burned. For instance, when burning a cistern together, longer tubes are necessary than when bench work is being done, as it would be inconvenient to have the whole of the apparatus and the plumber and his mate inside the cistern.

Fig. 13 is an illustration of the flam with the nipple N. This consists of a small brass jet with a hole in the point large or small, according to the work being done. The nipples screw off the brass bent-tube, and can be changed in a few seconds. The plumber generally carries

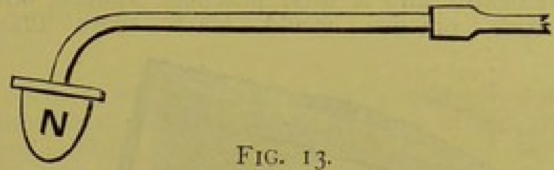


FIG. 13.

these nipples in his waistcoat pocket, to protect them from injury or being lost. It is important that the holes in the nipples should be perfectly true and round. If they get bruised or distorted it is difficult to get a true-pointed flame; hence it is difficult to apply it where wanted, with the result that instead of a clean and evenly burned seam, an irregular and slovenly looking one is made.

LEAD BURNING WITH COMMON COAL GAS.

IN some cases it is necessary to burn two pieces of lead together, but the flaming machine is not at hand. Or the work to be done is so small that it would take longer to make the gas than to do the work. In these cases common coal gas makes a very good substitute for the hydrogen gas. When coal gas is used, a different kind of burner is necessary. With the aero-hydrogen machine the air and gas are mixed before ignition, but when coal-gas is used the blow-pipe is made, as shown at Fig. 4 in an earlier chapter. The arm A is connected with a gas service by means of a flexible tubing, the gas escaping through the annular space between the nozzles of the two pipes. The arm B is connected with the bellows or air machine. The supply of gas and air is regulated by means of stop-cocks, similar to the burner shown at Fig. 12. With the blow-pipe, Fig 4, the pressure of gas from the company's main is sufficient, but the air blast has to be worked at a higher pressure By a careful adjustment of the stop-cocks, and the proper burner being used, lead can be burned together very easily and in the same manner as with the aero-hydrogen apparatus, but not nearly so quickly. What is meant by a proper burner is, the outer tube should be about ⅜ in. in diameter, and the inner one have a hole about the size of a common pin, so as to make a very sharp-pointed flame. If the gas and air are both highly heated before issuing from the blow-pipe a fiercely hot and pointed flame can be had, and by which flat burning can be done almost as quickly as by the other machine mentioned.

Fig. 14 is a rough sketch of a hot blast blow-pipe made for me several years ago by a plumber who worked with me and others at St. Thomas's Hospital, but who is now in business for himself at Torquay. He always uses this blow-pipe for lead burning, and I give it to the students to practice with at the Polytechnic In the illustration P, is the wind-pipe; O, the

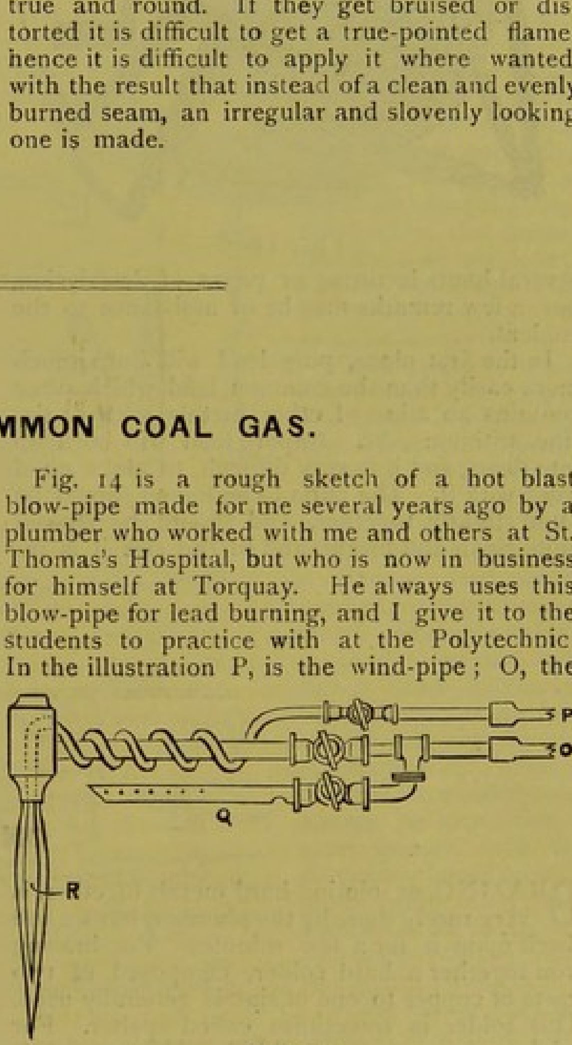


FIG. 14.

gas-pipe; and Q, a Bunsen burner for heating the air and gas as it passes towards the burner. Although the flame is not so hot, and does not melt the lead so quickly as the aero-hydrogen blow-pipe, still very good work can be done with it. With this blow-pipe we use a Fletcher's bellows, as shown at Fig. 15, and by which a very good regular stream of air can be had. This bellows is small in size and can be easily moved about from place to place. It can also be easily worked by the plumber, either with his foot, or under his arm, although the latter is very laborious work.

Lead burning is not at all difficult to do, the principal point being to have the proper conveniences and a little practice. Indeed, one hour's practice would teach more than

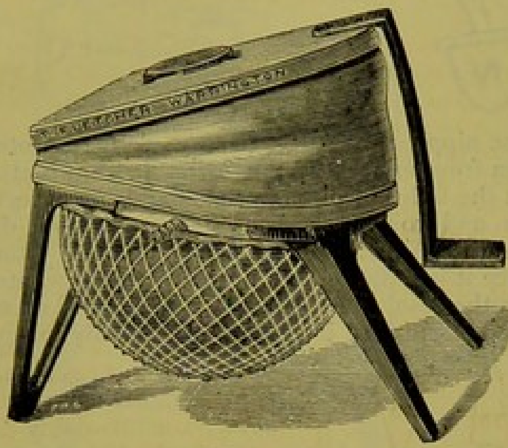


FIG. 15.

several hours lecturing or pages of description, but a few remarks may be of assistance to the student.

In the first place, pure lead will burn much more easily than the common lead which often contains an alloy of other metals such as tin, zinc, antimony, &c. Impure lead will burn up into dross, and it is very difficult to make good work with it. The parts to be joined should be fitted tightly together, and should be shaved quite clean and bright, and to the size it is intended to make the seam. The shaving should be done immediately before commencing burning. If the shaving is done sometime previous the shaved parts will tarnish and then not burn so readily, or make such a clean job. It is not necessary to use any flux to a burned up seam. After preparing the work the next thing is to adjust the burner or blow-pipe. After lighting the jet it will generally take some little time to so adjust the supply of gas and air as to get a fine pointed flame of the right size and colour and almost free from noise. Good burning cannot be done with a large, straggling, roaring flame. The only noise that should be heard is a low gentle hissing one. When using coal-gas the flame will be as shown at Fig. 14. The outer flame is useless, but the inner one, which should be a bright colour, between a green and a blue, is the one that is best for use, the point at R being brought down onto the seam.

A strip of clean-shaved lead should be melted onto the seam, so as to make it much stronger than it would be if only the edges of the pieces of lead were melted together. This applies to a butted seam, for a lapped seam the strip of lead is unnecessary.

The machine illustrated at Fig. 7, in an earlier chapter, can also be used for lead burning. I have only been enabled to use it for about a quarter of an hour, but I felt satisfied that with practice a fairly good job could be made by its means.

ON BRAZING.

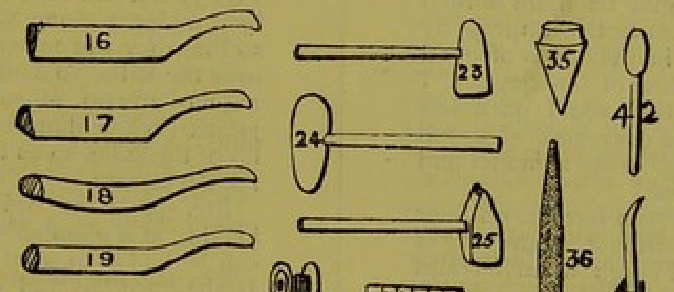
BRAZING, or jointing hard metals together, is very rarely done by the plumber, but we will dwell upon it for a few minutes. For brazing iron together a hard solder, composed of two parts of copper to one of zinc is generally used. This solder is sometimes called spelter. For joining copper and some kinds of brass work, it is necessary to use a spelter which melts at a lower temperature than that used for iron, as the copper and brass both melt at a lesser heat than iron. Zinc melts at a lesser heat than copper, and an alloy in which the zinc predominates melts more quickly than one in which the copper is in excess. The solder for brass is composed of zinc and copper in equal proportions. When brazing, it is necessary to use a flux to prevent oxidation of the parts to be joined, and also assist the free flow of the solder into the interstices, or spaces to be filled up by it. The flux used in brazing is "borax," which is a compound of boracic acid and soda. When brazing, the parts to be joined are first cleaned and then fixed together, so that they cannot move out of their relative positions. In some cases the fixing is done by binding with iron wires. The parts are then sprinkled with the flux and granulated spelter, and placed over a forge, or a blow-pipe is used to give a blast onto the joining, to give the necessary heat. Sometimes the borax and spelter are kept ready mixed with water, and a small quantity is placed on the joint. So soon as the borax has disappeared the spelter will melt and flow between the laps, if sheets are being joined, or between the faces if a butt joint is being made, when the work should be carefully removed from the source of heat. If this is not done, the joint would "burn," and require re-making. Or if the work was made too hot, the whole of it would melt into an unshapely mass.

ON TOOLS.

IT is an old saying that a "bad workman always quarrels with his tools." So will a good workman if he has not those suitable for doing the work he has in hand. A plumber will do more work, do it in a better manner, and with less fatigue to himself if he has a good kit cf tools and they are in proper order. A piece of lead cannot be dressed out quite flat with a dresser which has a rough and distorted face, and if a corner is bossed up with a bossing-stick which is much worn, he will so illuse and disfigure the lead as to afterwards require as much time to work out the tool marks as it took to boss up the corner. All cutting tools, such as saws, knives, shave-hooks, &c., should be kept sharp. It is not necessary that the tools should always be quite new, indeed, a good plumber prefers old ones that he is used to handling. And again, most of the wooden tools bought at toolmakers shops are generally so awkwardly made, that a good plumber will prefer to make for himself those that he may require. Boxwood is best for making a great many tools. This wood can be bought at some places for 1½d to 3d. per lb. So, for a shilling, a piece can be bought to make a dresser out of, and which would perhaps have cost half-a-crown at a toolmaker's. With this lecture is issued a pen and ink drawing, illustrating most of the tools used by plumbers.

Fig. 16 is a setting-in stick made of boxwood and principally used for setting-in the members of a moulding.

Some plumbers will use the chase wedge, Fig. 21, for this purpose, but the stick is the best, as the grain of the wood is lengthways and does not cut the lead so much as the chase-wedges, the grain of which is endways. Being longer, the stick does not distress the lead so much as the wedge which is perhaps only 2 in. or 3 in. wide on the face.



FIGS. 16 to 53.

Fig. 17 is a dresser. A good tough piece of hornbeam or holley is best for those in common use. These woods being rather softer than box, tools made of them do not mark and disfigure the lead so much as those made of boxwood. It is a good plan to have hornbeam dressers made slightly rounding on the face. When made quite straight they will sometimes wear hollow on the face, in which case a tool mark will be made on the lead at every stroke of the dresser. Some little practice is required before a man can dress out a piece of lead with a dresser. A beginner at the trade invariably digs the heel of the dresser into the lead, and leaves a bruise which can rarely be worked out again so as to be invisible.

These remarks apply also when lead-pipes are being straightened with a dresser. For this purpose a soft piece of deal quartering is best, the piece of wood being placed on the pipe and a hammer or mallet used to hit the piece of wood. When sheet-lead is to be dressed out flat a lead flapper is best to use, as no tool marks are left by it. A small hand dresser made of boxwood should always be kept with a very smooth face for planishing bends on soil-pipes, after they are finished, or for taking out tool marks when a corner has been bossed-up.

When laying lead on roofs, it is a good plan to keep a very long boxwood dresser, with a straight but not too sharp edge, to go over the settings-in, so as to leave them quite straight. As an example, to straighten the arrisses by the side of the rolls on a lead flat, or on a ridge of a roof. This could not be so well done with a short dresser, or one that was not quite straight.

Fig. 19 is a boxwood bossing-stick, principally used for bossing up corners and breaks, or for creasing the over cloak of a roll on a lead flat, although in this case a piece of rounded deal 2 ft. or 3 ft. long is better than the bossing-stick for the same reasons that a long dresser is recommended for straightening the arrisses when finishing off on a flat.

Fig. 18 is a bending-stick made of boxwood and used principally for dressing the throat when bending lead-pipes.

Fig 20 is a blunt-wedge, or drift, principally used when working down gutter drips, or the overcloak at the head of the rolls on a lead flat and other places.

Fig. 21 is a chase wedge, either blunt or sharp, and is used principally where a dresser cannot be.

Fig. 22 is a bevel drift, and is used for working lead into acute angles. Chase-wedges are generally made of soft boxwood. If very hard wood is used the lead is cut by them. These tools are very convenient and useful in certain places, but their use should be more limited than it is. They are frequently improperly used, and excepting when in the hands of good tradesmen, the frequent cause of birds-eyes. I know you will smile when I tell you I once saw a plumber (?) setting in the overcloak of a roll which was about 10 ft. long, using a mallet and chase-wedge for the purpose.

Most men have brass or iron ferrules on their wedges, but they are best without, as the face of the mallet gets worn and rough when ferrules are used.

Fig. 23 is a small boxwood-mallet with a rather flat face for using with chase-wedges. Some plumbers use this mallet for bossing up corners.

Fig. 24 is a bossing-mallet. The head has the sides slightly rounded so that it can be used sideways when bossing, or stretching lead. The faces are also rounded. Large mallets made this shape are used for setting-in with. Hammers are sometimes used for this purpose, but a mallet is best. Should a hammer be used it will soon destroy or wear out the dresser, or if a foul stroke is made the lead is not so much injured if made with a mallet.

Fig. 25 is a Tomahawk-mallet. The head has wedged-shaped faces. This tool is sometimes useful in narrow confined places for roughly working down drips where it is impossible to do them in the ordinary way.

Fig. 26 is a hammer, as generally used by plumbers. The pane is useful for driving nails in angles or other similar positions. The hammer should always have a rounded face similar to those used by engineers. When hammers have flat faces, the edges generally break off. This occurs more especially when used with the chipping-knife, Fig. 27. This knife is made of steel, and the handle consists of two pieces of thick leather rivetted on the blade. Fig. 28 is the ordinary drawing knife for cutting or trimming sheet-lead. Very little need be said about this tool, excepting the advice that the rivets would not get broken so often as they do if the plumber held the blade instead of the haft in his hand when he uses a hammer with it.

Fig. 29, 30, and 31 are respectively chalk-line and reel, fourfold rule, which is convenient for measuring in narrow positions, and a bevel for taking the angle of a gutter, or other position, prior to setting out the piece of lead for bossing to fit the place. Sometimes the bevel is used for taking the angle of a bent pipe, but this way of setting out a bend will be discussed when we come to geometry for plumbers.

Fig. 32 is solder or metal-pot. A strong one is shown. Light three-legged pots are generally used, but they are very frail and easily broken. In addition the stronger pot will keep up a heat much better, and this is of importance when the solder has to be carried some distance, say onto a roof, before being used. A great many pots get broken from the bad practice of dipping them when hot into cold water to cool them. Fig. 33 is a hand ladle. The handle is shown bent under, as done by a great many plumbers, so that they can have a better grip and command over the ladle, so as to be able to pour a more regular stream of solder on to their work or joints. Some plumbers have a small hole in the lip of the ladle, so as to be able to pour a more regular stream.

Fig. 34 is the ordinary plumbers-iron. On looking at a plumber's irons, a very good idea can be had as to what kind of a mate he has got. If they are covered with scales, or have the appearance of being pockmarked, it shows the mate to be inattentive to his duties, inasmuch as he leaves them in the fire too long, so that they get burnt by being made too hot. A plumber can do more work with one clean iron than two dirty ones. The handles of all irons or ladles should always be cooled by dipping them in water before giving them to the plumber. Neglect of this is the cause of the muscles in the palms of the hands being contracted, as is so often found amongst plumbers.

Fig. 35 is a boxwood tanpin. The top should be made as shown. Without this it is difficult to get them out of the ends of pipes should they be driven in too far. For soil and other large pipes it is not necessary to have them so pointed as the one shown.

Fig. 36 is a rasp. Those used by plumbers should have fine teeth, similar to the kind used by cabinet-makers. Coarse rasps drag, and distort the lead too much, and this is more noticeable when preparing the ends of pipes for a joint. Rasps frequently get broken, but, if on breaking, they were immediately tinned, using chloride of zinc as a flux, they can be soldered together again with fine solder. Broken rasps soldered together in this manner have been known to last a long time.

Fig. 37 is a straight shave-hook, and Fig. 38 is a bent hook for shaving corners or other positions inaccessible with the straight-hook. Fig. 39 is a spoon-hook used for the same purpose as the bent-hook. Fig. 40 is a guage-hook for shaving the edges of the lead prior to soldering the seam of a pipe or other similar work.

Fig. 41 is a hand-bolt used when opening a hole in the side of a pipe prior to making a branch joint. Some plumbers use steel-bolts, but a good tough iron one is best, as the hammer does not glide off it so easily as when a a steel one is used. Neither is an iron-bolt so injurious to the hammer face as a steel one. This tool is sometimes used as a tommy, or for making a bend near the end of a pipe.

Fig. 42 is a hand-dummy, the head being made of solder, and the shaft or handle of bamboo-cane.

Fig. 43 is a wiping-cloth. The plumber generally requires a good stock of these, and the sizes varied to suit all sizes and kinds of joints or seams. Cloths are sometimes made of bed-tick, but those made of fustian or moleskin are the best and last longer. The cloths should be folded and then sewn as shown in the sketch. Pins are sometimes used to fasten them together, but the solder will stick to the pins, or they will sometimes get hot and burn the fingers. Cloths should be of a good thickness to prevent the hands being affected by the heat of the solder. Better joints can be made with cloths of a moderate thickness than with those which consist of only three or four folds of the fustian.

Figs. 44 aud 45 are straight and hatchet-shaped copper-bits.

Fig. 46 is a pair of cutting-pliers for doing wire work, they are also very useful when making repairs or taking to pieces the innumerable and complicated fittings that a plumber has to do with. Fig 47 is a pair of two-hole-pliers, which are very convenient as pincers and also to use for screwing up unions where it is impossible to use the screw-hammer shown at Fig. 52.

Fig. 48 is a mouth blow-pipe which is often found to be a useful tool, either for making light joints on to pipes or for soldering small work where it is difficult to make a wiped joint, or which cannot be done with a copper-bit.

Fig. 49 is a pair of shears, or snips, and which it is unnecessary to remark upon.

Fig. 50 is now an obsolete tool called a boss-iron. Some years ago it was very much used for cementing the old square shank cocks into their bosses. The screw-boss has now superseded this way of fixing cocks.

Fig. 51 is a long-dummy, for use when making bends in soil and other large sized pipes. The plumber generally makes these tools himself, using pieces of iron gas barrel, with a bulb or head of solder cast on them. But these are only makeshift affairs, as the heads soon work loose, even when the end of the pipe is tinned before casting on the head. In addition, as the shaft has to be so frequently bent and straightened again, it soon breaks near the head. The one illustrated is made of solid iron rod, and has a bulb of iron welded on. This dummy can be heated, and then easily bent to suit the bends being made. It has also a bow handle, so that it can easily be turned in any direction to suit the work being done. As an example, after the throat of a bend has been worked up, the pipe can be laid on its side, and the cheeks worked out with the side of the dummy instead of the point. If the shaft had no bow to grip hold of, the dummy could not be used sideways, as it would slip round in the hand. Another advantage of this dummy is, it can be heated before using, and thus aid in heating the bend and making it more easy to work.

Fig. 52 is a saw. In selecting a saw for use by a plumber, one with fine teeth should be chosen in preference to one with coarse teeth which drag and distort the pipe ends when they are being sawn off. A plumber's saw should also be of a good substance and set rather wide, as lead pinches a saw very much, especially when it is not very sharp and drags the lead, instead of making a clean cut. Fig. 53 is a screw-driver.

In this lecture I may not have told old plumbers more than they knew before, but it is hoped that students may have gained some information of value to them. Students will find it advantageous to frequently sketch the illustrations which in this and all cases are made as free from complications as possible, so that they may present no difficulties to being copied.

GEOMETRY AS APPLIED TO PLUMBING.

If you refer to your syllabus of subjects, you will find that geometry as applied to plumbers' work is the next on the list. This is really a subject of so much importance that I think it necessary to dwell upon it at some length. Not that I am going to devote the whole session to it; there are several other matters on which I wish to enlighten you, and which are of equal importance. There are several students who attend geometry classes. I only wish they all did, as then my labours would be very much lightened by being enabled to at once apply the science in a special way to suit the requirements of plumbers. I now give a few definitions, without which I could not hope to make myself understood, and would only help to make more obscure what should be clear.

A point denotes position only and not size.

A straight-line is the nearest distance between two points. The extremities of the line being points. A line denotes distance and not bulk.

A circle is a bent line drawn through a series of points, which are equi-distant from a centre point. I want this to be remembered, as it will bear an important part when cutting out lead for finials and turrets, &c. A circle encloses a space, but the thickness or depth of that space is not known from that circle. A sphere is represented by a circle because, from whatever position a sphere is looked at, the outline is a circle, But a sphere has magnitude or bulk, and would have to be represented by two circles, one showing the plan and the other the elevation or front view, as shown by Fig. 54. where X-Y represents a ground line and the circles the plan and elevation. A cone would be shown on plan by means of a circle, but it would not be known as a cone unless an elevavation was also shown, as in Fig. 55. If these figures are drawn on a piece of paper and the paper bent, on the line X-Y, so that the upper half stood upright and the lower half lay horizontal, the horizontal would represent the plan, and the upright portion the elevation or front view of the objects, just in the same way that an architect draws the plan and elevation to represent a house, but shows them on a flat piece of paper.

A cylinder has circular ends. If a cylinder was stood on its end, the plan (see Fig. 56) would be a circle and the elevation a square, if the length was the same as the diameter of the the ends—or a rectangle or oblong if length and diameter were unequal. But if the cylinder was laid on its side, with one end to view, it would be shown as Fig. 57.

An angle is formed by the inclination of two lines, which meet. See Fig. 58, where B A C represents an acute or sharp angle, B A D a right angle, the line A D being perpendicular, or upright, to A B. E A B represents an obtuse, or blunt angle. Any line drawn from A, but between D and B, would represent an acute angle with A B, and any line drawn from A, but outside of D A, would represent an obtuse angle, so long as it was above the horizontal line A B. If the E on the line A E was dropped until it formed a right line with A B, it would appear as a straight line, and not forming any angle, but in theoretical geometry it would be considered an angle of 180°. An angle is usually described as being so many degrees, and is shown by a number, or figures, with a small ° placed at the end, as 45°, which represents the angle C A B, Fig. 58. Ninety degs. represents a right angle or square, as D A B, Fig. 58. Any of you who has a complete set of drawing instruments will find amongst them a small ivory, or boxwood scale, called a protractor, and on one side you will find the degrees marked for setting out any angle. These degrees are worked out by describing a circle of any size, the larger the better, and then dividing the circle into 360 equal parts. Each one of these parts is called a degree. Lines drawn from the divisions of the circle to the centre represent the angles. Degrees are sometimes divided into parts called minutes, and these minutes are again divided into parts called seconds. Any of you who has not a protractor can make one as follows: Take a stout piece of drawing-paper and draw a semi-circle, or half-circle, to any radius, as shown at Fig. 59. Divide the semi-circle by raising the perpendicular A B. Sub-divide the quarter circle, D, B, into nine equal parts, and draw lines, radiating from A, and cutting the circle at the division marks. Each one of these lines represents an angle of 10°. Divide the other quadrant of the circle, in the same way, and then subdivide all the divisions into ten equal parts, and then the protractor is ready for use. The use of the protractor is as follows:—Supposing you were setting out a roof, and were instructed that the slope of the roof was to be 68°. First of all, draw a base line to represent where the roof starts from; say the top of the tie beam of the principal rafter, if it is to be a timbered roof. At the extremity of the line place A, on the protractor, the bottom edge of the protractor being even with the base line from which you are working. Then make a mark on your drawing-paper, where 68 on the protractor comes. A line drawn from this mark to the position A will represent the slope or inclination of the roof. Other ways of using this instrument could be, given, but this one illustration is sufficient for our purpose. Another way to set out angles is by using a scale of chords. Those of you who have protractors will find a scale of chords marked on them. But for the sake of those who have not this scale, I will illustrate how to make one. Describe a semi-circle to any radius, and draw a horizontal line as shown at A B, Fig. 60. Divide one-half of the semi-circle into nine equal parts, as was done in Fig. 59, and then divide the other half in the same way. With A as centre draw circles from those divisions to the base line which will then be the scale of chords. To set out an angle by means of this scale, first draw a base line. Then with the compasses take off the chord A 60, and describe a section of a circle, radiating from the extremity A of the base line, see Fig. 61. If the angle is to be one of 30° (or any other number of degrees) set the compasses to that number, in this case 30° and with B as a centre cut the first arc drawn, which will be at C. Draw a line from A through C, and that will be the angle required.

It is very rarely that a plumber gets detail drawings for his work, but as a rule he has to prepare it from those supplied to the builders. As these drawings are usually made to a scale, less than full size, it is important for the workman to know what is meant by working to scale. Drawings are invaribly made to some standard dimensions which bear a relative proportion to the size of the work when executed. Builders drawings are generally made to some fraction of a foot, the foot being divided into inches and these inches are sub-divided into halves, quarters and eighths. Drawings made to a 6 in. scale means they are half full size. A 3 in. scale is called $\frac{1}{4}$ scale, that is to a scale of a quarter of a foot. One-and-a-half inch, called $\frac{1}{8}$, scale is a very good size for small details. This is a very easy scale to work to, as by it the workman can use his pocket rule. When this scale is used the $\frac{1}{8}$ of inches will represent inches. When a scale of 1-12th is used the inches on the scale must be divided into twelve equal parts to represent scale inches. One of the commonest scales in use on buildings in 1-48th, that is, a scale in which $\frac{1}{4}$ of an inch will represent one foot. This scale is often improperly called $\frac{1}{4}$ scale. Most of the drawings for large buildings are made to a scale of 1-96th, that is, $\frac{1}{8}$ of an inch equals one foot. In some cases other scales are used and if these are not shown on an

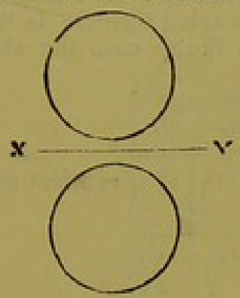


FIG. 54

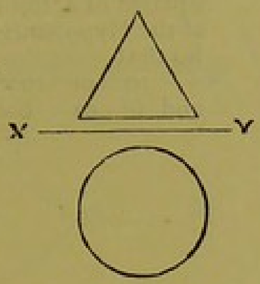


FIG. 55

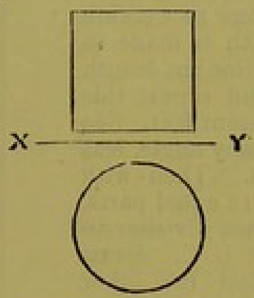


FIG. 56

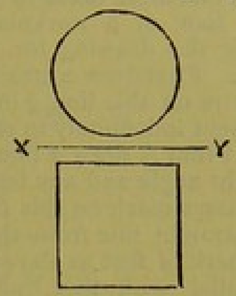


FIG. 57

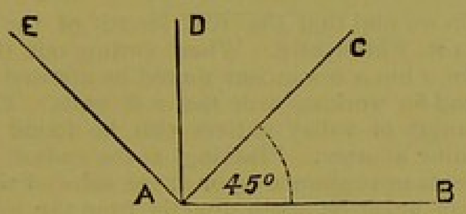


FIG. 58

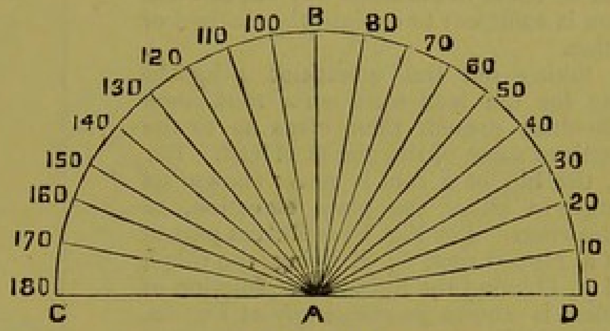


FIG. 59

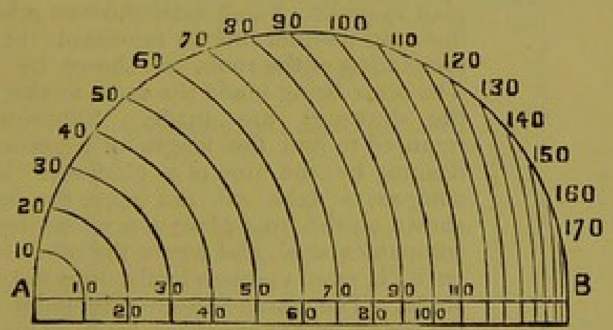


FIG. 60

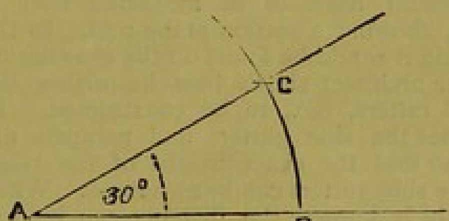
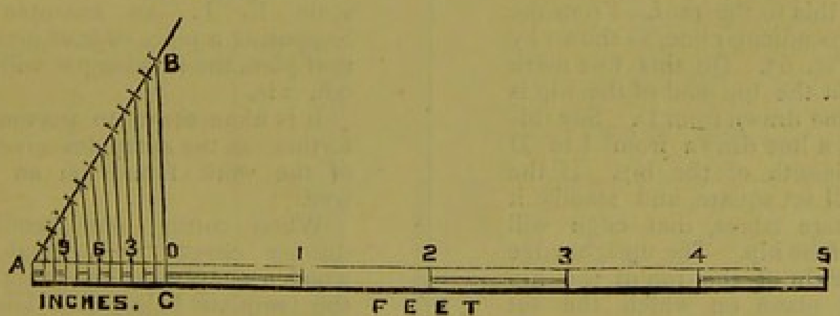


FIG. 61



SCALE 5/8" = 1 FOOT.

FIG. 62.

ordinary rule a special one has to be made. For temporary use one can be made on a stiff piece of cartridge paper. As an example say a drawing has to be made to a scale of $\frac{3}{8}$ of an inch to a foot, or a workman has to execute some work the drawing for which is made to that scale. First draw a straight line any length and measure on this line $\frac{3}{8}$ in. and repeat this measurement indefinitely to represent feet. See Fig. 62. From A draw a line at any angle, less than a right angle and any length. Then with the compasses mark on this line 12 equal parts. Draw a straight line from the last division to the first mark of feet as shown at B C. Draw lines parallel with this one from the other division lines when A C will be divided into 12 equal parts which will represent inches. Other scales can be made in the same way but this one illustration is sufficient to explain the method of construction.

When taking out the quantities prior to estimating for the lead-work on a roof, some little difficulties present themselves as to the exact length of some of the pieces of lead. For instance, the hip of a roof is never shown its exact length in either the plan, elevation, or section drawings. Let Fig. 63 represent part of a plan of a hipped roof, A, B being the ridge, A, C and A, D being the hips. The solution of this problem is shown geometrically at Fig. 64. Let the line E, F represent the plan of the hip. Now the top end of the hip is higher, above the horizontal plane, than the other end. This height would have to be measured from a drawing, showing a section of the roof. In the above case it would be found on the drawing on which the architect shows how he wishes the principal rafters, &c., to be constructed. In some cases the side gutters and parapets are shown, so that the exact height of the ridge above the side gutters can be measured. When this height is known, the distance can be projected above X, Y, as shown by dotted lines E, G, Fig. 64. A line drawn from G to X, Y immediately over F is the exact length of the line. Now to apply this to the roof. From the hip A, D raise a perpendicular line, as shown by dotted lines A, H, Fig. 63. On this line mark off from A the height the top end of the hip is above a horizontal line drawn from D. Say this height is equal to I, a line drawn from I to D represents the real length of the hip. If the student takes a small set square, and stands it on one of its square edges, that edge will represent the plan of the hip. The upright edge will represent the height of the top of the hip above a horizontal plane on which the set square stands. The slant side of the set square will represent the length of the hip, but this cannot be shown on paper, unless the set square is laid down flat, which can be done to illustrate what is meant. Now instead of using a set square, we set out two lines at right angles to each other, and of the length required. A line drawn from the extremities of these lines is the real length required. This problem can be solved mathematically as follows—Say the plan of the line A, D measures 10 ft., and the vertical height of A above D is 6 ft. The rule to work from is this. The square root of the sum of the squares of a right-angled triangle is the length of the Hypotenuse; in this case the slant side. So that

10^2 or $10 \times 10 = 100$
and 6^2 or $6 \times 6 = 36$

```
           ———
     1)  136 (11·7 feet nearly
          1
         ———
    21)  ·36
          21
         ———
   227) 1500
        1589
        ———
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So we find that the real length of the hip is 11 ft. 8 in. nearly. When cutting out the lead for a hip a few inches should be allowed at each end for working over the roll ends. The real length of valley gutters can be found in the same manner. Flashings at the ends of sloping roofs next chimneys, or at the sides of skylights can never be taken directly from the roof plan of a house, but must be set out before the exact lengths can be found. When taking out the lead quantities for a very large roof, it is a good plan to make a small scale show on a horizontal line, and another line to represent the angle of inclination of the roofs, as shown by Fig. 65. The scale being made the same as that to which the drawings are made. Supposing it is required to find the length of a piece of step flashing by the side of a chimney. With the compasses take off the apparent length as shown on the roof plan; place one leg of the compasses at K, and where the other leg comes on K, L, raise a perpendicular line until it cuts K, M. The distance from this point to K is the length of the piece of lead. This can be found by describing an arc with K as a centre, from the point found on K M down onto the scale K, L. An example is worked out. Supposing a piece of lead measures 8 ft. on the roof plan, the real length will be found to be 9 ft. 2 in.

It is unnecessary to pursue this subject any further, as the examples given will cover most of the work found on an ordinary sloping roof.

When cutting out sheet-lead for covering dormer cheeks it is usual to first make a wooden template to the exact size of the cheek, the template being then laid on the sheet of lead and scribed all round. Margins beyond these scribings are then marked to certain widths for the lead to be creased or folded for turning round the edges of the dormer, or laying on the slates. Fig. 66 is a sketch of a common kind of window dormer, and usually fixed for lighting the rooms when situated immediately inside the house roof. A is the cheek as commonly called. Now if the lengths of the sides of the cheeks are known that is all the information that is required. No matter what kind of a triangle is shown by the dormer side, if the lengths of the sides are laid down properly they will form a triangle of the exact shape and size required. As an example, let the dormer be 4 ft. long on the top edge, 5 ft. high on the front edge, and the slant side which lays on the roof 6 ft. long. These are the exact dimensions of the cheek, but it is usual to allow 1 in. to turn on the top edge, for nailing to the woodwork; 3 in. on the front, for nailing and also for turning a flat or single welt over the nail-heads; and 6 in. on the slant side for laying on the slates. To set out the lines for cutting out the piece of lead, first strike a

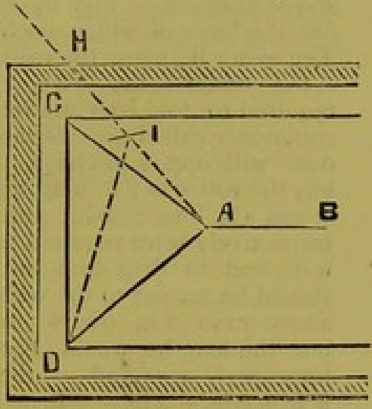


FIG. 63

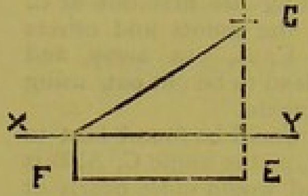


FIG. 64

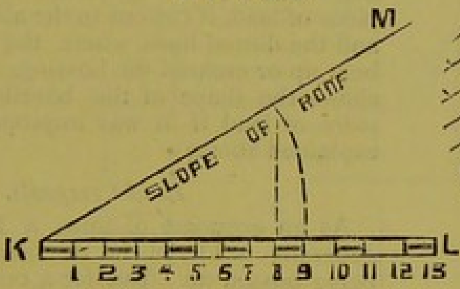


FIG. 65

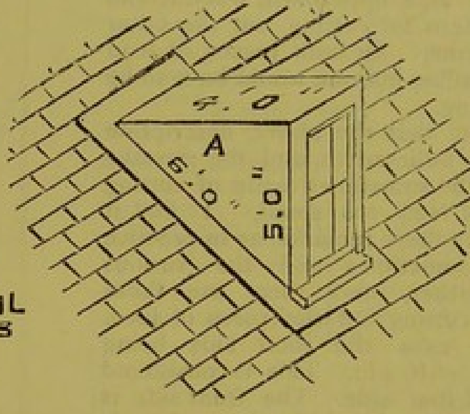


FIG. 66

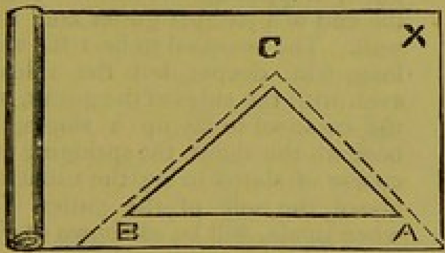


FIG. 67

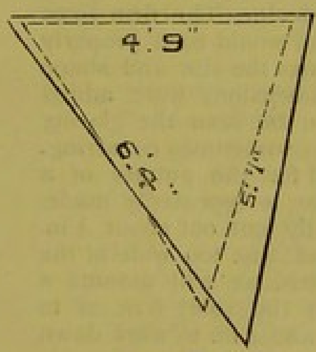


FIG. 68

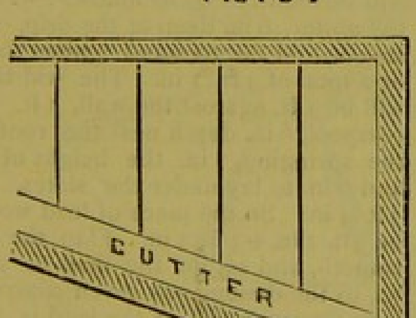


FIG. 69

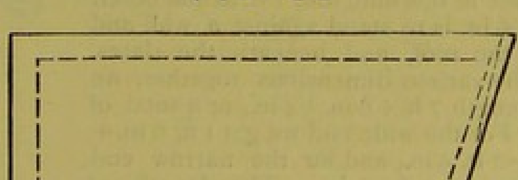


FIG. 70

chalk mark 6 in. from the edge of the sheet, which is supposed to be rolled out ready on the floor. See Fig. 67. On this line mark two points, 6 ft. apart, the length of the slant side. With the point A as a centre, and a radius of 5 ft., describe an arc, and with the point B as a centre and a radius of 4 ft. the length of the top, describe an arc cutting the first one at C. Draw lines to connect the points and others parallel with them on C, A, 3 in. away, and C, B, 1 in. away. The lead to be cut out, using the outside lines as the guide.

In actual practice it would be found best to work from the line C, A, as the angle C, A, B is nearly a right angle, and would more nearly fit the angle of the sheet of lead, and so avoid cutting to waste the corner marked X. When the piece of lead has been cut out it should be turned the other side uppermost, when it can be used as a pattern for cutting out the other cheek for the dormer. Or both pieces of lead could be cut out alike, but one would have to be turned before using.

It is important that the above description should be strictly adhered to, and the mistake would not then be sometimes made of cutting out the piece of lead too small, I find it necessary to make these remarks, as in practice plumbers will sometimes add the various dimensions together, and then use those dimensions for cutting out the piece of lead. In the above case the slant side being 6 ft. + 1 in. + 3 in. = 6 ft. 4 in. This is considered as the length of that side. The front side is 5 ft. + 6 in. + 1 in. = 5ft. 7 in. The top edge is 4 ft. + 3 in. + 6 in. = 4 ft. 9 in.

Fig. 68 is drawn to scale. The firm lines showing the size the lead would be if properly set out, and the dotted lines the size and shape it would be if the dimensions were added together. From this can be seen the glaring error above mentioned as sometimes occurring.

When cutting out lead for the gutters of a house the same mistake is repeatedly made. These gutters are generally cut out about ½ in. too narrow at one end and ½ in. too wide at the other end. To explain this, we will assume a gutter to be 7 ft. long in the sole; 6 in. is to stand up at the top end, and 4 in. to work down into a drip at the other end. The gutter is 1 ft. 6 in. wide at one end, and 1 ft. at the other. In addition, 6 in. is to stand against a wall and 9 in. lay up the roof, and beneath the slates. If we add the various dimensions together, we get for the length 7 ft. + 6 in. + 4 in., or a total of 7 ft. 10 in. For the wide end we get 1 ft. 6 in. + 6 in. + 9 in. = 2 ft. 9 in., and for the narrow end 1 ft. + 6 in. + 9 in. = 2 ft. 3 in. The length of 7 ft. 10 in. can be set out, but the width of 2 ft. 9 in. must be measured at a distance of 6 in. from the end, and not on the extremity of the piece of lead. The width 2 ft. 3 in. should be measured at a distance of 4 in. from the other end. The student is invited to set out the above lines on a floor, and then note the difference.

So much sheet-lead is cut to improper shapes and sizes, not only wasting the material, but giving extra trouble to the workman, that another example is given to further illustrate the above problems. Fig. 69 is a plan of a lead flat, the bays of which discharged into a gutter. The width between the rolls averaged 2 ft. 9 in. —the undercloaks were 3 in., and 6 in. was required to fold over the rolls, to form what is commonly called the overcloak. We will only deal with one of the bays. On one side of the bay the roll was 7 ft. long, and on the other side it was 8 ft. long; 6 in. and 4 in. at the ends respectively were required to stand up against a wall and to drip into the gutter. The lead should be set out to the width required. In the above case 2 ft. 9 in. + 3 in. + 6 in. = 3 ft. 6 in., but the lengths would, generally speaking, be improperly accepted in the same way, namely, 8 ft. + 6 in. + 4 in. = 8 ft. 10 in., and 7 ft + 6 in. 4 in. = 7 ft. 10 in. Fig. 70 shows the shape of the piece of lead, if cut out to the above dimensions, and the dotted lines where the lead would be bent up or creased for bossing. The chain line shows the shape of the bevelled end of the piece of lead if it was improperly cut out, as explained above.

Lead Cesspools.

As an economy of time, a lead cesspool is generally soldered in the angles, instead of being bossed up. But for a cesspool to fit, the lead must be cut out to the exact size, and to the shape of the intended position of the cesspool. Supposing one has to be made to fit at the end of a parapet gutter and next to a party wall. The cesspool to be 1 ft. wide, 1 ft. 6 in. long, 6 in. deeper, but the sides to stand up even with the sides of the gutter, and one side of the cesspool to lay up a sloping roof to 6 in. beneath the slates, the springing under the eaves course of slates being the usual height of 3 in. above the sole of the gutter. The cesspool, when made, will be as shown at Fig. 71. Now, if we add the various dimensions together, they will be found to be as follows:—1 in. to lay on the gutter, 6 in. deep at the drip, 1 ft. 6 in. the length, and 1 ft. to stand against the party wall, or a total of 3 ft. 1 in. The width of the lead will be 1 ft. against the wall, 1 ft. the width of cesspool, 6 in. depth next the roof, 3 in. up to the springing, 1 in. the height of the springing and 6 in. to lay under the slates, or a total of 3 ft. 4 in. So the piece of lead would require to be 3 ft. 1 in. + 3 ft. 4 in. Flap the lead out quite smooth, and set out the lines as shown at Fig. 72, to the dimensions given above. The chain lines represent where the lead is to be creased or folded, and the dotted arcs show the parts that will come together when bent up prior to soldering. The rake or slope of the roof must be taken, and marked on at A. This is necessary in all cases, as the pitch of roof varies very much. In some cases, cesspools come in the centre of a range of gutters in which case it is necessary to prepare both ends as shown at B,

Fig. 72. The small piece left on at D is useful as a tack to fold over the edge of the gutter when that is being laid, and so hold it firmly down while the plumber is working the drip end down into the cesspool. In some cases a cess-pool has to be made to fit a position where a

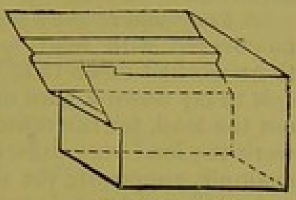


FIG. 71.

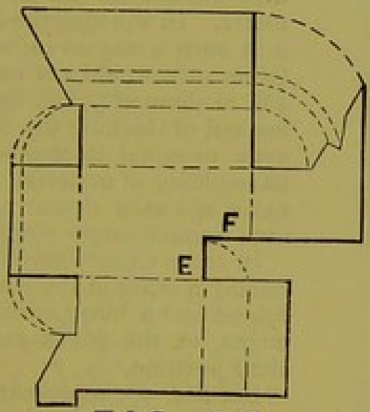


FIG. 73.

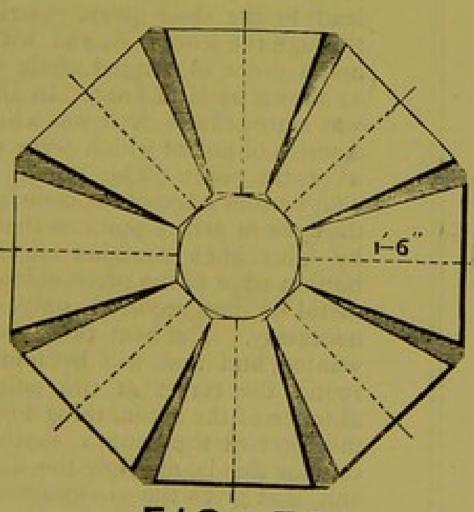


FIG. 76.

brick or stone angle projects. To fit a position of this kind, the lead has to be cut out rather differently. As an economy of time, we will assume that one has to be made to the same idmensions as the last one, but to fit a 4½ in. angle, projecting in front of the party and parapet walls, say at C, Fig. 72. The lead, as cut out, would appear as shown at Fig. 73. In this case, part of the soldering would be in the bottom, as shown from E to F.

It is here necessary to explain that upright sides of cesspools should always be squared

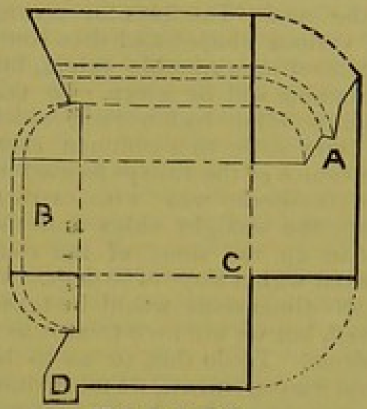


FIG. 72.

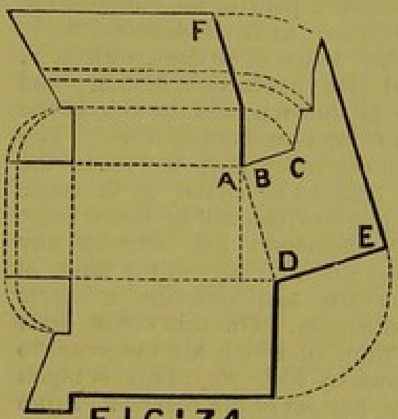


FIG. 74.

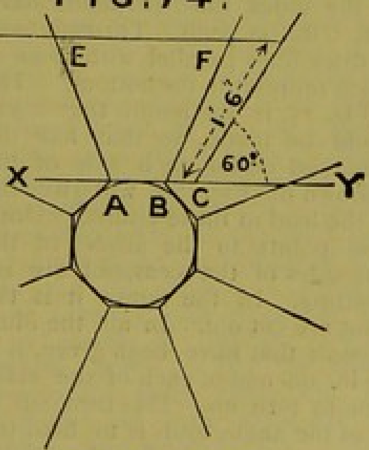


FIG. 75.

from the folding line of the bottom. Let Fig. 74 represent a cesspool, the dimensions of which are the same as those given for Fig. 71, excepting that the acute angle projects 4 in. beyond a square line drawn from A, and as shown by dotted lines. The lead, as cut out, would appear as shown by the Fig. in which the lines B, C and D, E must be drawn at right angles to the folding line, B, D. The side that lays up the slope of the roof must also be cut, as shown at F, to suit the acute angle, which is supposed to represent the party wall of the next house, and which is continued from the cesspool to the ridge of the roof. The lines for setting out cesspools of various shapes and sizes could be given to an almost interminable extent, but only one more example will be given. In this case an octagonal building had a roof, which sloped from the outer walls to a common cesspool fixed in the centre of the valleys formed by the roof. The cesspool was 1 ft. across, measured between the straight sides and the sides laid 1 ft. 6 in. up the slope of the roof. The roofs were fixed with a slope of 60 degs. In actual practice, all dimensions would be taken from the roof itself, but we will here treat it as a geometrical problem. To do this, so as to be able to take actual measurements, we must show the angle of slope of the roof and also a front view, so as to get the width of one of the sides. Let Fig. 75 represent a plan of the valley of the roof. On one side, say at A, B, draw an X, Y. On this at C draw a line at 60 degs. with X, Y. On the inclined line mark off 1 ft. 6 in., and project this line as shown across the side of the roof, which is in front view from E to F. The distance between the valley lines represents the actual width of lead to be cut out to fit those positions. The piece of lead will be found to be an octagon, which measures 4 ft. between any two of the parallel sides. Flap out the piece of lead, find the centre, and describe a circle which is 1 ft. in diameter. On this circle draw an octagon, the sides of which are tangental to the circle, as shown by Fig. 76. This octagon will represent the bottom of the cesspool. From the centres of the sides raise perpendiculars, and mark off 1 ft. 6 in. on each. Through each of these marks draw lines parallel with those of the octagon which represents the bottom. The distance E, F, Fig. 75, is the length that these last lines should be made, so that half the distance E, F marked off on each side of the perpendicular shown on Fig. 76, will give the actual width of the lead at those points. Draw lines from these points to the angles of the octagon, and the sides of the cesspool are set out ready for cutting. In the figure it is the shaded parts that are cut out. In all the illustrations of cesspools that have been given, it is usual to leave ½ in. on one of each of the sides forming an angle to turn up. This turn up is on the outside of the angle, and is to hold the sides together, as well as to prevent the solder running through when they are being wiped. If cesspools are carefully cut out, the lead can be soiled and shaved before being bent or folded up to the required shape ready for soldering. By a careful study of the examples given above the student will be enabled to adapt the principles to roof cesspools of any shape or size, also to cut out sheet-lead for lining cisterns, sinks, and similar fittings.

On Turrets, Spires, &c.

Plumbers have so often to cover turrets, finials, and spires, that it is here thought necessary to give a few illustrations showing how to cut out the lead with the least amount of waste of materials or of the workman's time.

In cases where the apex or summit only is to be covered with lead in one piece, which has to be worked down to fit its position, it is difficult to lay down a hard and fast rule for cutting out the lead, for the reason that some men will work the lead very differently to others. As an example, supposing the shape is a cone and has to be covered for a distance, measured from the point and on the slant side, of 3 ft. 6 in. Some men will cut out the piece of lead 7 ft. in diameter. In working the lead down they will do it in such a way as to considerably thicken it. Other men would cut out the piece of lead only 5 ft. in diameter, but by careful manipulation, instead of thicking the lead, would keep it an even or equal thickness throughout and thus have plenty of material to cover the cone the same distance down as the other man who used a much larger piece of lead.

In some cases where no objection is raised to having a seam in the lead, it can be cut out and folded and a burnt seam made to join the two edges, or the edges can be welted together in their position.

Let Fig. 77 represent the apex, of a round turret, to be covered with lead. The turret measures 3 ft., though at the point near the bottom edge of the lead and the slant side measures 4 ft. Make a triangle on the sheet of lead to the sizes given. Drive a clout nail through the lead at A, and with the chalk line and a piece of pointed chalk describe a circle as shown by faint lines. In an earlier lecture it was stated that a circle was a line drawn through a series of points which were equi-distant from a centre point. The same rule holds here. The bottom edge of the cone is equidistant from the apex or centre point so that the circle shown by faint lines contains all the points of the bottom edge of the piece of lead. But a disc of metal is not required only a portion being necessary. The next thing is to find the size wanted, and that will be found by measuring round the turret at the point B, C.. In the absence of the actual thing for us to measure we must get at the length mathematically. The rule for this is, multiply the diameter by 3·1416 and that gives the circumference. So we have 3 ft. × 3·1416, and we get 9·4248 or a little over 9 ft. 5 in., which should be measured on the circle shown by faint lines. This is best done by measuring only a short distance at a time. In this case a pair of compasses set to 3 in. and stepped on the faint line 37 times and then 1 in. deducted from the last measurement would give very nearly the exact size of the piece of lead.

To save time, lessen the liability to error and also to be more exact the compasses could be set to 1 in. and measured on the faint line twelve times, the compasses could then be set to this dimension and stepped on the line eight more times and then add on the odd 5 in. The lead should then be cut out on the circle, and also the lines A, D, and A. E. If the edges A, D, and A, E, are to be jointed by means of a welted seam, 1 in. should be left on one side and 2 in.

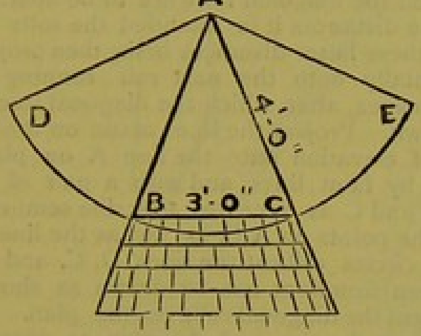


FIG. 77.

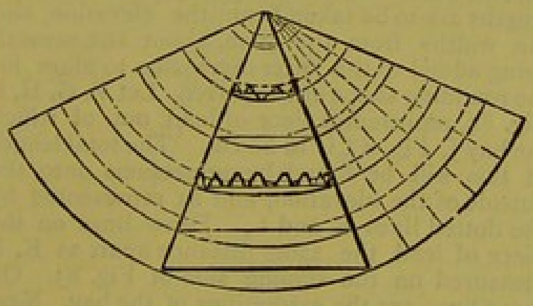


FIG. 78.

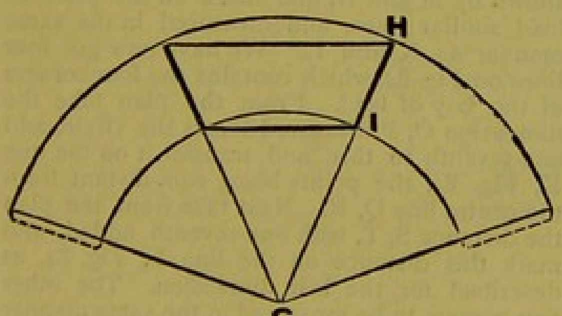


FIG. 79.

on the other for the seam. If the edges are to be burned or soldered together the lead should be cut out on the lines first given.

In some cases turrets are covered with a series of pieces of lead arranged as aprons, the top pieces overlapping those beneath them as shown by Fig. 78. These pieces of lead can be cut out in the same manner as described for Fig. 77, with the exception that as the pieces are not required to extend to the summit other circles have to be drawn, which will represent the top edges of the aprons. In the figure the firm line circles represent the bottom edges and the dotted line circles the top edges of the pieces of lead. The pieces of lead can be cut out and any fancy design set out on them, and the exposed edge trimmed before fixing, thus giving an ornamental appearance. Fig. 78 shows alternate courses of straight and vandyked lead aprons. On large turrets it will be found impossible to get sheets of lead large enough for cutting out the pieces as shown at Fig. 78. These turrets require special treatment and will be dealt with in my next lecture, when the dotted lines radiating from the centre will be referred to.

It will elucidate the last problem to give a further example which the student can at once work out for himself. Each section, if the turret was cut through on the various horizontal lines, would represent the frustrum of a cone, that is a body the ends of which are circles concentric to each other and have flat top and bottom surfaces parallel to each other, as shown in elevation at Fig. 79. Assuming this to be a bowl 4in. deep, 10in. across the top, and 6 in. across the bottom. To cut out the piece of sheet metal to form this bowl, first continue the slanting sides until they meet at G. With G as a centre, and G, H as a radius, describe a circle as shown. With G, I as a radius describe another circle. Find the circumference of the outer circle as described for Fig. 78, and draw lines from the outer points to G. Outside of, but parallel with these last lines, measure off sufficient to form a lap, or welt, or for dovetailing if the seam is to be brazed together. If the bowl is to be made of copper or other hard metal sufficient should be left on the outer circle for turning over a wire, and on the inner circle for turning in for brazing, or outwards for welting, to the bottom.

If a trumpet-mouthed waste-pipe, or a tapering-pipe of any description, has to be made out of sheet-metal, the elevation should be first drawn to the full dimensions, and then the cutting-out lines found in the same manner as the bowl shown at Fig. 79. The student can assume some such piece of work, and after deciding upon the dimensions can set out the necessary lines on a piece of cardboard or stiff paper, after which he can cut it out and fold it and thus test the correctness of the problem.

In my last lecture I described how to cover a turret with pieces of lead arranged as a series of aprons. We will now consider how to cut the sheet metal for covering the same turret with lead shingles, or pieces of lead arranged in the same manner as slates. The whole of the lines necessary for use will be found on Fig. 78. First set out the lines as if aprons were to be fixed. Then divide the bottom circle into a number of equal parts. The spaces being equal to the width it is intended the shingles are to be. From the points made on the outer circle draw lines to the apex or centre point, as shown by dotted lines on the right-hand section of Fig. 78. The spaces between these lines show the width, and between the bottom firm line circle and the dotted line circle just above the second firm line circle shows the length, of the pieces of lead, and also the curves necessary for cutting out the ends. Fig. 80, which is drawn to a larger scale than Fig. 78, shows the shape of the piece of lead as cut out to represent one shingle and which can be used as a pattern for the rest of the bottom course. The next row of shingles will be narrower than the first row, so they must be cut out by using the next series of lines, shown in Fig. 78. If the shingles are to have pointed bottom ends, the corners can be cut off as shown by the dotted lines. If they are to look like leaves they would be cut as shown by thick line. Fig. 81 is a fragment of a turret, showing how they are arranged. The laps are generally about 3 in., that is, the bottom course extends beneath the course immediately above it, and 3 in. beneath the second course, in the same manner that slates are fixed on a roof. When fixing lead shingles the top edge should be let into the woodwork the thickness of the lead, so as to avoid any unsightly bumps at the laps. Shingles should be fastened on with copper nails as iron ones rust, so that the heads fall off—a better way for fixing is to leave a tack, as shown at A, Fig. 80, to pass through a saw cut in the boards. This tack being turned down inside the turret and nailed, but it is not possible to do this in all cases, as the plumbers cannot get inside by reason of its smallness and the timbering to which the boards are nailed.

In some cases turrets standing on round bases have rolls extending the lengths of the sloping sides, as shown at Fig. 82. The lead for these turrets would be set out in the same manner as if they were going to be covered with one piece, and then divided into sections with allowances made for the undercloaks and overcloaks of the rolls. As it is almost impossible to work the top ends of the lead bays into the acute angles formed by the intersection of the rolls it is sometimes found in practice best to let the rolls terminate at the thick line, Fig. 82, and then have a capping piece worked down on the terminal so as to cover the top part and extend a few inches over the tops of the bays and the roll ends.

Turrets are sometimes covered with lead in small bays, the rolls forming the bays being laced. Fig. 83 shows, by plan and elevation, two ways, in which this is sometimes done. The left half shows the diagonal rolls meeting at a straight roll, and the right half the lacing intersections being at or near the centre of the bay between the rolls.

To cut out the lead for these bays it is first necessary to set out the plan and elevation. First make a circle of the same size as the base of the turret. Divide this circle into the same number of parts it is intended there shall be bays. For our present purpose, we will assume there will be twelve rolls, extending from the base to the apex, thus making twelve bays or spaces between the rolls. Above the circle or plan draw an X, Y, and project the divisions of the circle on to that line, as shown by dotted lines. Continue the centre line to an indefinite height, and mark off on this line, measuring from the X, Y, the height of the turret. From this point draw lines to the base points, as projected from the plan to represent rolls. On the extreme edge of the elevation, which represents the side of the turret, set out the lengths it is intended the diagonal rolls are to be apart, and also the distances it is intended the rolls shall slope, these latter distances being then projected horizontally onto the next roll running from base to apex, after which the diagonal lines can be drawn. Project the lines made on the outer edge of elevation onto the line A on plan, as shown by faint lines, and with a pair of compasses and C as a centre, describe semi-circles from the points on A C, as far as the line C, Z. These circles will cut the lines D, C, and E, C, and then firm lines can be drawn as shown to represent the diagonal rolls on the plan. After setting out the plan and elevation as described, we can proceed to cut out the pieces of lead, as follows, but it must be first explained that the lengths are to be taken from the elevation, and the widths from the plan, about one-seventh being added to the latter dimension to allow for the rounding shape of the turret. Let F, G, H, I, Fig. 84, represent a piece of lead, out of which the bay J, Fig. 83, is to be cut. The total length of this will be found by projections onto the outside of the elevation, and as represented by the dotted lines K and L. Draw lines on the piece of lead the same distance apart as K, L measured on the sloping side of Fig. 83. On these lines are the extremities of the bay. Next project the other two corners of the bay as shown by M and N, and mark on the piece of lead similar lines, and measured in the same manner as K and L. We have now got four lines on Fig. 84, which contains the four corners of the bay of lead. From the plan take the dimension O, P measured across the circle, add one-seventh to this, and transfer it on the line K, Fig. 84, the points being equi-distant from the centre line Q, R. Next take from the plan the distance S, T, with one-seventh added, and mark this distance on the line L, Fig. 84, as described for the last dimension. The other two corners to be measured in the same manner from the plan, and transferred to the piece of lead as shown at U, V, W, X. We have now got eight points marked on the lines K, M, N, and L, but only four are required. A glance at the elevation will show which they are when lines can be drawn to connect them together to represent the shape of the piece of lead. Outside of these lines, and parallel with them, should be marked the distances necessary for the lead to fold round to cover the rolls. The usual allowance is 3 to 4 in. for the undercloaks, and 6 or 7 in. for the overcloaks. This is a very good geometrical problem, the student can make a cone out of a piece of cardboard, set out on it lines to represent the rolls, and then cut out pieces of paper by the method above shown and thus test its accuracy. When one piece of lead has been cut out it can be used as a pattern for other pieces for fixing in similar positions, but as the turret becomes smaller as it goes upward it will be necessary to set out each horizontal series of bays separately.

side the figure as shown by dotted lines, when the pieces of lead can be laid over the firm lines and a chalked line used, the ends being held on the dotted lines, when the shape and size will be marked on the lead. Margins should then be measured from the above lines to form the undercloaks and overcloaks of the rolls.

By a careful study of the above problems the whole of the pieces of lead can be cut out for a turret so it is unnecessary to work out any

FIG.80

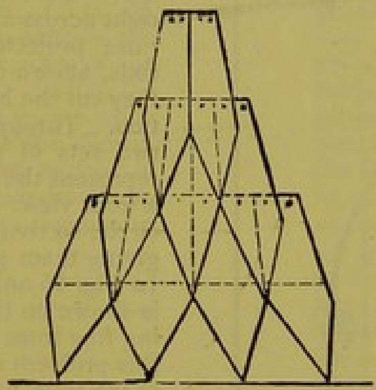


FIG.81

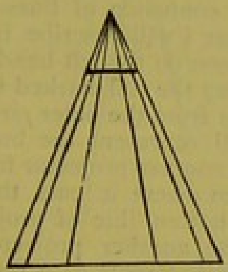


FIG.82

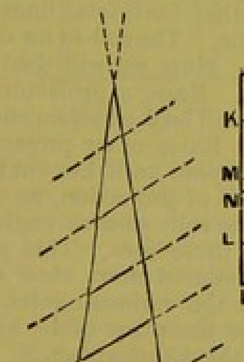


FIG.85

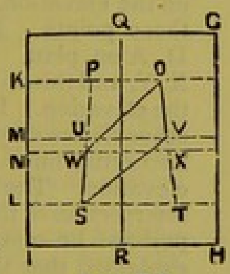


FIG.84

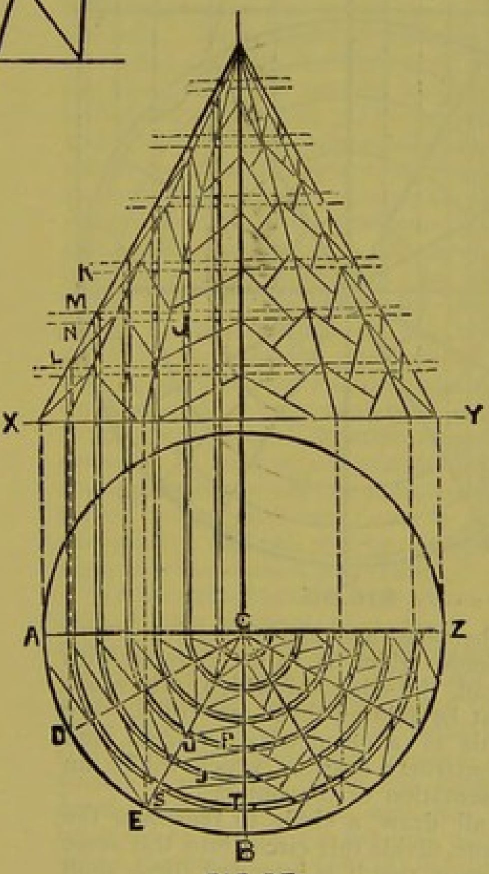


FIG.83

In practice the plumber would be able to take his dimensions from the actual turret, the lines he would then want would be one for the base, and two others for the rolls running from top to bottom, as shown by Fig. 85, and thus represent one series of bays. The diagonal rolls should also be marked as shown in the figure, the whole being set out full size on the floor or bench. All the lines should be continued out-

further examples. It has now only to be stated that when the diagonal rolls are intersected between the vertical rolls, or arranged in any other manner the whole of the lines for cutting out the pieces of lead can be found in the same manner as described above, the only variation being that the lines of projection would be as shown on the right-hand portion of Fig. 83, if the rolls were arranged as there shown.

On Domes.

Small domes can be covered with one piece of lead, it only being necessary to cut out a round piece, lay it on the top, and boss or work down the sides until they fit closely to the rounded surface of the dome. But for a dome or hemisphere of a large size, the lead has to be put on in pieces in the same manner as described for a conical turret, the only difference being that the lead must be cut to fit the rotundity of the object. Let Fig. 86

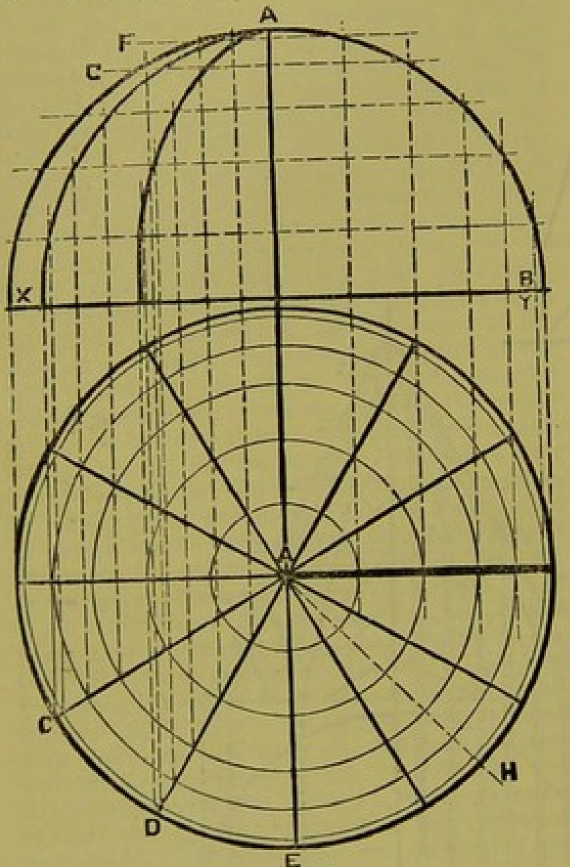


FIG. 86

represent the plan and elevation of a hemisphere, or dome, which is to be covered with pieces of lead, the edges of which are made weather-tight by folding them over rolls. We will treat this as a geometrical problem, and first of all construct a drawing which will be an exact representation of the object

First of all draw a circle to represent the plan of a dome, divide this circle into the same number of parts that it is intended there shall be bays, and from these points draw lines to the centre which represents the crown. Above the plan draw an X, Y, or ground line, on which the dome stands, project the centre of the plan onto this line. With this as a centre, and the compasses set to the same radius as was used for the plan, draw a semicircle to represent the elevation or front view of the dome. Divide the outer circle A to B into any number of parts which are of equal distance from each other. The closer these marks are together the more exact will be the drawing when finished, but if too many divisions are made the lines will be so close together as to lead to confusion, so we will assume, say six. Drop projectors from these marks down to the thick line on the plan as shown. With one leg of the compasses placed in the centre of the plan describe circles cutting these latter points. Now go back to the elevation and draw horizontal lines from the points on the circle A to B right across as shown by dotted lines. We now raise projectors from the circles cutting the rolls, shown on the left half of the plan, until they cut the horizontal projectors on the elevation. Through the points of intersection of the two sets of projectors draw lines, which will represent the position of the rolls as seen from a front view. These lines form no part of a circle, so they have to be drawn in by freehand giving them gentle curves between the points. In Fig. 86 only one half of the number of rolls is shown on the elevation for the sake of keeping free from a confusion of lines. To make this problem clear I will describe in detail two of the rolls, as seen on the left hand side of the elevation. Taking the roll marked C, A on plan. Raise a projector from the outer circle at C on to X, Y, this will represent the bottom end of the roll. Raise another projector from the next circle on the plan where it cuts the line C, A until it cuts the bottom line of projection in the elevation. Raise another projector from the second circle where it cuts C, A on plan until it cuts the second line of projection in the elevation, and so on for the other circles on the plan and the other horizontal lines of projection on the elevation. The roll to be drawn through these points. Now we will deal with the roll D, A on plan. Raise a projector from D onto X, Y, and this will be the bottom end of the roll in the elevation. Raise other projectors from the other circles on plan until they cut the respective horizontal lines of projection, as shown on the elevation. The rolls pass through the points of intersection of these lines. This problem would perhaps be rendered more clear still if it was explained that the various circles on the figure below X, Y are the plans of the horizontal lines drawn across the figure above X, Y. To prove this, the student could draw a circle below, and a semicircle above, X, Y, and show the radiating lines on the former as at first. On the side A, B, Fig. 86, mark off a short distance, and draw a horizontal line, as at F. He could then drop a perpendicular line down to a point below A on plan, and with this A as a centre, describe a circle tangental to the line drawn from the elevation. Where this circle cuts the lines radiating from the centre of the plan perpendiculars could be projected onto the line F in elevation. Another space equal to the first one could then be marked on the circle A, B, and from this point a perpendicular could be dropped onto the plan, and another circle drawn tangental to it as described for the first one. Projectors drawn from the radiating lines (here sometimes spoken of as rolls), at the points cut by the circle, onto the elevation would represent the bottom ends of the rolls should the elevation be cut off at the line G. These operations could be repeated until the whole figure was constructed. The dotted line A, H, will be referred to in the next lecture.

We will now proceed to explain how to cut out the lead bays for the dome. Open out the sheet of lead and draw a line on it the same length as A to B on the elevation of Fig. 86. For our present purpose we will assume the dotted lines A, H on plan to be the plan of the line we are using to work from. Divide the line drawn on the sheet of lead into the same number of divisions, and to the same dimensions as those marked on the outer surface of dome as shown A to B. This is illustrated by dotted lines Fig. 87. With the compasses

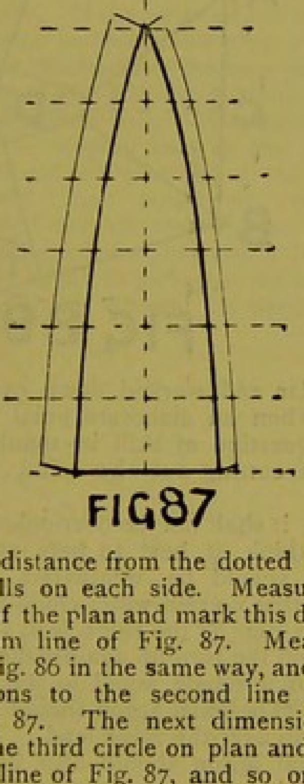


FIG 87

measure the distance from the dotted line Fig. 86 to the rolls on each side. Measure on the outer circle of the plan and mark this dimension on the bottom line of Fig. 87. Measure the next circle Fig. 86 in the same way, and transfer the dimensions to the second line from the bottom Fig. 87. The next dimension to be taken from the third circle on plan and marked on the third line of Fig. 87, and so on for the other circles. The seventh line Fig. 87 contains the extremity or the highest point of the dome. Firm lines are now to be drawn through the points found on Fig. 87, and these lines will represent the true shape of the bay of lead. Margin lines must now be drawn parallel with the last ones at distances of 4 in. and 7 in. respectively for lapping over and round the rolls. These last lines are shown by faint lines on Fig. 87. The piece of lead can then be cut out and used as a pattern for the other bays.

For very large domes the bays would of necessity require several pieces of lead to cover them. In these cases it is best to set out one bay, to its full size, on the floor, and divide this into the spaces it is intended the sizes of the pieces of lead shall be. These sizes can then be transferred to the lead, and margins left on the ends for the horizontal lappings. In actual practice it will be found necessary to set out two sets of bays—for the reason that the lappings should not all come at the same horizontal line in all the bays, thus causing four thicknesses of lead to lap round the rolls and make unsightly looking bumps at the points of the lapping. If this problem is studied the student can apply it to cutting out lead shingles or any other shaped pieces of metal for covering a dome. Before leaving the subject of a dome it is necessary to say that when one is being covered with bays of lead the pieces of lead have either to be hollowed on the back side to fit the rotundity of the body to be covered or else the outer edges dressed or worked down with the same object. In practice the latter course is usually followed, as by doing so the substance of the lead is not reduced in any part. The only difficulty that presents itself is the parts that stand up for folding over the rolls. These stand up parts should be folded down flat, until the lead has been dressed to fit the dome, and then worked up afterwards and folded over the rolls. The subject of turrets and domes could be continued to a much greater extent and examples given of those that stand on square, hexagonal, octagonal, or any other shaped bases; but the problems given will to a certain degree apply to all cases. The only difference being that with flat sided figures fewer lines are necessary for developing the figure as a drawing, or for cutting out the metal for covering it. And neither is it necessary to allow for the rounding shape of a turret, on a square or octagonal, base as for one that is round on plan. The same remarks apply to domes. In working out certain problems it is sometimes convenient to assume that a conical turret, or a round based dome is a figure with many sides, and this will be referred to when we come to measuration of surfaces.

We will now consider how to cut out a piece of lead for a terminal of a roof. Let Fig. 88 represent the plan and side elevation of one, at the end of the ridge of a roof, and a piece of lead is wanted for covering the top part. In some cases a piece of lead could be cut out, laid on the top and then worked down to fit closely to the sides, but in the case of a large finial, a deal of labour and hard work would be saved by cutting out the lead and folding it round the finial. To cut out the piece of lead we will at first assume that we are dealing with a turret standing on a square base, and set out the side which represents the end of the building. The dimensions to be taken from Fig. 88. From plan, Fig. 88, measure the line A, B, and draw this line on a piece of lead. Raise the perpendicular C, D, from the centre of the line and mark off a distance equal to C, D, Fig. 88. This distance being from the bottom edge of the lead to the centre of the tree of the finial.

With D as a centre Fig. 89, and A as a radius, describe a circle as shown by dotted lines. Mark off on this circle two distances, E and F, equal to A B, and join the points. Measure on these lines the distances A, E, and B, F, Fig. 88. The three lines E A, A B, and B F, will then

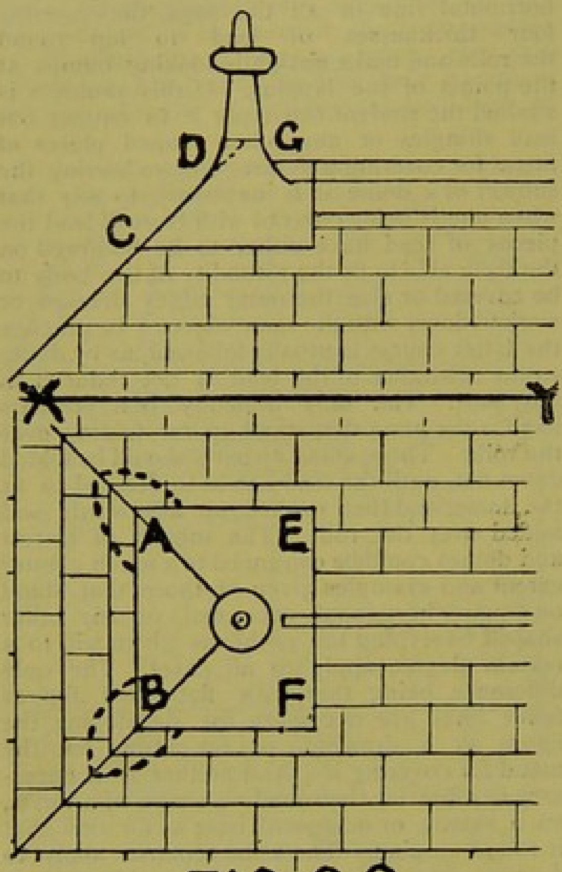


FIG 88

represent the bottom edge of the lead on the three sides of the roof. On E and F, respectively, raise perpendicular lines to represent the ends of the piece of lead laying on the sides of the roof. With D as a centre, describe a circle equal to the diameter of the tree or post of the finial at a point about 3 in. above the level of the ridge of the roof. This circle must not be cut out, but the lead must be bossed out to the size shown by the circle. Lines should be projected across the elevation of Fig. 88 so that we can measure the distance of the part G above the bottom edge of the piece of lead. This distance can then be marked off on the perpendicular lines E and F, Fig. 89. Beyond these distances a few inches should be left for lapping or fold-into a welt on the ridge roll. In practice it will be found best not to cut this part too exact as a little spare lead is found to be useful for the plumber to work into the hollow neck G, Fig. 88. The bottom edge of the piece of lead could be vandyked or trimmed to any fancy design, or the angles could be trimmed, as shown by thick dotted lines, to lay on the hips of the roof, presuming the roof is a tiled one, or has secret hips, but if hip rolls are used the lead should be worked round the rolls first and trimmed afterwards so as to leave a straight in distinction to a ragged edge.

If the upper portion of the tree is tapering and long, the lead could be cut out as described when writing on Fig. 79. But if an ornament of a simple kind is fixed the lead should be cut

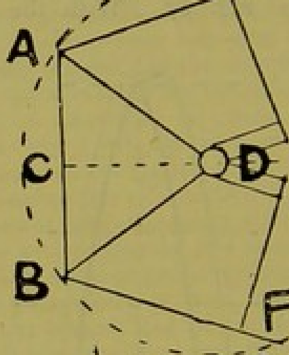


FIG 89

out circular and worked down over the ornament. When an elaborate finial is fixed it is more a question of skill in manipulating the lead than cutting out the metal to cover the finial.

So that it shall not be overlooked at a future time I think it best to here state that all lappings should be weathered, that is, so arranged that no rain-water could pass between them. In Fig. 88 the ridge lead should be put on first, and the turn-up against the finial should be let into a rebate equal to the thickness of the lead. The finial apron should then be fixed so as to lap over the ridge lead. The top edge of the finial apron should also be let into the woodwork beneath, and the tree of the finial covered afterwards. In all cases the appearance of lead work on roofs, &c., is much improved if the undercloak of all passings or laps is let in a distance equal to the thickness of the lead. With these remarks we may leave geometry as applied to roofs, but if there is any part that I have not touched upon, and on which you wish for further information I shall be pleased to help you to the best of my abilities.

ON SETTING OUT BENDS.

WE will now describe how to set out the lines for working to when making bends in lead pipes. This problem is so easy and simple that I am sure those who have been in the habit of making wooden patterns or templates will for the future adopt the more simple one which I will now explain. Supposing a 4 in. lead socket-pipe has to be made with two bends in it to pass through a 9in. wall. First of all draw two chalk lines on the bench, and 9 in. apart to represent the thickness of the wall. From one line measure say 3 in., so that the joint of the socket-pipe to the cesspool shall not come close to the wall, and draw another line parallel with the others. If the outer end of the socket-pipe is to enter an iron down-pipe ¾ in. should be left for the thickness of the iron-pipe socket, so draw another line ¾ in. away from the other line representing the wall. After deciding what fall or pitch the sloping part of the pipe is to have that should be marked on the drawing; 4 in. should be measured from the two outside and also the sloping line, to represent the diameter of the pipe, and a line drawn through these points to represent the pipe. Fig. 90 will explain the details. If bends have to

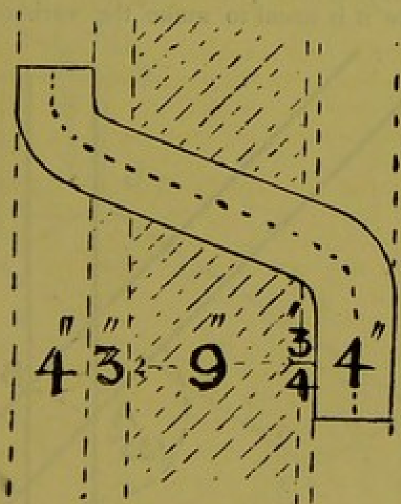


FIG 90

be made for a pipe fixed on one face of the wall to pass through and be continued on the other face of the wall the distances 3 in. and ¾ in. in last figures should be omitted. The required lengths of the ends beyond the bends should be exactly measured and the bends drawn rounded either by free hand or the aid of a pair of compasses. No matter what position a bend has to be made to fit, that position should always be drawn full size, and then the pipe drawn as it would appear in that position. If the pipe is then bent to suit the drawing it will be found to fit the place it is intended for. The dotted lines on the side of the bent-pipe Fig. 90 will be referred to in the next lecture.

In some cases it is necessary to make two drawings to represent the bends when two or three are required to be made in one piece of pipe. Let Fig. 91 represent a plan of a pipe

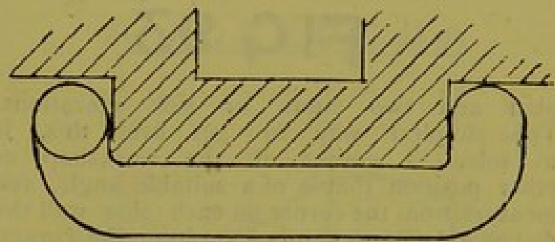


FIG 91

bent to pass round a projection from a building, such as a chimney-stack. This pipe should be fixed with a fall towards the outlet, but the plan does not show this, so it will be necessary to draw an elevation of the pipe as shown by Fig. 92. In this pipe four bends are necessary, but

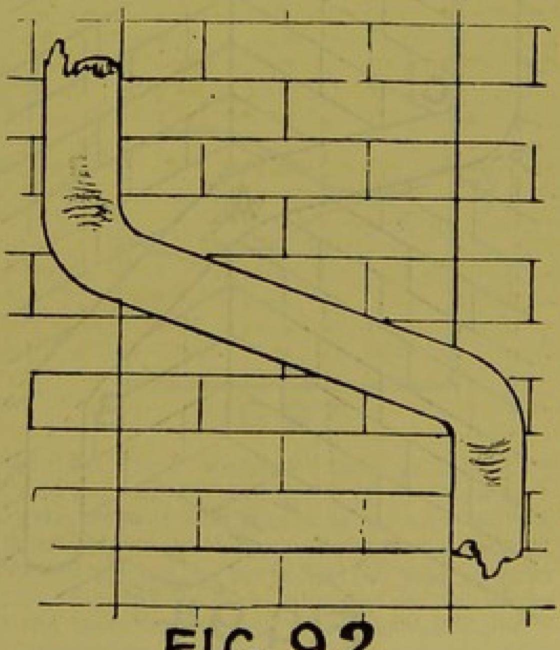


FIG 92

only two are shown on the plan, the other two and also the real length and slope of the pipe, are shown in the elevation

One more illustration is given. Let Fig. 93 represent the plan of a pipe to fit round an angle of a building, one end being continued upwards and the other one downwards. In this case three drawings are necessary, one for the

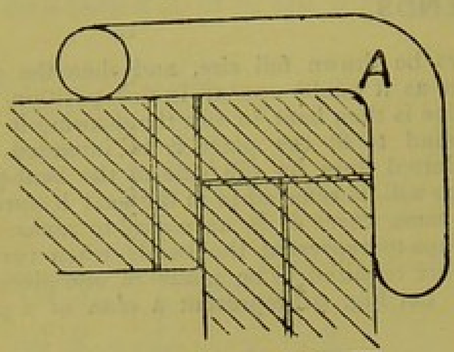


FIG 93

plan and two views or side elevations. The simplest way to get over this, is to select a corner of the workshop or other position that is of a suitable angle, and measure from the corner on each side wall the distance the vertical pipes are from the corner. In this case the dimension should be measured on the outside of the bend shown in Fig. 93.

Fig. 94 is a sketch view of an angle of a room and the dotted lines show the setting out for

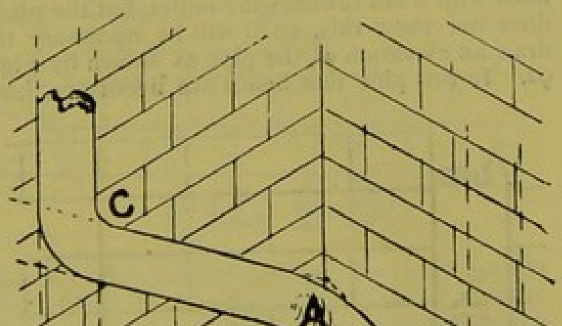


FIG 94

the vertical pipes. The necessary fall for the pipes should then be drawn and the pipe marked out full size, as shown in the illustration. The student will notice that the bend A Fig. 93, appears to be a right angled, or square, bend but on referring to Fig. 94, he will see that it is an obtuse bend. If the work is set out, as shown by Fig. 94, the plan, Fig. 93 would be of no use as a working drawing. When making these bends, it will be found advantageous to make the bend A, Fig. 94, first, and the other two afterwards. After making the first bend, the pipe should be held on the lines on the walls, and the points B and C marked on the pipe as the position for the other bends. In practice it is found necessary to make the marks B and C about 1 in. nearer the ends of the pipes, for the reason that when bends are being made, and all the dummying done from one end, the bend appears to be driven, so to speak, further inwards, or from the end, and thus the distance between the bends gets too short. This really arises from the contraction of the lead in the throat of the bend. As an illustration, supposing a bend is made on a piece of 4 in. pipe, which is 2 ft. long, when finished, *if properly made* the bend would measure 2 ft. on the outside, but considerably less on the throat or inner side.

In some parts of the country it is usual for plumbers to make bends out of two pieces of sheet lead and then solder them together; the seams being as shown by dotted lines on the side of the pipe Fig. 90. All the lines necessary for setting out the work are shown on the same figure. For bends similar to those shown by Figs. 92 and 94 it is very difficult to make them out of two pieces of sheet lead and in practice it is usual to make the various bends

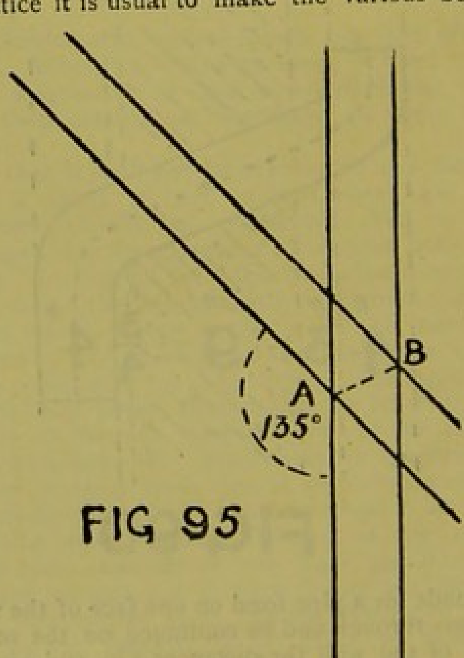


FIG 95

separately and solder them together afterwards. This is rather a bungling way of getting over the difficulty, and there is no doubt that it will drop into disuse now that plumbers are getting to be very proficient in the art of bending lead-pipes to fit into any position. In some cases the pipe is made out of one piece of sheet lead, a seam soldered on the side and the pipe then cut and soldered so as to form an elbow, but, where possible, it is always the best method to make bends instead of elbows, Where, in the absence of the necessary conveniences for bending pipes, an elbow has to be made, the lines should be set out as shown by Fig. 95. In this case we will assume an elbow has to be made to an angle of 135 degs. First make a straight line on the bench or floor, and then by the aid of a protractor, or a scale of chords as explained in an earlier lecture, set out the angle required and draw another line. These two lines will represent one side of the elbow when finished. Two other lines should now be drawn parallel with the last two, and at a distance from them equal to the diameter of the pipe out of which the elbow is to be made. The pipe should then be laid between one pair of the lines, and the points A and B marked on the pipe, which should then be laid between the other two lines still keeping the point B on the pipe over point B on the lines. A should then be marked on the pipe as it lays in its new position. If the wedge-shaped piece is now sawn out, the pipe bent round it will be the angle required. It is usual to allow about ⅛ in.

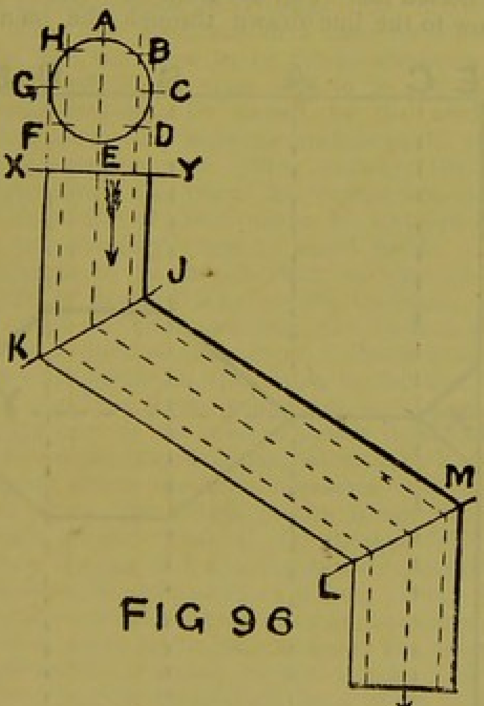


FIG 96

on one side of the part cut out for the other side to enter, and thus prevent the solder running through when the joint is being made. If several elbows have to be made in one piece of pipe, and they are all of different angles, each angle must be set out separately, but care must be taken that the various elbows are at the necessary distances from each other. It is possible to cut out a flat piece of sheet lead so that when folded up it will form any elbow that may be required. This is rarely, if ever, done in practice, but we will explain how it is done, treating the method as a geometrical problem. First of all describe a circle equal to the size of the pipe, and divide this circle into an equal number of parts. The more parts the circle is divided into the more accurate will be the piece of sheet metal when cut out, but to save a complication of lines in the drawing we will assume eight divisions as shown in the elevation Fig. 96. Drop projectors from the outside of the circle and draw the elbow, as it would appear if laid on its side. The proper angles and distances all being as required for the position the pipe is going to be fixed in. Now draw projections from the divisions of

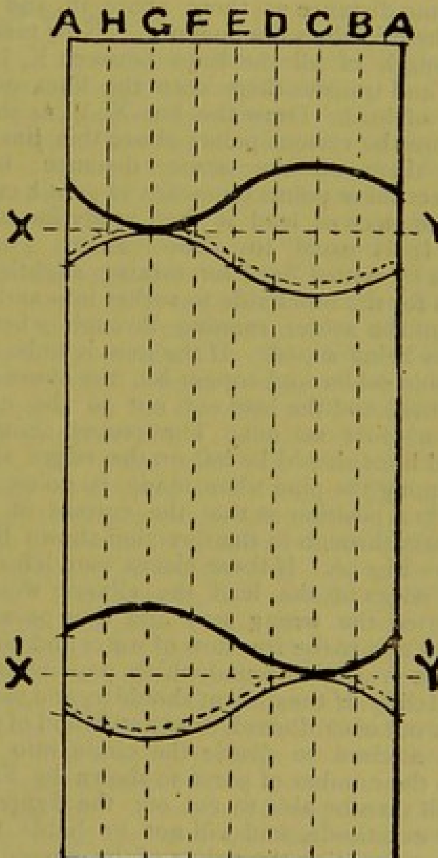


FIG 97

the circle, and continue them as shown by dotted lines on the plan below X, Y. Now ope out the piece of lead that is to be used for the elbow and set out the necessary lines as follows. We will assume the seam on the pipe is to be at A, Fig. 96, so A, A, Fig. 97, on the edges of the piece of lead will represent that point.

Draw seven other lines parallel with the sides of the piece of lead and the same distance apart as the divisions on the circle, Fig. 96, measured on the edge of the circle and no across from point to point. Mark all these last lines, using the same reference letters as are used round the circle.

To begin with A, this point is immediately behind E, so measure the length of the line E, on the plan, from X, Y to the line K, J, and transfer this dimension onto the piece of lead on A, A. We now take the line B and transfer it in the same manner onto B on the piece of lead. As D is immediately behind B, the same dimension should be marked on D on the lead. Next take the length of C, Fig. 96, and mark it on the line C, Fig. 97. Next measure G and transfer the dimension as before. H and F are of the same length, and should be measured and transferred as the other lines were. Now draw curved lines through all the points found on Fig. 97, and draw an X Y through the point of intersection on the line G. Below this line measure points the same distance as those above it, and connect them in the same manner. Now measure the length of all the lines between K, J, and L, M, and transfer them onto the lines on the piece of lead. Draw the line X^1 Y^1, as shown, measure the various points above this line and mark them off the same distance below. Connect these points by means of gentle curves, and the piece of lead is then ready for cutting out. It is usual to allow about ¼ in. as shown by dotted lines for turning slightly outwards for the other side to socket into and thus prevent the solder running through when the joint is being wiped. If the joint is to be made with fine solder and copper-bit, the above piece is omitted and the lead cut out to the curved lines as first set out. The pieces shown by dotted lines should be left on the edges shown, presuming the pipe when made is going to be fixed in a position so that the current of water will pass through in the direction shown by the arrows Fig. 96. If these pieces were left on the other edges of the lead the elbows would be socketted the wrong way and thus present an obstruction to the free flow of water and possibly leave a projection round which passing objects would cling. If the student should try and make an elbow out of cardboard, or any stiff kind of paper, he is advised to divide the circle into about twice the number of parts as shown by Fig. 96, he will then be able to cut out the figure with more exactitude, and will not be liable to err when connecting the points of the curved lines. If it is assumed for the time being, that the pipe instead of being of a round section, is one with many sides, this would perhaps help to make the problem more clearly understood. As a further aid to this end we will now proceed to cut out the lead for an elbow in a square piece of pipe.

First draw a section of the pipe and then a side view as shown by plan and elevation, Fig. 98. Assuming the pipe is 4 in. square, the ends of the elbow are each 1 ft. long, and the elbow forms an angle of 100 degs. The piece of lead would require to be 2 ft. long × 1 ft. 4 in. wide. It is best to have the seam at the side of the pipe as shown at E, in elevation, and by dotted lines on the plan. On the piece of sheet lead set out the necessary lines as follows. Measure 2 in. from the edges of the lead and

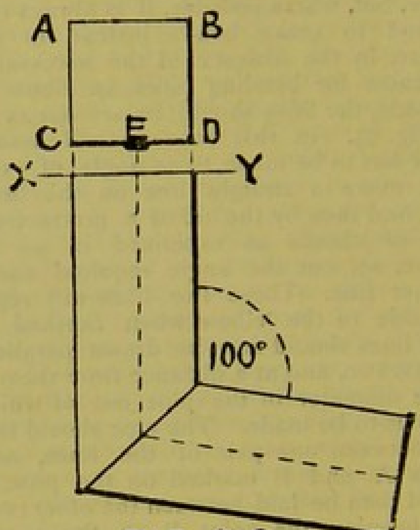


FIG 98

draw lines parallel with them. Then draw two other lines 4 in. from each other, and also the last one's drawn. Now measure the length of the dotted line (Fig. 98) from the end of the elbow to the line drawn through the point of

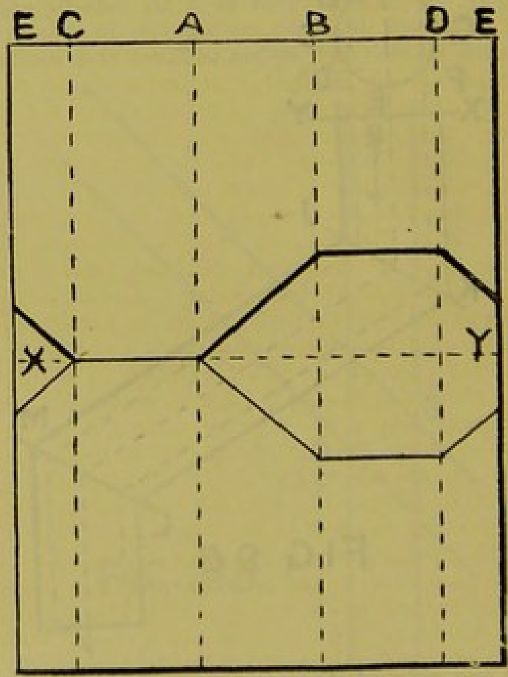


FIG 99

intersection and transfer this dimension onto the edges E of the piece of lead. Now take the length of the inside face of the elbow as shown at B, D, Fig. 98, and measure that distance on the lines B, D, Fig. 99. Now take the length of the outside of the elbow, on the side shown at A, C, and transfer that to the piece of lead. If these points are all now joined together they will represent the lines for cutting out one half of the elbow. An X Y, can now be drawn as shown in the figure, and the same distances marked below, as the various points are above it. The piece of lead can now be cut out and folded on the lines set out when the elbow will be found to be the one required.

Innumerable examples of elbows made out of pipes of any section to any angle, to fit over plinths, string courses, cornices, or any other position, could be given, but with the above examples the student will be enabled to apply the problem to any work he may have to execute. Other problems will be found worked out in my book on "Plumbing Practice."

ON OVALS OR ELLIPSES.

IF the upper portion of a cone is cut by an oblique plane, the exposed surface will be an ellipse or oval. The perforations in W.C. seats are usually cut to this shape, so we will now consider how to develop the figure, using a cone as the basis for arriving at the true shape of the hole required. We will suppose the major axis, or diameter of the hole measured across its longest opening, is to be 13 in., and the minor or smallest diameter is to be 11 in. First draw a plan and elevation of a cone as shown by Fig. 100, the base to be 2 ft. in diameter, and the length of the slant side to be 2 ft. These dimensions may be varied by the student—those given are only assumed so as to answer our present purpose. After drawing the circle representing the plan, the compasses still set to the radius of the circle to be stepped round it, thus dividing it into six equal parts. These divisions to be sub-divided, so that now the circle is divided into twelve sections. Lines are now to be drawn from the various points so as to meet in the centre. Raise projectors from the points on the circle to the line X, Y, and continue these projectors until they meet at the apex of the cone as shown in elevation.

Draw the line A, B parallel with X, Y, but at a point where the cone measures 11 in. across, this being the length of the minor diameter. Draw another line C, D through the point where the line A, B cuts the axis or centre line of the cone, this line to be 13 in. long. From where this line cuts the raking lines on the cone drop projectors on to the plan and join the points of intersection as shown in the figure. This will now represent the plan of the oval as lying on an inclined plane and a templet could be made from it, if a cone was made and a portion cut off on the lines here laid down. But for our purpose we must show the exact shape of the oval when laid down flat, and so that we may cut out a templet from the lines themselves—with this object we must raise perpendiculars from the line C, D, where it cuts the sloping lines on the cone. Now draw the line E, F parallel with C, D, and, with the dimensions taken from the oval as seen on the plan below X, Y, mark off the distances the sides of the oval are from the centre line G, H. It will be found that two of the points cannot be taken from the plan, but must be measured on the elevation from the axial line of the cone measured on A, B to the outer surface. On working out the problem the student will find which two points will have to be so measured from the elevation. He is advised to put a number or letter against each of the divisions on the circle, which represents the plan of the cone, and use the same references on the elevation and also on the new plan projected from the assumed ground line C, D. By doing this the student will more clearly understand the solution of the problem. These reference letters are omitted in Fig. 100 so as to save any confusion which might arise; the figure of necessity being drawn to a small scale. If this problem is carefully studied the student can afterwards vary it and produce other figures besides ovals by shifting the line C, D to any other inclination, or could draw another line at right angles to the base, or parallel with one of the sides. Young beginners would find it easier perhaps to commence with a square pyramid, then proceed with an octagonal one. These last figures being easier to draw, as all the lines could be ruled instead of some of them being filled in by free hand.

There are several ways for drawing ovals, some by geometrical and others by mechanical means, but there are so many good books on geometry published, and at prices within the reach of all, that I do not think it necessary to go any further with the subject, excepting to illustrate how to set out by lines the section for a public sewer. Sewers which are of a round section are much the strongest, as they will resist the greatest amount of pressure from the top, sides, or bottom. But as the amount of sewage which passes through sewers varies very much, they being sometimes nearly or quite full, and at other times having only a very small stream running along the bottom, sanitary engineers almost unanimously recommend oval or egg-shaped sewers for ordinary purposes, although the larger sewers are usually made to other sections which are governed by the

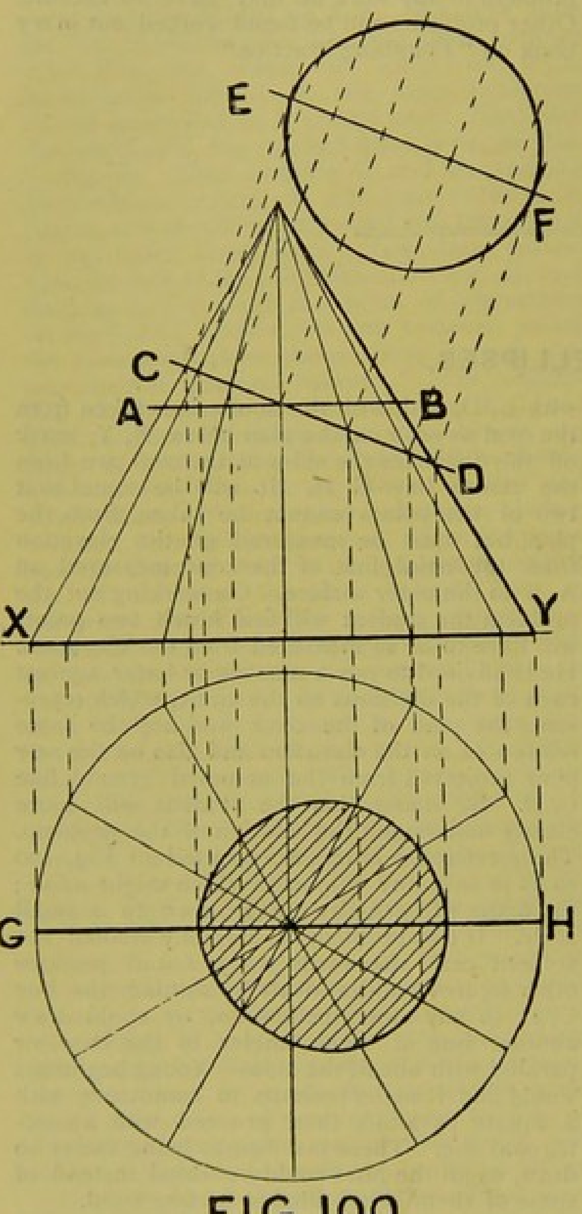


FIG 100

requirements of the various cases. Most sanitary engineers have their own ideas as to which shape is the best for ordinary purposes, and several illustrations could be given of those recommended by different experts, but an illustration of one only I will now lay before you. One of the commonest sizes for sewers is 4 ft. 6 in. high × 3 ft. across at the widest part. The invert or bottom of the sewer is generally a part of a circle, the radius for which is half that of the crown or arch over the sewer. First describe a circle which has a diameter of 3 ft. and then another circle, touching the first one, with a diameter of 1 ft. 6 in. This is shown by Fig. 101. Draw a line through the centre of

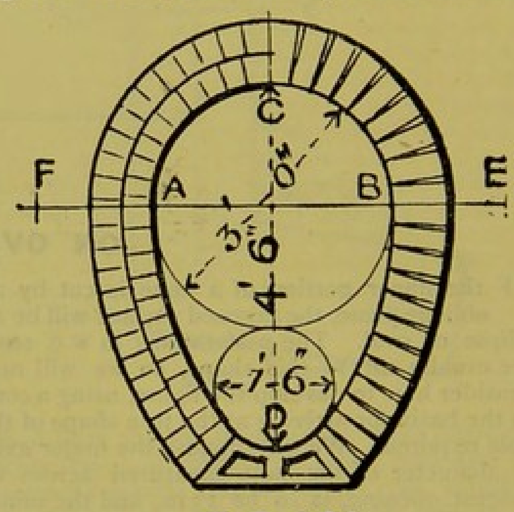


FIG 101

the first circle, and continue it indefinitely on each side. Set the compasses to the height of the sewer, that is, C to D, which measures 4 ft. 6 in., and with A as a centre cut the horizontal line at E. Now use B as a centre and cut the line at F. With the compasses still set to the same radius, using E and F as centres, describe arcs connecting the sides of the circles and the completed figure represents the inner surface of the sewer. Measure two distances of 4½ in. outside the figure, and describe arcs to represent the joint between the courses of brickwork and also the outer surface of the sewer. By building the brickwork in two courses, the bricks are laid much closer together than if they were fixed endways in the arch. Some engineers will have bricks made wedge-shaped, so that all the joints are parallel. With ordinary bricks fixed endways the joints are quite close on the inner side of the arch, but some distance open on the outer sides, these latter openings requiring a considerable amount of cement or mortar to fill them up. Fig. 101 is drawn with one half, to show the brickwork in two 4½ in. and the other half in one 9 in. course.

SETTING OUT PLUMBERS' WORK.

THIS subject is closely allied to geometry. In the lectures on geometry, as applied to plumbing, the writer had this in view, and made the problems as practical as possible by giving illustrations of cases that occur in practice. It is proposed to show how to set out by lines the pipes and fittings that are commonly used in a building, in which undertaking geometry plays an important part. We will first assume that a range of four wash-hand basins, 14 in. diameter, have to be fixed in a space which is 10 ft. long. The top of the basins to be 2 ft. 6 in. above the floor-line, a 1¼ in. trap to be fixed to each basin, the branch waste-pipes to be 1¼ in. diameter and branched into a common waste, which is 1½ in. in diameter. Each trap to have a 1¼ in. vent-

8 in. between the outside basins and the ends of the slab. This last dimension should be measured from the end of the top line, Fig. 102, and then 1 ft. 2 in. to represent the width of a basin. Now measure 1 ft. 4 in. to represent a space, and then 1 ft. 2 in. for another basin. Repeat the dimensions for the other basins and spaces, and 8 in. will be left to represent the margin beyond the last basin. Find the centres of the openings for the basins and drop perpendiculars, as shown by dotted lines. Basins of the diameter above specified generally measure about 6 in. deep, so the basins should now be drawn to that depth as shown in the figure which is all drawn to scale. Assuming the waste-pipe is to be fixed with a fall towards

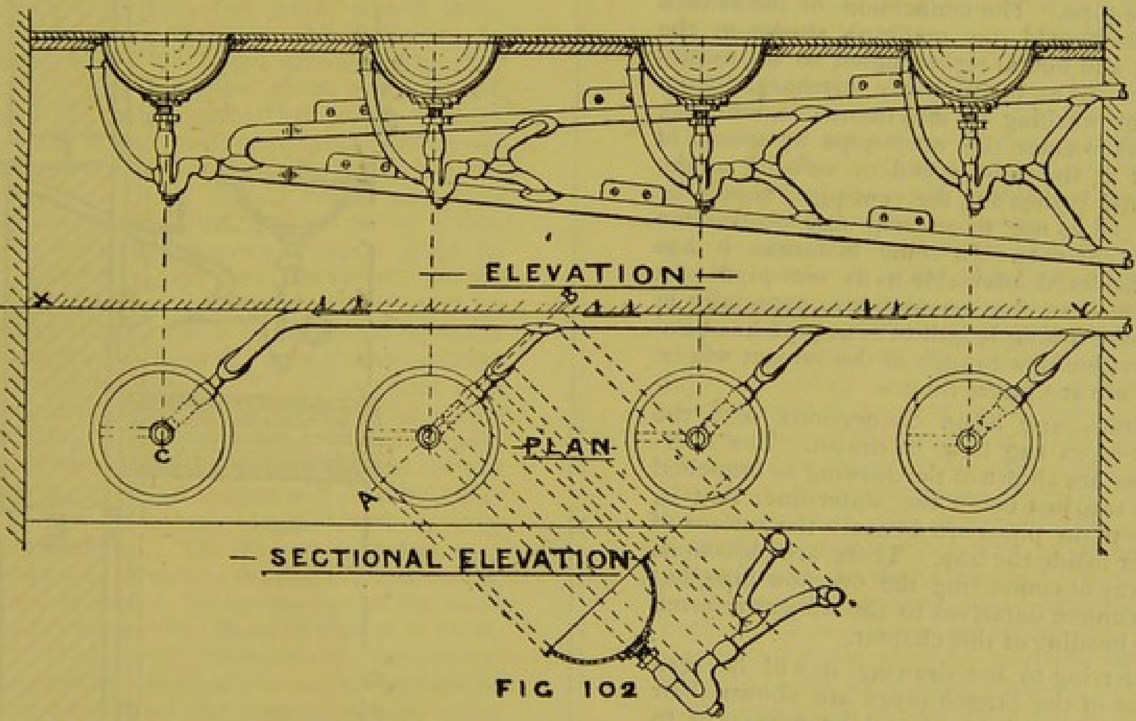


FIG 102

pipe branched into a 1½in. common ventilation-pipe and 1¼ in. branch-pipes to be fixed from the traps to the overflow arms of the wash-hand basins. First draw a line to represent the floor as X, Y, Fig. 102, and then another line 2 ft. 6in above the last one, to represent the top edge of the basins. These lines to be 10 ft. long, equal to the size of the space in which the basins are to be fixed. The positions of the basins are now to be set out. The four basins themselves, if placed close together, would, omitting the rims, occupy a space of 4 ft. 8 in. This dimension, deducted from 10 ft. will leave 5 ft. 4 in. to be divided into the spaces between and at the ends of the basins. This will be found equal to 1 ft. 4 in., as the space between the basins and

the right hand end, we will now draw two lines 1½ in. apart, and with an inclination as shown in the figure to represent the waste-pipe. The top end of this pipe should be level with the outgo of the trap fixed to the end basin, and a fall of about 9 in. should be allowed in the total length of the waste-pipe.

It will now be necessary to make a plan of the wash-hand basins, so that the length of the branch waste-pipes can be seen. First draw a line to represent the back edge of the top or slab and another line for the front edge. We will assume the width of the slab to be 2 ft., so these last two lines must be 2 ft. apart. Next continue the centre lines of the basins from the elevation onto the plan, see Fig. 102. With the compasses describe circles 1 ft. 2 in. diameter, as shown in the drawing, the circles to be kept 3 in. back from the front of the slab. Now draw from each basin two lines 1¼ in. apart to represent the traps and branch waste-pipes. These branches, to be so arranged, that what is sent through them will run down the waste-pipe and not run back or towards the highest end. On reference to the figure, the student will observe this principle, which is much better than if the branches had been joined to the main waste-pipe at right angles. These branch-pipes should now be projected onto the elevation. The joints should also be drawn so that when arranging the ventilation-pipes care can be taken that no two joints come in the same position, which would show want of thought on the part of the plumber. The common vent-pipe can now be drawn with an inclination towards the left hand end basin, so that should any waste water get into it, or any steam or vapour condense inside, it will run out again and into the waste-pipe. The connection of the branch vent-pipes should be made as shown in the drawing, and not at right angles, so as to prevent as much as possible any discharges from the basins washing up into them. In addition, as air has to enter the waste-pipe by means of the vent at the same speed or velocity as the waste water rushes out, the vent-pipes should be so arranged as not to present any obstruction to the air currents. In some instances it has been considered advisable to fix vent-pipes of a larger size than the waste-pipes, especially in cases where a long length of vent-pipe has been necessary, but this branch of the subject will be entered into at a future time.

The traps and basin connections, also the overflow-pipes can now be drawn. The overflow-pipes are shown in the drawing as branched into the trap just below the water-line; that is, the ends of the pipes are beneath the surface of the water inside the trap. There are objections to this way of connecting the overflow-pipe, but we will confine ourselves to the subject referred to in the heading of this chapter.

On referring to the drawing it will be seen that none of the branch-pipes are shown their proper length, and that it will be necessary to make a sectional elevation to show these pipes in such a way that the plumber can prepare them ready for joining to the main-pipes. With this object in view we will take one of the basins as shown on the plan, and draw the section line A, B. Drop projectors from this line and draw the basin and trap. Measure from the elevation the positions of the main, waste, and vent-pipes. Mark these pipes on the sectional elevation, and draw in the two branch-pipes as shown on the diagram. Only one basin is shown by a side elevation. Instead of drawing the others this one can be used for all by adding in the positions of the main-waste, and vent-pipes in the positions they occupy in relation to the other basins.

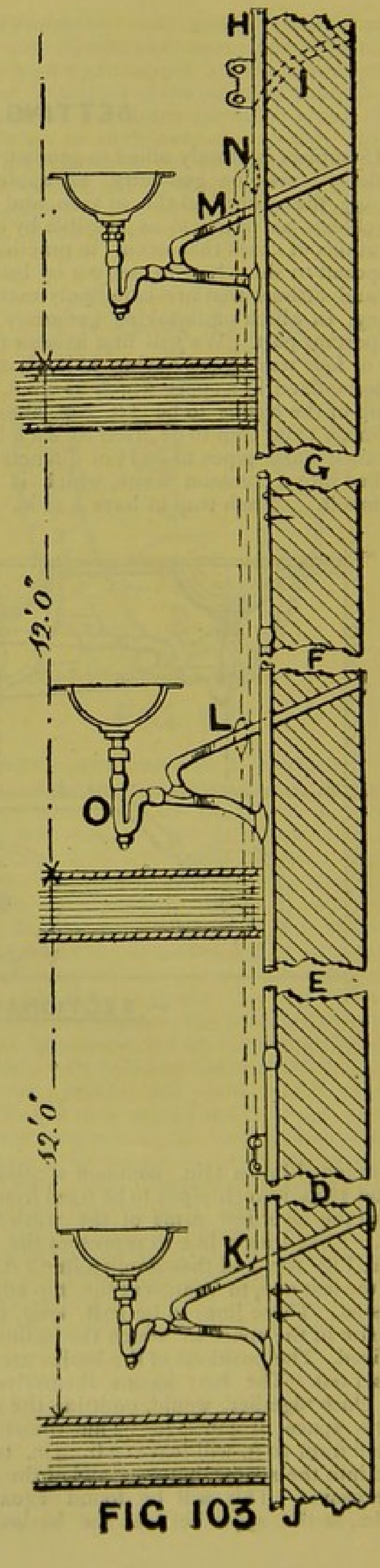


FIG 103

The working drawing is now complete, and the plumber can proceed to cut off the various pieces of pipe, bend and prepare them for joining together.

In large buildings, which are used principally as offices, we frequently find a tier of wash-hand basins. In some cases a range of basins is fixed on each floor, but if Fig. 102 is carefully studied it will be unnecessary to repeat any portion of that matter, so we will simply deal with a case in which one basin is fixed on each floor. Fig. 103 is an elevation of a tier of basins as sometimes found in practice.

The plan of these basins would be set out similar to the one marked C on plan of Fig. 102. For the elevation we will first consider the lengths of the pipes we are to use, and arrange them so that none of the piping is cut to waste, and the joints come in easily accessible places for making. Assuming that the various floors are 12 ft. apart, and the piping is in 12 ft. lengths, if we were to start the above stack with a 12 ft. length of pipe, the joints would probably come between the floors and ceilings. In this case it would be found advisable to start with half a length of pipe, which would be 6 ft. long, and the joints would then come midway between the floors. The next thing would be to consider the position of the tacks for fixing the vertical-pipe. These should be as nearly as possible equidistant apart, and yet be in places where the necessary screws or nails could be fixed. And then again the tacks should not be soldered to the pipe close against any branch or other joint. The branch joints should be made so that discharges from the upper basins will not run up the branch-pipes. To obviate this it is a good plan to bend the end of the branch-pipe downwards at or near the joint with the main stack. With these remarks and the aid of the diagram Fig. 103, the student will clearly understand how to set out any similar work he may have to deal with. The Figure is drawn to a scale, but so as to reduce the size of the drawing, a part is supposed to be broken out of the walls and pipes between the floors as shown at D, E, F, and G. The plumber would do the same thing, in setting out the lines on the workshop floor or bench for the reason that most likely the place where he was working would not be long enough to set out the whole length of the main stack.

If the floors of the building in which the work is to be fixed are all of the same height it would be only necessary to set out the work for one floor and as the others would be similar the same lines would do for all the floors.

The top end of the vertical waste-pipe, H, should be continued to the roof of the building, but in some cases it would only be necessary to turn it through the wall as shown at I. The bottom end of the waste-pipe, at J, should be turned through the wall and be made to discharge into an interceptor trap fixed outside the building. In some cases the air-pipes to the basin traps would be fixed as shown by dotted lines, branch joints being made at L and M, the top end of this pipe being continued to the roof or branched into the waste-pipe at N. The reasons for these variatians will be dealt with at a future time, and also the questions of water seal of traps, those drawn in the figure having considerably more "dip" than those generally used. The trap O will also be referred to. It will be noticed by the student that the branch waste-pipe from the top wash-hand basin, Fig. 103, goes straight into the vertical waste, but the two lower branches have bends near the joints. These bends are made for the purpose of preventing the water discharges from the upper fittings running back into those at the lower levels. When fixing sinks, baths, or any other fitting, the pipes should all be first set out by lines. By doing this their arrangement can be made to look much better, or, if I may be allowed to so express it more artistic. Good joints and bends in pipes always carry a certain amount of credit for the plumber who makes them, but if they are huddled together in a kind of happy-go-lucky way, it shows a want of taste on the part of the workman. Neither can a man know how his work will look unless he first makes a drawing to represent it when finished. And again, a full-size drawing that shows the whole of the pipes, &c., will enable the plumber to measure exactly what materials he will require, cut off the necessary lengths without waste, or the better use up odds and ends of pipes that would otherwise go away as waste or cuttings. Where a number of branch waste-pipes are joined to a common waste-pipe, mistakes are frequently made in the arrangement that would have been noticed by the plumber if he had first made a drawing showing how they would come, and so avoid having to make alterations after the work had been completed. As an example of this, a case recently occurred, which was not at all an uncommon one, where on emptying a wash-hand basin, part of the dirty water ran back into a bath and sink. When emptying the bath the waste-cock could only be partially opened, or the sink would have been filled to overflowing. And when a pail of slop water was thrown down the sink a portion of the water generally found its way into the bath.

Fig. 104 is a sketch of the arrangements

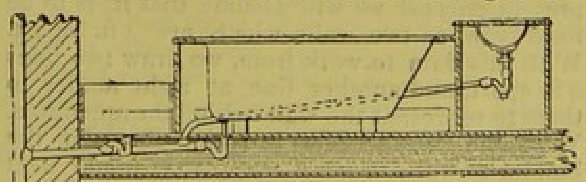


FIG 104

The faults are so prominent that it is unnecessary to say any more on the mattter excepting that none of the traps were ventilated, and when the bath was used part of the water would be siphoned out of the W.H.B. trap.

Fig. 105 represents a copy of the lines made by the plumber who had to alter the defective arrangements shown in Fig. 104. The common waste-pipe was fixed on the external face of the wall. The building was a very high one, and there was a sink, bath, and W. H. B. fixed on each of the upper floors. So the plumber who altered the work on one floor made all his branch waste connections with a bend downwards as seen at Z. He also deemed it advisable to make three separate connections with the common waste-pipe and a separate branch

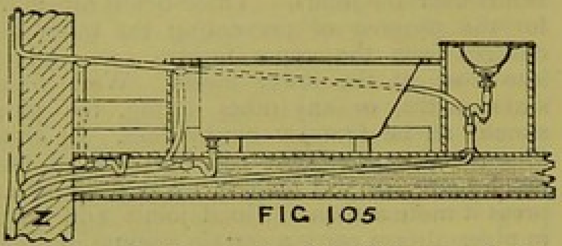


FIG 105

waste-pipe fixed to each of the fittings. A ventilating-pipe was fixed from the W. H. B. trap, and branch vent-pipes from the other traps were connected with it. The vent-pipes had to be kept down so low as to be hidden by the bath enclosure, and also by the back side of the sink which stood up about 2 ft. 3 in. high above the level of the floor.

Several similar blunders, as shown by Fig. 104, will be referred to at a future time. This case was introduced here partly with the object of showing to the student the importance of cultivating the habit of always setting out his work so that he would know what he had to do and also be better enabled to make it look to the best advantage. He would also be less liable to blunder which is almost invariably the case with those who *begin before they are ready*.

I will now describe how to set out the trap and soil-pipes for a valve, or other W.C., which requires the trap to be beneath the flooring. This is an important problem, and I hope you will carefully study it, so that you may carry it out in practice, and thus avoid the censure that an architect has been known to lay on a plumber because of his want of this knowledge.

Before we can set out the lines it is necessary to know what is the shape and size of the place in which the W.C. is to be fixed. For our present purpose we will assume that it is to be fixed between two walls which are 4 ft. apart. With this data to work from, we draw two lines 4 ft. apart, and another line at right angles to them to represent the wall behind the apparatus. Where an architect has provided plans for the builder to work from, these plans should next be consulted as to the width of the wooden enclosure which is generally fixed to a W.C. The writer once had a severe scolding for neglecting this precaution, and which neglect necessitated an alteration being made to several traps after they were fixed. The traps were fixed at the ordinary distance from the back wall, but the architect for the work had his seats made 4 in. deeper from back to front than was usually done by other architects, hence the traps had to be removed 4 in. further towards the front. For a seat which measures 2 ft. from back to front, the trap should be fixed so that the centre is about 16 in. from the back wall. We will now go back to our lines which represent the side and back walls, and draw a line, which is equi-distant from the side walls. On this line measure 16 in. from the back wall. On the centre thus found describe a circle 4 in. in diameter, to represent the inlet end of the trap.

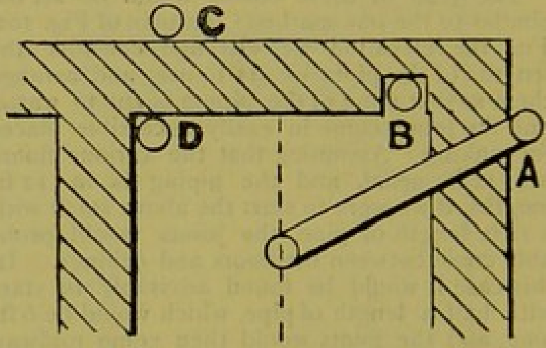


FIG 106

We will now assume that the soil-pipe is going to be fixed external to the wall of the W.C., as shown at A, Fig. 106. A circle should be drawn here to represent the soil-pipe. If the soil-pipe was to be fixed at B, C, or D, the circle should be drawn in one of those positions. The next thing is to accurately measure the distance between the two circles, representing the soil-pipe and trap. To avoid any possibility of a mistake, it is a good plan to get a piece of lath,

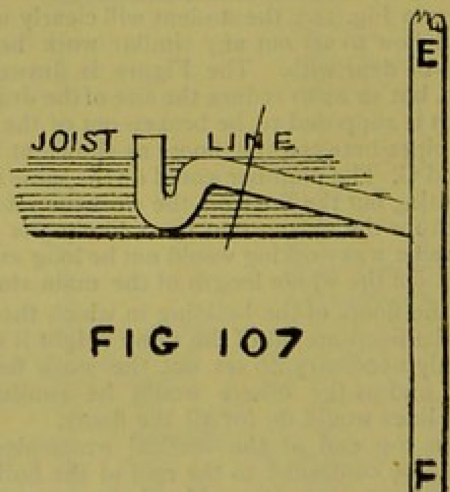


FIG 107

or narrow strip of wood, and cut it to the exact length of the distance between the two circles. This lath will afterwards be found useful when making the branch joint to the soil-pipe. We may now rub out the whole of the lines, as shown by Fig. 106 as being of no further use.

The next proceeding is to draw an elevation of the work to be executed, and we begin by drawing two parallel lines to represent the vertical soil-pipe, as shown from E to F, Fig. 107. With a 10 ft. rod measure from the last length of soil-pipe that was fixed, or from the drain if it is for the first length, to the joist line of the place in which the W.C. is to be fixed, and transfer this distance onto the lines E, F. The end of the rod should be placed ½ in. above F, to allow for this end to enter, or socket, into the length of pipe that was last fixed. Draw a line at right angles to E, F to represent the top of the floor joists, and on this line mark off the distance between the trap and the soil-pipe using for the purpose, the lath that was cut to that length. Measure 4 in. from the last point to represent the inlet, and draw the trap as shown in the figure. The under side of the floor joist should also be drawn so that the plumber can see how much fall he can give the branch soil-pipe without its showing through the ceiling below, presuming there is one. The branch soil-pipe can now be drawn, when the figure will be complete. The plumber can now proceed to open the hole in the vertical for the branch-pipe, the branch-pipe can be cut off the exact length, ½ in. being allowed onto the length for the outgo of the trap to socket into, and the whole of the work prepared for soldering before being fitted together. The whole of the necessary lines can be drawn in about a quarter of an hour, and if care is taken in the construction of the work it will fit its intended position much better than if put together by the rule of thumb process. I hope I have made myself quite clear in working out this problem, and that all students will make a practice of applying it in their daily work. If a range of W.C.'s is to be fixed on an upper floor of a building, the whole of the traps and soil-pipe can be prepared on the bench. In this case a full size plan of the closets should be first made on the bench or floor of the workshop. Let Fig. 108 represent a plan of a range of three W.C.'s. The traps are to be fixed beneath the floor, the horizontal soil-pipe to be inside the building and the vertical-pipe outside the walls as shown at G. If the plumber's bench is fixed near the wall of the workshop an elevation of the work can be drawn on the walls. Let the line X, Y represent the top of the bench, and the line U, V the floor line of the closets. The horizontal and vertical pipes, and the traps can be drawn as shown. The horizontal-pipe can then be bent at the end to meet the trap H, after which the pipe can be fixed on blocks close to the wall, and the branch-pipes for the other traps bent and fitted. After the whole of the work has been fitted together the joints on the traps can be made, and then the pipes can be removed to the centre of the bench and the branch joints wiped. It is a good plan to fit wooden plugs in the inlet ends of the traps, and then nail a stout strip of wood to them. This will help to support the traps and branch-pipes during the time the branch joints are being made, and also ensure the traps being kept the proper distance apart.

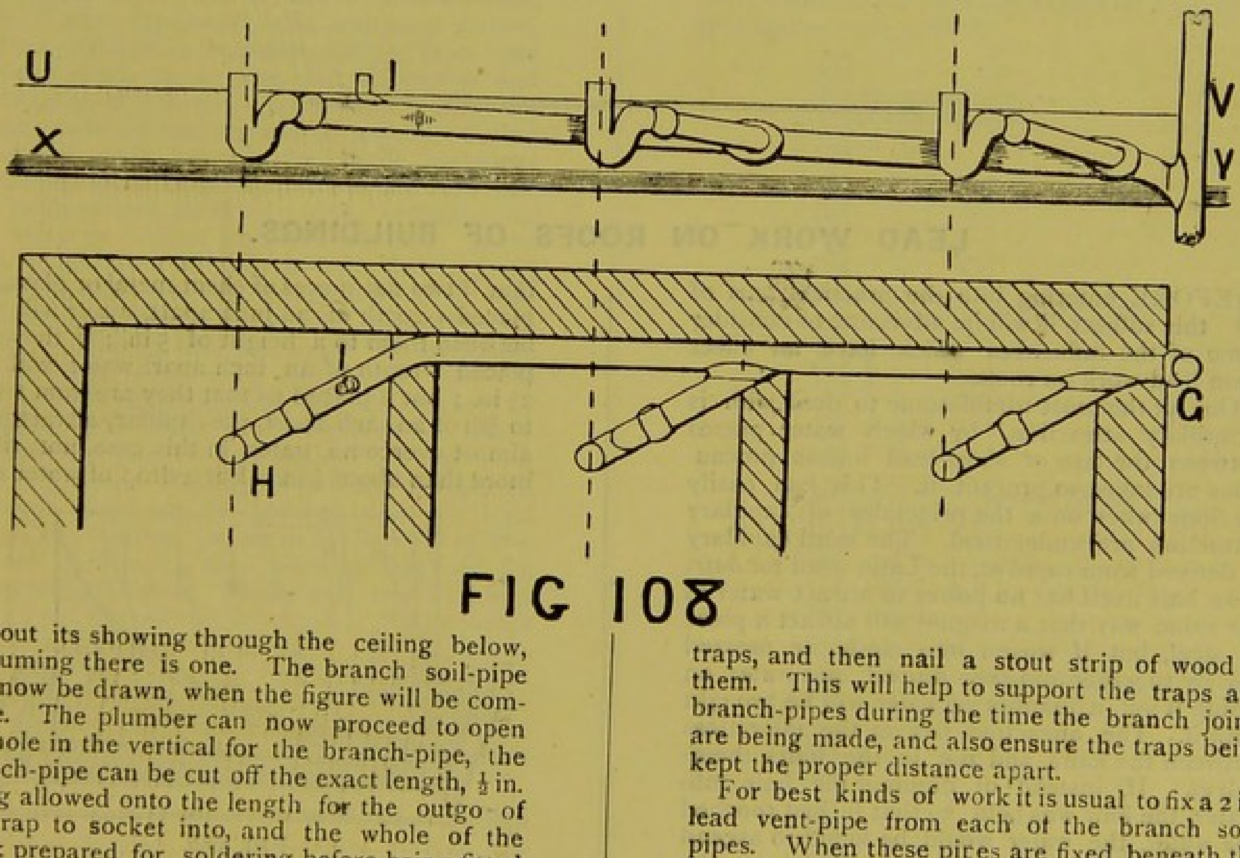


FIG 108

For best kinds of work it is usual to fix a 2 in. lead vent-pipe from each of the branch soil-pipes. When these pipes are fixed beneath the floor a short piece of 2 in. pipe should be soldered to each of the branch soil-pipes as shown at I, I, and then after the wooden flooring has been laid, this vent-pipe can be continued upwards, a flange joint being wiped on the floor. Where a lead safe is fixed and the vent-pipe passes through the safe, the flange joint would be wiped on the safe.

In some cases water closets are situated in irregular shaped positions, in which case it is necessary to set out the soil-pipes slightly different to the last problem that has been illustrated. Let Fig. 109 represent a case of this kind. If the centre of the trap was fixed on a line perpendicular to the back wall, and

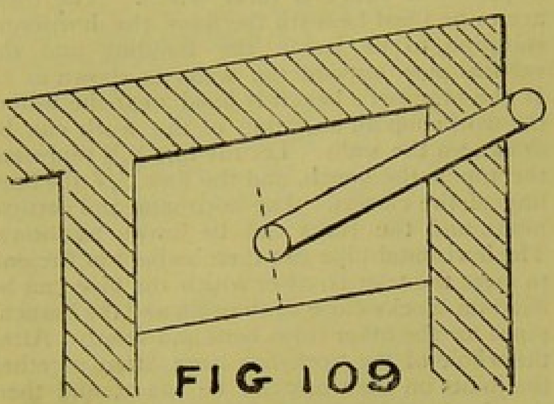


FIG 109

from a point which is equi-distant from the side walls, the W.C., when fixed, would appear to be out of the centre. And again the user of the place would have his knees touching one of the side walls if the place was a narrow one. In this problem the seat should be set out first, and a perpendicular line drawn from a central point from the front edge of the seat. If the seat is to be 2 ft. deep the centre of the trap will be about 8 in. from the front edge of the seat. With this centre a circle should be drawn to represent the trap. The soil-pipe can then be shown by another circle, and then the whole proceedings repeated as explained for Fig. 106.

If problems 102 to 109 are carefully studied the student can set out almost any kind of work that he may have to execute.

Illustrations of sinks, baths, and urinals could be given, but this would be unnecessary, as the same rules that have been laid down will apply to all cases. The above fittings will be dealt with at a future time from another point of view, that is, the sanitary aspect.

LEAD WORK ON ROOFS OF BUILDINGS.

BEFORE entering into the practical part of this subject, it will be advisable to consider some of the influences which have an effect upon lead work on roofs.

One of the most troublesome to deal with is "capillary attraction," by which water passes between the laps of sheet-lead unless precautions are taken to prevent it. This can easily be done when once the principles of capillary attraction are understood. The word capillary is derived from *capillus*, the Latin word for *hair*. Now hair itself has no power to attract water in the same way that a magnet will attract a piece of steel, but if woven into cloth, or pressed closely together and then dipped into water, on lifting it out, a quantity of water will be brought with it. The attraction lies in the interstices between the hairs, and not in the hairs themselves. If, instead of dipping the hair into water, the hair was held so that it just touched the water, the water would be found to ascend until the hair was saturated. This can be further illustrated by holding the end of a capillary tube (which is a tube with a bore about the size of a hair) in a vessel of water, when the water will be found to ascend in the tube to some height above that contained in the vessel. A very old illustration is given at Fig. 110, which represents a shallow vessel containing water and two pieces of common sheet-glass standing in it, the edges of the glasses being in contact as shown. The water, between the two pieces of glass, will be found to rise as shown by the curved line. It has been found by experiment that if two flat pieces of sheet-metal or glass, are placed 1-200th of an inch apart, water will rise between them to a height of 5 in.; if they are placed 1-100th of an inch apart water will rise 2½ in.; bnt if placed so that they are from 1-10th to ⅛th of an inch apart, the capillary attraction is almost overcome, water in this case not rising more than about ¼ in. Put a drop of water on a

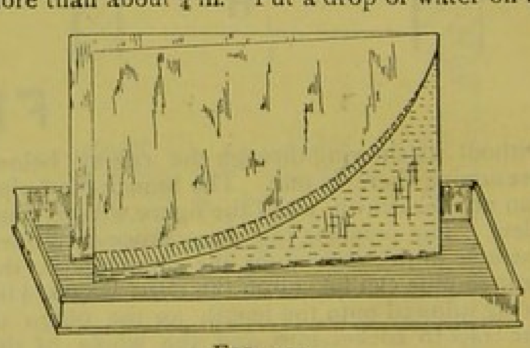


FIG. 110.

flat surface, and a lump of sugar would, so to speak, suck it up by capillary attraction. By the same force water is drawn up between the laps of glass in a skylight. Visit a slated roof immediately after a shower of rain, press upon one of the slates, and a quantity of water will be squeezed out that had been suspended between them by the same power. It is on record that the water has been emptied out of W.C. traps by capillary attraction. Innumerable examples could be given, but enough has been written to show the way in which this force acts. When we come to construction of lead roofs, we will consider the various ways that are practiced to prevent water passing between laps in lead.

We will now proceed to consider heat as a force that has a great influence on lead roofs. For our present purpose we will assume that all metals are at their greatest density when cold, and at their greatest bulk when heated to boiling points. Most of you, no doubt, have noticed that if molten lead is poured into an open mould that it shrinks as it cools, and that instead of the surface remaining quite even and smooth, as when in a fluid condition, that a depression is left at or near the centre position of the casting. Professor Perry, in his book "Practical Mechanics,"* makes the statement that on heating from freezing to boiling point lead expands ·0028 of its bulk. In another part of the above book Professor Perry states that lead expands ·00002818 of every dimension for one degree Fahrenheit. This being the case, a very little consideration will lead to the conclusion that, when lead is exposed, it is in continual motion, and may be said to be never still for more than a few seconds at a time, but expansion and contraction of the metal is continually going on. In one case I found a piece of sheet-lead that measured 12 ft. long in the shade measured 12 ft. ½ in. after being exposed for one hour to a hot summer sun, all things being arranged for the metal to expand without hindrance. If the ends of this piece of lead had been fastened, the whole of the expansion would have been concentrated on the centre part, causing it to buckle or rise up like an arch. To overcome this action it is necessary to have the pieces of lead as small as convenient, and the lappings or joinings would then act as expansion joints. Gutters and bays on flats should not be more than 7 ft. long. Nailing should not be resorted to more than can be avoided, and the lead should be "set up," so as to fit loosely in the desired positions, thus allowing freedom for expansion all round. Cover and step flashings should not exceed 6 ft. in length. Ridge pieces should not measure more than 7 ft. in length. Dormer cheeks, when very large, should be put on in two or more pieces. When dormer tops are very large, a roll should be put on to divide it into two pieces. When small, the lead has room to expand over the edges.

When lead is used for lining sinks, in which hot-water is used, the sides and ends of the woodwork should be made to slope similar to a common washing-tub, and hollow fillets placed in the angles. This has been done with good results where the water was boiled in the sinks by means of steam escaping from perforated pipes, but yet, in spite of the excessive heat, the lead expanded without buckling or breaking.

When lead is laid in gutters and on flat surfaces, a great deal depends on the way in which the woodwork is prepared. The boards should always be laid in the direction of the current; that is, they should have the grain of the wood laid in the same direction as any water that may fall upon the gutter or flat would flow, for reasons, firstly, to allow the lead to slide backwards and forwards, as it is affected by variations in temperature; secondly, the lead will last much longer if there are no ridges formed by the edges of the boards curling up, which edges invariably, sooner or later, show through the lead. This may be noticed after a shower of rain when these ridges, across a gutter or flat with a sluggish fall, prevent the water flowing away, causing pools to remain. The boards should not exceed 4½ in. in width. Nine inch boards are generally used, but they are much better if only half that width. When laying the boards they should be well nailed near the edges to the joists. Should the boards vary in thickness, and they generally do, the thickest should be planed down level with the others, so that the lead can be laid on a perfectly true and smooth surface.

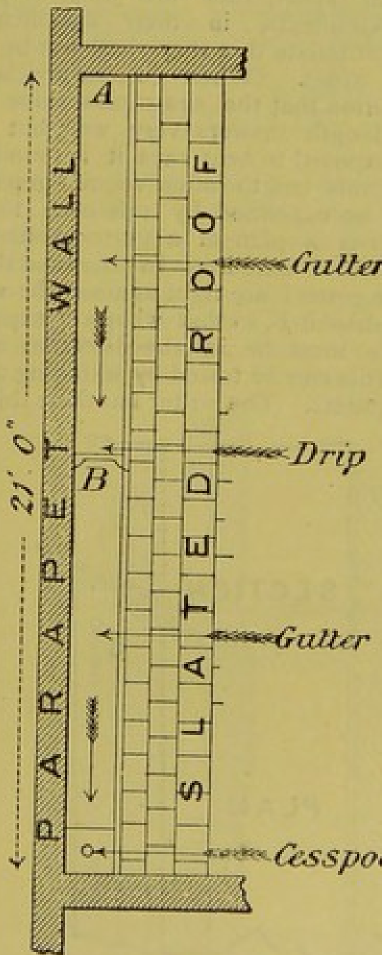


Fig. III.

The force of expansion and contraction of metals is almost irresistible, and in the case of lead on roofs, if it is fixed too rigidly it will either break away from its fastenings or itself be broken.

* Published by Cassell and Co.

One great cause of leakage in roofs is to be found where lead gutters are connected to each other by means of a step arrangement called a drip. This is a very convenient way for joining, or, more properly speaking, lapping the lead, so that no water will pass through at that point. In some cases a drip is saved, and the lead laid in long pieces. This applies principally to gutters. In other cases the gutters may be laid in short pieces and the ends soldered together, so that they are in one continuous piece. When gutters are laid in this manner they very soon

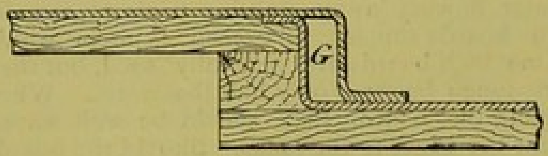


FIG. 112.

break by alternately expanding and contracting. Drips act as expansion joints, but if the drips are too far apart, they are only of partial utility. Architects, in their specifications, sometimes stipulate that they shall not be more than 10 ft. apart. When gutters are laid in such a position that the sun cannot shine upon them, this length answers very well, but when they are exposed to heat rays it is found that gutters of this length often require repairing. This may be explained by reference to Fig. 111, which is a plan of a gutter behind the parapet wall of a house. In this case the top end of the gutters are tight against the wall at A and the drip at B, so that whatever expansion takes place must be in the direction of the arrows. This can be tested by watching newly-laid lead gutters. The writer has done this, and

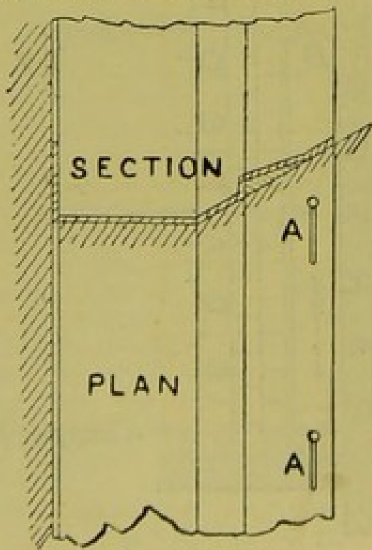


FIG. 113.

has found that a few weeks after laying some gutters (in which case the drips had been worked tightly down) he has found the overcloak ⅜ in. or ½ in. away from its original position, as shown at G, Fig. 112, which is a section through a drip of a gutter. This has not occurred all at one time, but has been the result of a series of movements, which may be compared to those of a snail or worm. The expansion has taken place downwards in the first instance; but the lead, on contracting, has not gone back to its original position, but has dragged the top end away from the wall or drip. In this way lead will "crawl" down the roof to a very serious extent. It may be noticed on stripping old roofs that where nails have been driven in to hold the lead down under the slates that these nails have cut long slits in the lead, as shown at A, A, Fig. 113, which is a fragment of a gutter, thus showing that nailing is not sufficient to counteract the forces which affect the lead when exposed to the sun, alternated with cold. All lead work should be laid and fastened in such a way that it is free to expand and contract. The first point that suggests itself is the smaller the pieces of lead the less expansion proportionately takes place, and the smaller the

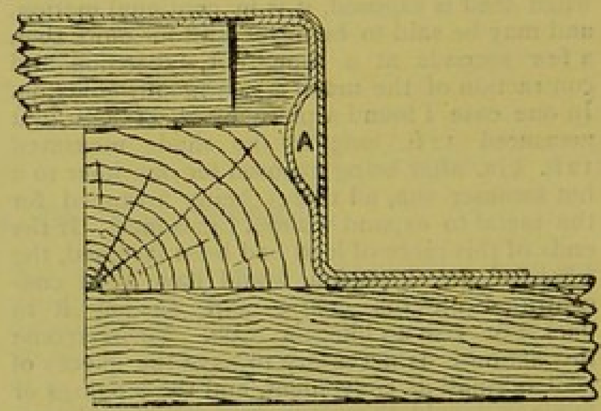


FIG. 114.

pieces of lead the more passings, laps, or drips will be required. For work on upright or steep pitched roofs, ordinary laps answer very well, but on flats or in gutters these laps would not do, as water would flow back between the sheets of lead, and so gain access into the building. The usual way of doing this part of the work is to make what is commonly called a drip, a section of which is shown at Fig. 114. In this case any water that flows back between the laps of the lead would have to rise vertically before it could pass through, and so get into the house. These drips, unless properly done, are a constant source of trouble, from the fact that usually they are not made deep enough. It is a common error to think 1 in. or 1½ in. drip is sufficient for the purpose, the item of capillary attraction being entirely lost sight of. The writer has found that a 2 in. drip is scarcely deep enough to counteract the evil complained of, and that in a great many cases a 2½ in. drip was only just sufficient to resist this action. It has been suggested that if the overcloak was cut off at the point A Fig. 114, that would be sufficient for the purpose; but no advantage whatever is gained by this, as any water passing that point would be drawn up between the lapping pieces.

As stated further back, a space of ⅛ in. to ¼ in. is sufficient to break the capillary attraction. This space can be made as illustrated at A, Fig. 114, where the end of the bottom gutter is shown as being chased into a sinking cut in the woodwork. The overcloak can be worked down in such a way as to leave an air space beyond which any water cannot rise. When covering the ridge roll of a roof with lead, the undercloak should be let into the wood roll the thickness of the lead and a water-groove cut in the wood roll into which the undercloak should be chased, care being taken not to bruise the overcloak or work it into the chasing. Fig. 115 is a longitudinal section of a lap of lead on a ridge roll showing the groove at B.

There are several positions on roof of buildings where these water-grooves are a necessity, but I think that we may now leave this matter as the illustrations given will enable you to apply the principle in any position that may arise in your work.

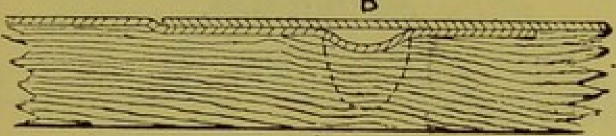


FIG. 115.

Fixing Flashing.

When a young plumber first "takes the tools," it is usual to give him the easiest kind of work to do. If working on the roof of a building he is generally put to fixing lead flushings. These are simply long strips of lead with one edge turned into the horizontal joints of the brick walls, the other portion of the lead hanging down over the turned up parts of the lead laid in gutters or on flats, &c., to prevent any water getting between the turned up parts and the walls. This work is very easy to do as no great skill is required in the manipulation of the lead, but, for all that, there is a certain amount of thought and care in fixing required, there being no more frequent causd of leaky roofs than defective flashings. One common cause of trouble is shown at C, Fig. 116, which is a section through a gutter, where it will be noticed that the turned-up part of the lead gutter stands above the edge of the joint in the brick wall. The result of this is, that when the turned in part of the flashing is wedged so as to fix the lead in the joint, the inner edge is lower than the outer. Thus, any water running down the face of the wall is caught on the projecting ledge and runs into the joint, in this case the flashing being of little or no use for its intended purpose. Another evil is shown at D, which represents the wedge, for fixing the flashing, driven in so far as to force the lead into the frog of the brick. The proper remedy is to have a portion of cement drawn over the lower brick as shown at E, and to have the stand-up part of the gutter cut down at least ¼ in. below the joint in the brickwork. It will readily be seen that when this is done any water caught at this point must of necessity run outwards and into the gutter. The old-fashioned way for fixing lead flashings was by means of iron wall hooks, but where lead and iron are in actual contact, in a wet condition,, a voltaic action is set up, and, although little or no harm is done to the lead, the head of the wall hook is soon rusted away so that it is perfectly useless. The most common way now practised, for fixing flashings is to drive in wooden wedges as shown at F, Fig. 116, but these are not to be trusted;

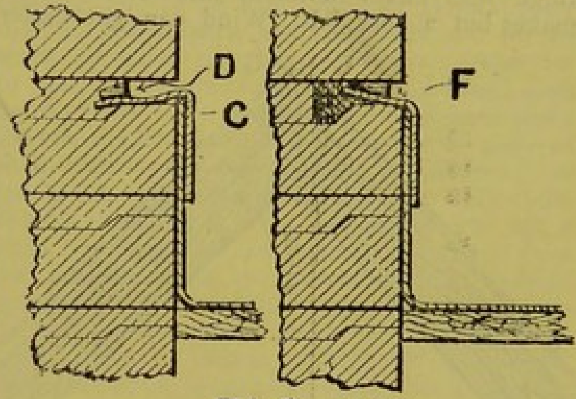


FIG 116

no matter how tightly they be driven in, they soon become loose. When wet they swell and on becoming dry they shrink and so lose their power of fixing the lead. Cast-lead wedges are the most trustworthy, as they are not liable to be affected by the above influences and in addition, when driven in, the driven end bulges outwards and fits into any irregularities in the

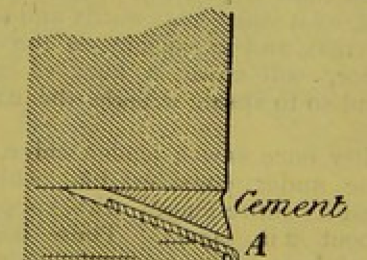


FIG. 117.

bricks. Flashings fixed to brickwork should always be pointed with cement, as being harder than lime mortar. Neither does cement shrink on setting. Mortar sometimes does this and leaves a space as shown at A, Fig. 117, into which water is drawn by capillary attraction.

Covering Ridges with Lead.

FIG. 118 is a section of a ridge of a slated roof showing an old method for fixing the lead. The lead is simply laid on and dressed down at the sides, aud then a couple of iron clout nails with large leaded heads driven in at the laps as shown in the figure. This way of fixing the ridge lead has now fallen into disuse as it makes but a poor job. Wind can get under

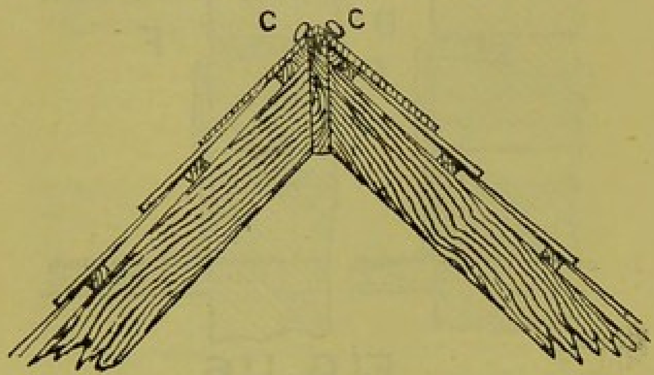


FIG. 118.

the edges of the lead and, when blowing very hard has been known to take the lead right off. The lead headed nails (C C) are perfectly useless for holding the lead in its position. Moisture in the atmosphere sets up a voltaic action between the iron nails and the lead head until the iron is rusted through and the head rolls down the roof into the gutter. Sometimes the nail will come out bodily. The movement of the lead, as it slides backwards and forwards by contraction and expansion on the wooden ridge piece, will cause a kind of shearing motion, and so to speak wriggle the nail right out.

The writer once saw a leaden ridge, similar to the one under consideration, which had been nailed its entire length with copper nails placed about 2 in. apart. These nails were nearly all of them drawn out, some having rolled

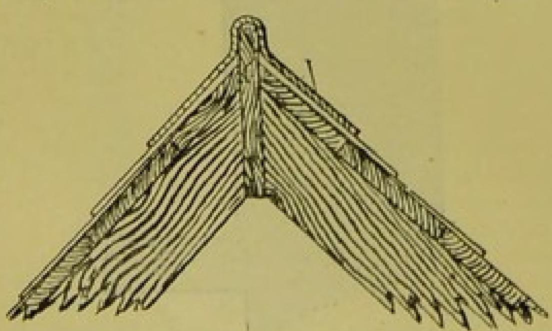


FIG. 119.

down the roof, the others were standing on their points and would soon have followed the others.

Where lead flashings have been nailed to wood work round dormers and skylights, this shearing motion has often caused the nails to come out as above described.

In some cases where large nails have been used for fixing the lead on ridges, a long slit has been cut in the lead similar to those described at A A, Fig. 113. In these cases the woodwork near the nail has become rotten by exposure to the elements.

Fig. 119 is a section of a ridge which is an improvement on the last one described, but there is little or no resistance to prevent the lead being blown off during a high wind.

Fig. 120 shows an improved way for finishing

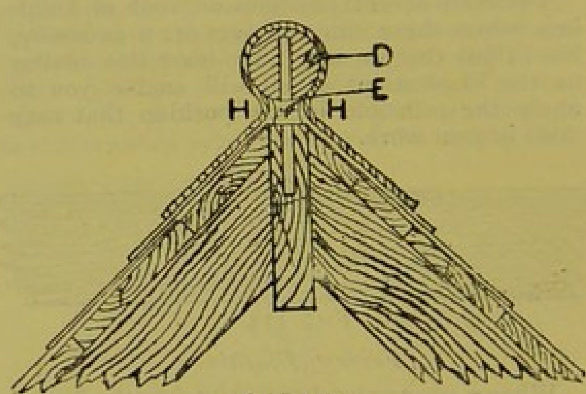


FIG. 120.

the apex of a roof. In this case a wooden ridge roll (D) is fixed to the ridge piece by means of a kind of double pointed iron nail, with a large head in the centre, called a roll-iron. This is shown at E. For covering these rolls the lead is first set up as shown by the fragmentary sketch, Fig. 121. The width of the base G to G being equal to the girth on the roll as

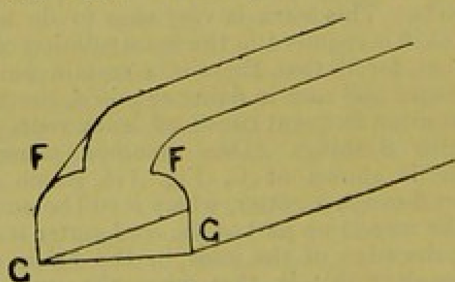


FIG. 121.

measured from H to H, Fig. 120, and the sides to stand up 6 in., this dimension being the usual allowance for lead to lay on the slates. The corners are generally curled inwards, as shown at F F, for the plumber to grip hold of. The piece of lead after being set up is carried to the ridge, and the plumber and his mate, one at each end, alternately "bash" the lead on the roll. This causes the lead to bend round the roll. The wings are then pressed down on to the slates at the sides causing the angles G G, Fig. 121, to clip round the roll as shown at H H, Fig. 120.

Fig. 122 shows another way, and which is more commonly practiced than the last one described, for fixing the ridge-roll on a roof. When properly done this forms a neat finish to a roof, and is at the same time a firm fixing for the lead. Before the wooden roll is nailed to the ridge piece, the necessary distances should be marked out and pieces of sheet-lead about 16 in. long by 3 in. wide nailed on to the ridge piece to form what are called "tacks." This is shown at I, Fig. 122. The wood roll

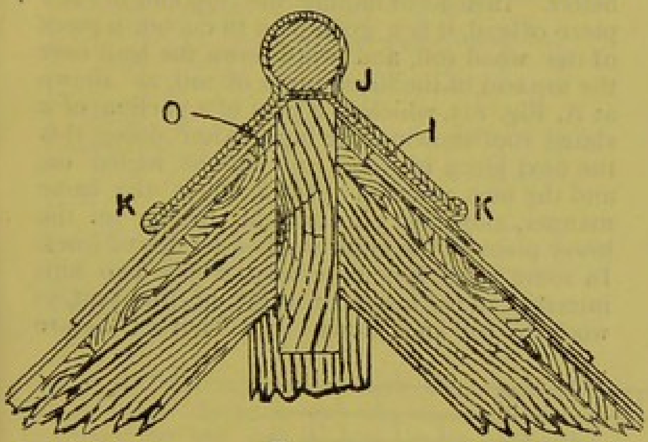


FIG. 122.

should then be nailed on to the ridge piece, the lead turned up and fitted as before described. After straightening the arrises at J, the wings should be dressed close to the slates, or tiles if used, the edges trimmed straight, and the tacks turned as shown at K K, Fig. 122. The tacks should be of lead a little thicker than that used for covering the ridge-roll and the ends turned as tightly as possible, an iron "plate" being held beneath the tacks to prevent injury to the slates when the tack is being turned. These tacks hold down the edges of the lead, and so prevent the wind getting beneath. At the same time the wings are held up so that the lead will firmly grip the wood roll as shown at J, and yet not interfere with the expansion and contraction of the metal.

The plumber should always be consulted by the carpenter before he nails on the ridge roll, as it so frequently happens that it is done in a bungling way. This can be better explained by a sketch, see Fig. 123.

In the first place, the roll is too low down When, in framing the roof, the ridge piece is too low, a wooden fillet should be nailed on for the roll to stand upon. If this is not done, the slates will sometimes finish half-way up the roll as shown at L, so that when the lead is put on it presents the appearance as shown by Fig. 119. When the roll has been fixed too low, the slates have sometimes been left too short at the top. The result being that an ugly-looking bump is made at M, and also a source of weakness at the laps, as rain-water can run back along the channel formed in the lead, and so get into the roof. Another evil is shown at M. The top edge of the heading course of slates is left hollow, so that when putting on the lead it presses the top edge of the slate downwards, and causes the bottom edge to kick out, as shown at N. This is a frequent cause of complaint, as the slates so fixed nearly always get broken. Some slaters, to avoid this, will bed the top edge of the heading course of slates in lime and hair mortar, but it is a much better plan to nail on a small wooden fillet, as shown at O, Fig. 123. If some such precaution is not taken, great numbers of slates get broken, and the plumber gets blamed for it, whereas the censure should be laid onto the general foreman far not properly arranging this part of the work. A good plumber is always careful not to make any more tool marks on his lead than he can help. He will not use a dresser more than he can avoid, but will prefer a small piece of sheet-lead, commonly called a "flapper," to straighten out the piece he is going to work upon. When "setting in" the arrises, he will use a good hornbeam dresser, as it is softer, and does not bruise the lead so much as one made of boxwood. Neither will he have the edge of his dresser too sharp, so that it will cut the lead in the arrises. When a ridge-roll is covered with lead not a single tool mark should be seen anywhere excepting at the extremities, near the walls or intersections, with the hips, which of necessity must be worked to fit those positions.

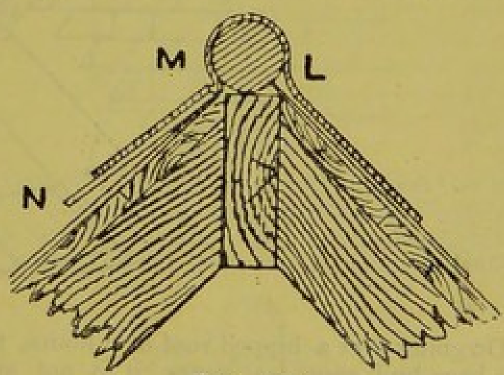


FIG. 123.

When dressing the lead wings close to the slates or tiles, an iron plate should be held beneath the lead, so that it may be left straight. It is not necessary, and detracts from the appearance of the work if the lead is dressed into every little irregularity that may occur in the parts that are to be covered. When covering the ridge roll of a roof, it is not a good plan to work up the end piece of lead sufficient to turn into the joints of the brickwork. Doing this fixes the piece of lead too rigidly, with the result that it soon breaks away from its fastenings, or perhaps pulls away from the wall just far enough for water to get in when it is raining. Where the chimnies or gable ends of a house have been rendered over with cement, the motion of the lead, as it increases by expansion or shrinks by contraction, has very often pulled away a large piece of the cement work, and thus left an opening for wet to get into the roof. In addition to the above objection, it takes some time to work out the end to get sufficient lead for turning into the joints of the brick wall. Time is saved, and a better job made, if the end of the ridge lead is turned up about 2 in., as shown by dotted lines, Fig. 124, and a capping piece put on, as shown at A. About ½ in. can be worked on the bottom edge of the capping piece to fit over the roll and wings of the ridge. The corner of the stand up part of the ridge can be folded over the edge of the capping, and thus form a tack, as shown at B. I do not propose to enter now into the question of ornamental leadwork on ridges, as the matter is too large to be briefly dealt with. Some architects make a feature of ridging, and elaborate their designs by ornamental lead cresting, in some cases made of hardened cast-lead, and in others made by hand out of sheet-lead. We will now proceed from the ridge down the roof, and describe the hips. These are usually covered with lead in the same manner as was described for the ridging, and shown at Fig. 122.

extent of 1-1000th part of an inch in one day, in 1,000 days it would have crawled down to the extent of 1 in. So that if the nails were driven in 1 in. from the top end the lead would have broken away from the nailing in about three years, after which it would slide downwards very quickly, and leave a space at the top end, through which rain could pass into the roof. To overcome this difficulty it is necessary the lead should be put on in short pieces, not exceeding 7 ft. in length. A shorter length is better. Instead of nailing the top end of each piece of lead, it is a good plan to cut out a piece of the wood roll, and work down the lead over the top end of the fixed piece of roll, as shown at A, Fig. 125, which is a plan of a portion of a slated roof showing one hip. After doing this the next piece of wood roll can be nailed on, and the next piece of lead fixed in the same manner, allowing 5 in. or 6 in. to lap on the lower piece to the point marked by dotted lines. In some cases it is necessary, where two hips intersect at the apex, or ridge of the roof, to work the roll ends down on a "horse" before

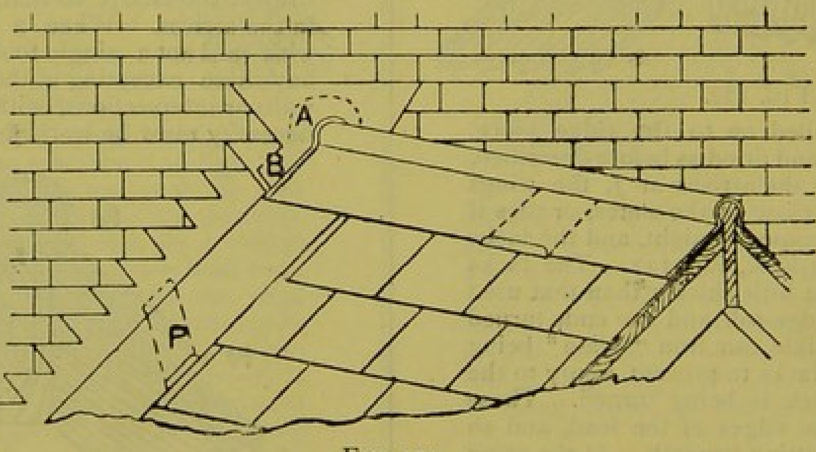


FIG. 124.

On going over a hipped roof of a house, that has been built some few years, it is not at all unusual to find the lead with which the hip rolls are covered has slipped, or "crawled" down. It used to be the practice to fix the lead by means of lead-headed nails, but these fail to hold the lead in its position. The general practice is to nail the lead near the top edge to the wooden roll. But these nails do not always prevent the lead slipping down. Mention has been made of the fact that metals in exposed situations are in constant motion arising from the expansion and contraction that takes place with every change of temperature. In the case of lead hips the expansion takes place downwards, partly by reason of the top end being fixed, so that it cannot expand upwards, and partly by the weight of the lead dragging from the fixed end. On contracting, the weight of the lead and friction between the lead and the wood roll, prevents the lead being pulled back to its original position. Supposing that this downward motion of the lead took place to the

fixing. As the hip rolls are mitred at the junction, it is impossible to work both roll ends down in their position. One can be so worked, but the other must be done, as suggested, on a horse before fixing. A glance at B, Fig. 125, may help to make this more clearly understood. Hip rolls are generally made 2 in. in diameter, thus requiring the lead to be cut out 19 in. wide, that is, 6 in. for the roll, 6 in. on each side, to lay on the slates, and ½ in. allowance on each edge for trimming to a straight line, also to turn as a tack at the lapping, and thus prevent any loose corners which would flap about during a high wind. Lead tacks should be fixed about 3 ft. apart, and in the same manner as described for the ridging.

Care should be taken that the tacks are fixed at right angles to the hip roll, and not parallel with the longitudinal joints or lappings of the slates, otherwise the tacks act as conveyors of water, that may run down the slates, up to the hip, where it can pass beneath the slates into the roof.

In some cases the hip rolls of roofs have been covered with hip soakers. After the first course of slates, commonly called the under-eaves, has been fixed by the slater, the plumber

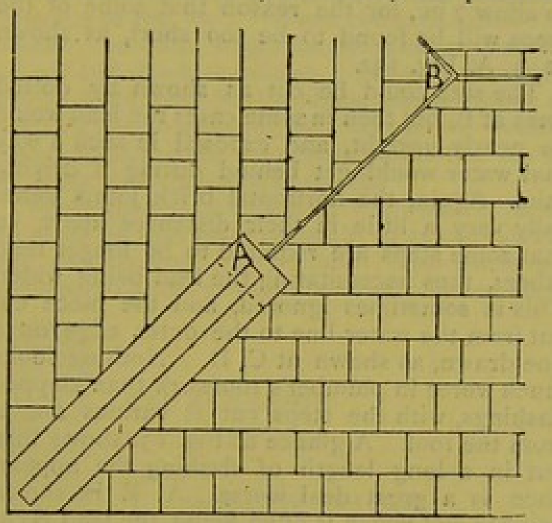


FIG. 125.

covers the wooden hip roll with a piece of lead for a short distance up, this distance being governed by the size of the slates, allowing sufficient lead to lay on the slates for a distance of 6 in. on each side of the roll. The next course

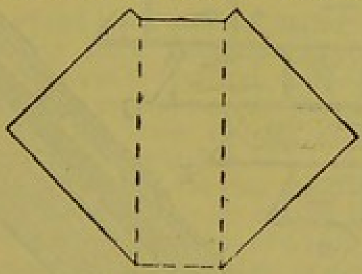


FIG. 126.

of slates is then fixed over the lead, and the edges cut to fit close to the hip roll. The shape of the pieces of lead is as shown by Fig. 126 When laid in their position they have the appearance as shown by dotted lines for the three bottom courses, and firm lines for the top course, in Fig. 127. None of the lead is seen

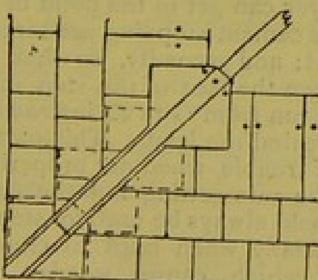


FIG. 127.

when the work is completed, excepting the part that covers the roll. In some cases the wood roll is omitted, and the slates cut up so as to meet at the hip, lead soakers being placed one to each course of slates. These soakers are cut to the shape, shown by Fig. 128, but this shape is

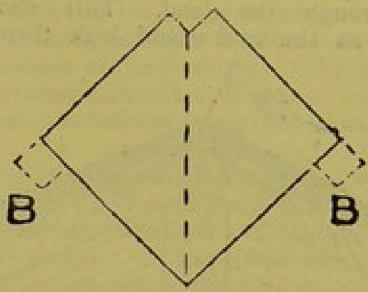


FIG 128.

varied, according to the pitch of the roof. The dotted lines, Figs. 126 and 128, show the creasing, or where to be bent to suit their positions.

If the lead soakers are intended to show on the face of the slates, instead of being fixed on

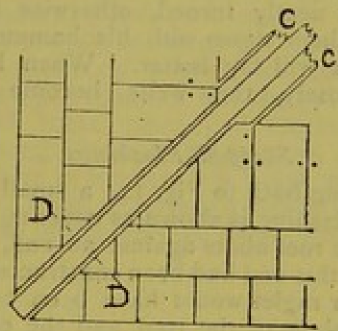


FIG. 129.

the face of the lower slate, and beneath the one immediately next above it, they require to be cut out a little larger, and it is a good plan to leave two lugs, as shown at B, B, Fig. 128, for folding

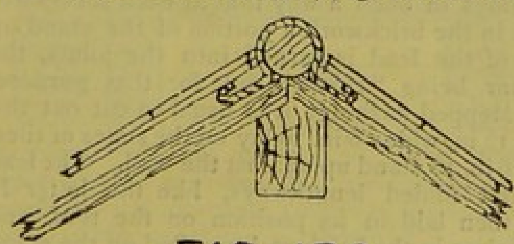


FIG 130

under as secret tacks, and so clip under the slates, to keep the wind from flapping the lead about. Secret hips are sometimes fixed to slated roofs. There are two ways of doing these; one with a wooden roll and the other without any roll. Fig. 129 is a plan of a fraction of a hipped roof, showing the slates, wood roll, and the secret hip, with welted edges, as shown at C, C. Fig. 130, which is a section on the line D, D, Fig. 129, is drawn to make this construction clear.

Fig. 131 is a fragmental section of a hip, showing a secret hip covering. In this case the lead is not seen, the slates being cut up so as to meet. It is not necessary for the lead to be more than about 2 in. or 2½ in. wide on each side of the hip. If the lead is put on wider than this the slater would probably drive his slate nails through the lead. This should be avoided, as the lead would leak through the

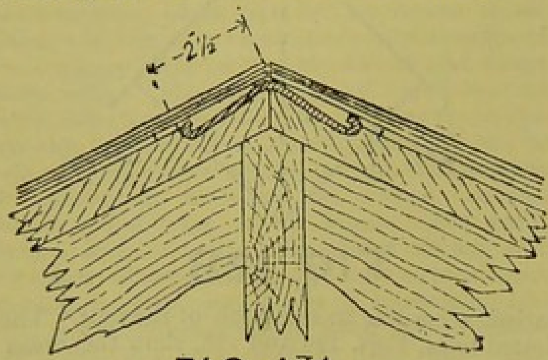


FIG 131

perforations made by the nails. The welts, too, should be neatly turned, otherwise the slater will beat them down with his hammer, so that his slates will lay better. When hammered down closely, the welts become perfectly useless.

Stopped Flashings.

Referring back to Fig. 124 a small portion of stepped flashing is shown as covering the point where the roof abuts against an end, or gable, wall. If this end had been constructed of stone, a chase or raglet would have been cut parallel with the slope of the roof, and the edge of the flashing turned in as described for cover flashings. But, in the case of brickwork, a chase would be difficult to cut in the bricks, and there would be some difficulty in making a neat-looking job. For this reason it is usual to cut the flashings in such a way that at each successive joint in the brickwork a portion of the stand up part of the lead is turned into the joints, the mortar being "raked" out for that purpose. For stepped flashings it is usual to cut out the lead 12 in. wide; 6 in. to lay on the slates or tiles, and 6 in. to stand up against the wall. The lead is first folded lengthways, like the letter L, and then laid in its position on the roof, and the joints in the brickwork marked on the stand up part. A line is also drawn on the lead about 2½ in. above and parallel with the roof. This is called the "water line," and marks the extent or length of the steps.

About 1 in. or 1¼ in. above the horizontal lines, which represent the joints in the brickwork, other lines are drawn; the pieces of lead between these parallel lines are afterwards folded for turning into the joints of the brickwork. Other lines are drawn from those representing the brick joints, where they cut the water line, to those immediately above on the outer or top edge of the lead. The small triangular pieces of lead are cut out, and the pieces between the parallel horizontal lines folded as before described, and wedged into the joints of brickwork as shown by Fig. 124.

I have said it is usual to have 6 in. of lead to stand up against the wall, but it is much better to allow 7 in., for the reason that some of the steps will be found to be too short, as shown at A, A, Fig. 132.

The step could be cut as shown by dotted lines at B, but then in some cases the lead would be nearly upright, and exposed in such a way that water would get behind during a driving rain. Again, the horizontal brick joints generally vary a little in their distances apart, so that some steps are required to be longer than others, thus necessitating the lead being wider. This is sometimes ignored, and the piece cut out from the water-line to the outer edge on a line drawn, as shown at C, D. Nothing looks much worse in plumber's roofwork than stepped flashings, with the steps cut at various angles from the roof. A glance at Fig. 132 shows this, but in a long length of flashing the appearance is a great deal worse. At E is shown another evil which is often found, the lead is cut further than necessary with the knife. Sometimes this cut opens and leaves a small gap through which water can pass. The end of the turned in part of the step at F should be driven well into the wall and the part at G should be

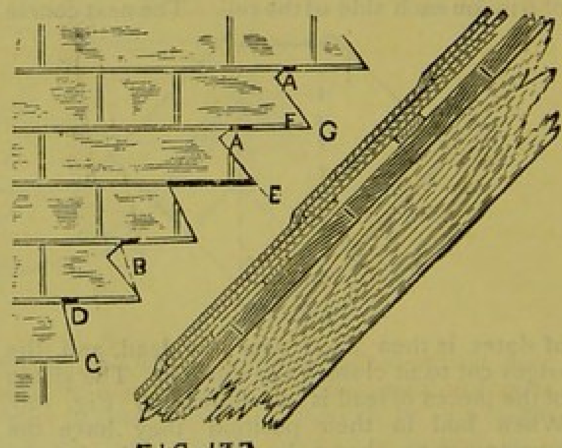


FIG. 132

pushed outwards by the point of a chisel. This should be done for two reasons; first, so that the bricklayer can get in the point of his trowel to force the cement stopping well into the joint at this point; and secondly, so that any water running down the face of the step immediately over would run from G to E, instead of into the wall and behind the lead. This part is always a source of trouble, when not properly done, by reason of the rain getting into the roof. Lead wedges should always be used for step flashings, more especially when fixed to chimneys, the heat from which causes wooden wedges to shrink and fall out. At P, Fig. 124, is shown, by dotted lines, the proper way to fix the tacks for holding down the outer edges of the flashings that lay on the slates. These tacks are generally fixed at right angles from the wall and parallel with the longitudinal joints, or laps, of the slates. Any water that may be running down the roof and get under the lead flashing would be diverted by a tack, so fixed, and conducted inwards to the wall. When the tack is fixed as shown, the water would be induced to run outwards and down the slates. The tack should be firmly fixed, with lead wedges, into a groove or joint in the brickwork, and not, as is usually done, nailed to the woodwork under the slates, or hung onto the edge of a slate.

When turning the tack, care should be taken to place an iron plate beneath, so as not to run the risk of breaking a slate. The slates are generally hollow at these positions by reason of

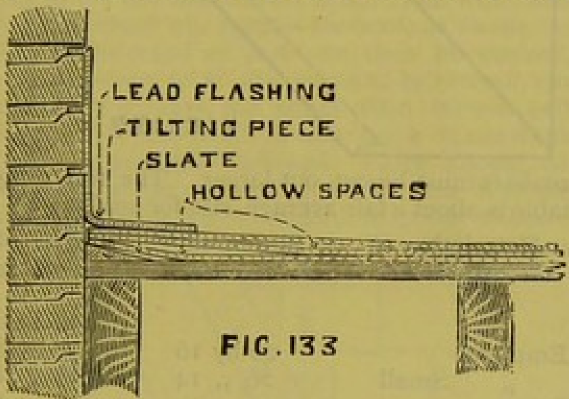


FIG. 133

a feather-edged piece of wood, called a springing or tilting piece, being placed under the edges of the slates to tilt them, and so cause any water that may get beneath the flashings to run out again in the same manner as described when speaking of the tacks.

Fig. 133 is a section showing the tilting piece, slates, and lead flashings as usually fixed near the gable end, or a chimney, of a roof, and the hollow spaces beneath the slate caused by the tilting piece.

A much better way, than fixing stepped flashings for making the junction of a roof with an end wall weather-tight, is to make what is

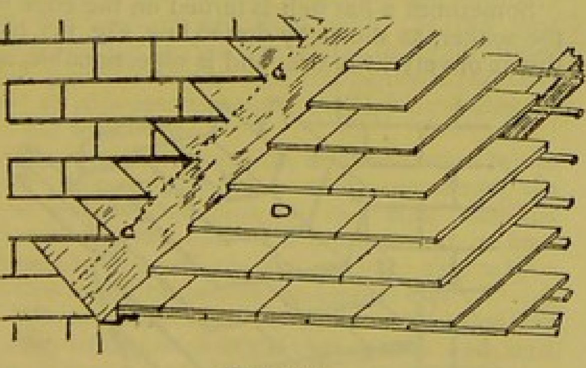


FIG. 134.

generally known as a secret gutter. This is shown by Fig. 134. In this case the lead should be cut out 14 in. wide, that is, 8 in. to stand up against the wall, 2 in. for the sole of the gutter 1 in. for the springing and 3 in. for the turnover and hollow welt. The reason for having 8 in. to stand up against the wall is to get the water line of the steps, shown by dotted lines between C, C, above the face of the slates or tiles. If only 6 in. stand up was allowed this line would be level with the slates, or perhaps lower than the tiles if used, and thus allow water to get behind the steps of the flashing. This evil would be aggravated if the tiles were cut tight up to the flashing instead of being kept 2 in. clear of the wall.

Fig. 135 is a section of a secret gutter fixed next to a brick gable wall. A is the sole, B the springing over which the lead is folded and C the hollow welt. Some architects have the tiling, or slating, kept about 1½ in. clear of the wall, as shown by Figs. 134 and 135, so that should anything fall into A to cause an obstruction it can readily be removed. Other architects prefer to have the tiling cut tight up to the wall so that nothing can get into the secret gutter to form an impediment to the free escape of any water that may get in. Both ways have their advantages. Sometimes, when plain tiles are used and bedded in mortar, pieces will fall in and entirely choke up the gutter and so render it perfectly useless for its purpose. When the open space is left the gutter can be cleared of these pieces of mortar. When tiles are hung dry onto the battens, instead of being bedded in mortar, it is usual to bed the slips, or half-tiles necessary to break the lap, as there is no other way of fixing them. Some

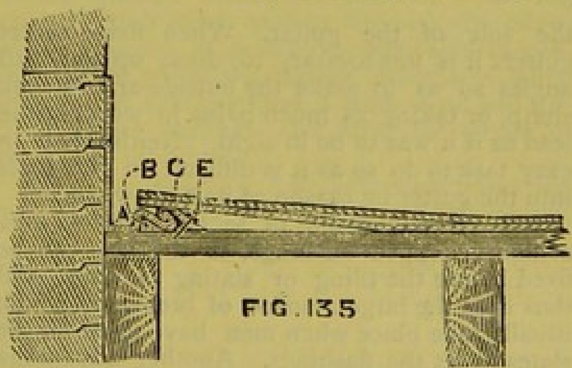


FIG. 135

architects will not allow slips to be used but specify what is known as a tile-and-a-half to be used at each alternate course at the ends of the roof. One of these is shown at D, Fig. 134. These large tiles save a great deal of cutting, and the accompanying waste of material, and they also extend beyond the welt of the secret gutter so that two out of the three nibs, which they generally have, will hang on the wooden batten for support. For this reason the secret gutter should not be made wider than really necessary. Not more than 2 in. should be lapped over the springing, and an extra inch allowed for the hollow welt. This welt, as its name implies, should be hollow as, if it was dressed down flat, it would not offer any resistance to water escaping over it. Care should be taken not to nail through the lead anywhere inside the welt. For fastening down the edge of the lead a lead clip can be hooked round the edge of the hollow welt and a nail driven in as shown at E, Fig. 135. Slaters generally have a dislike for secret gutters when made as shown by the above Fig. The slates cannot be made to lay so closely as they desire, and very often they will hammer down the hollow welt until it is quite flat when it ceases to be of much use as a barrier for rain-water to pass. Some slaters, too, are careless how they fix the slates, and will drive nails through the lead inside the hollow welt. When these nails get loose, which they invariably do after a time an opening is made for water to leak through the nail hole in the lead.

Another way of making secret gutters is shown in section Fig. 136. In this cass the roof boards are cut 1½ in. or 2 in. short as shown at F, and the top face of the jack rafter forms

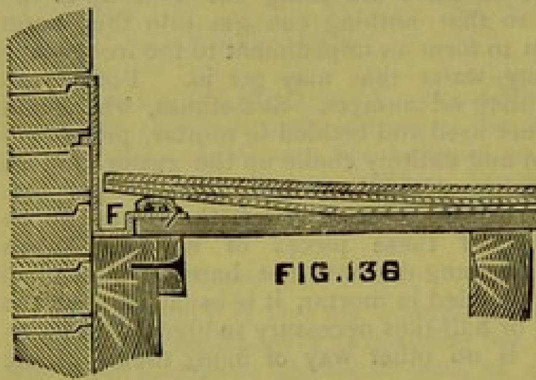


FIG. 136

the sole of the gutter. When fixing secret gutters it is unnecessary to dress up the lead angles so as to make the outside arrises look sharp, or taking as much pains in working the lead as if it was to be in sight. Neither is it an easy task to do so as it is difficult to get tools into the gutter by reason of its narrowness.

A great advantage of secret gutters, over ordinary stepped flashings, is the lead can be fixed before the tiling or slating is done, and thus save the large amount of breakages which usually take place when men have to sit on the slates to fix the flashings. Another advantage is, rain cannot drive beneath the edges of the tiling or slating as the end wall forms a shield or protection.

On Soakers.

Another way, practiced by plumbers, of making good a pitched, or sloping, tiled or slated roof to an end wall or gable, is to fix what is commonly called "soakers." These consist of pieces of 4 lb. sheet-lead (or sometimes 5 lb. is used), cut out and folded, as shown by Fig. 137. The sizes are governed by the sizes of the slates or tiles, whichever are used. Plain tiles are generally about 11 in. long by 6 in. wide. When the tiles are laid with a 3 in. lap, the soakers should be cut 7 in. long, and 1 in. left on, as shown at A, for turning down over the end of the tile, as a preventive against the soaker slipping down. The width of the soaker should be the same as the tile, that is, 6 in., 3 in. to stand up and 3 in. on the flat, and bent, as shown by the figure. For slated work the

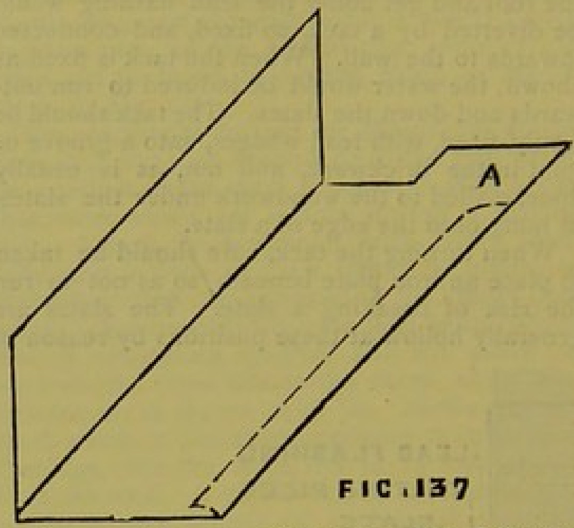


FIG. 137

soakers must be cut out larger. The following table is about a fair average size for soakers—

Description of slate.	Size of slates in inches.	Size of soakers in inches.
Empress	26 by 16	15½ by 8
" Small	26 " 14	15½ " 8
Princess	24 " 14	14½ " 8
Duchess	24 " 12	14½ " 7
Marchioness	22 " 12	13½ " 7
" Small	22 " 11	13½ " 7
Countess	20 " 10	12½ " 7
Viscountess	18 " 10	11½ " 7
Ladies	16 " 10	10½ " 7
" Small	14 " 8	9½ " 7
Doubles	13 " 10	9 " 7
"	13 " 7	9 " 7
Small	12 " 8	8½ " 7
"	12 " 6	8½ " 6

The above table of sizes for soakers is calculated on the basis of 3 in. lap at head of slates, and 1 in. allowance for nailing beyond the slate.

Sometimes a flat welt is turned on the edge of the soaker, as shown by dotted line, Fig. 137, but this is of very little use and is objectionable, as

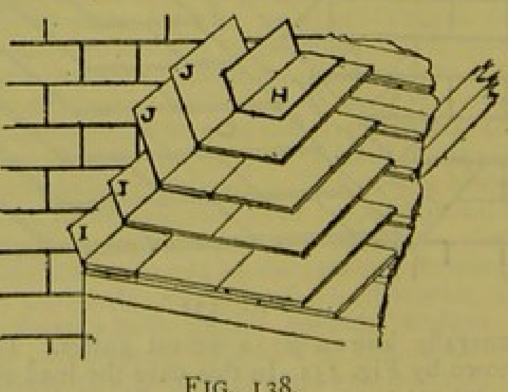


FIG. 138.

it causes the slate to lay hollow at that point. Fig. 138 is a small perspective sketch, showing how the soakers and tiles, or slates, are fixed.

At H is shown the last soaker that was fixed ready for the next course of tiles. The only part of a soaker that is seen, when the tiles are fixed, is the stand up part against the wall. Sometimes a chalk line is struck parallel with the slope of the roof, and the points I, I cut off. A strip of lead 6 in. wide, for a cover flashing, is next cut out and placed in position; and the joints of the brickwork marked upon it, after which the steps are cut and turned, and wedged to the wall in the usual way. The bottom edge of the cover flashing should be pushed down so that the corners of the tiles will hold it from flapping about during a high wind.

It takes longer to do, but it makes a better job to cut out the soakers about 11 in. wide, and let 7 in. stand up against the wall, as shown at J, J. The stand up part can then be marked, and the steps, to fit the joints of brickwork, cut out of the soakers, the edges then turned and wedged to the wall in the same manner as ordinary stepped flashings. Pains should be taken to, as far as possible, let the turn-in of the lower soakers be continued a good distance

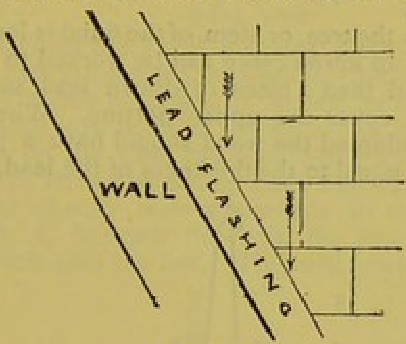


FIG. 139.

behind those immediately next above. By doing this there are fewer places left, as shown at G and E, Fig. 132, for water to get in and behind the lead-work

Secret gutters or soakers should always be used when the end wall is at an acute angle with the ridge of the roof. When ordinary stepped flashings are fixed with the flat part laying on the top of the slates, all rain water falling near that part will run beneath the lead and so pass into the roof, the flashing being of no use whatever.

Fig. 139 illustrates this, and the arrows represent the way that water streaming down the roof would pass beneath the lead flashing. Sometimes the end of a pitched-roof is constructed, as shown on plan at Fig. 140, with a gutter at the bottom of the hipped end.

Where soakers are used to make good the slating of the sides of the roof to the end wall, the gutter at the end can be made to discharge onto the slates at the sides. In cases where large quantities of water would be collected in the end gutter it is much better to make provision for taking away the water by continuing the gutter down the sloping sides of the roof. A special construction is necessary for this side gutter, which is shown on the plan as running from the gutter next the parapet wall up to the hips. The way this gutter is usually arranged is shown by the section, Fig. 141. A wooden

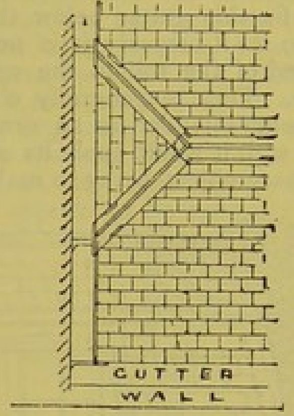


FIG. 140.

roll is nailed on the roof at the same distance from the wall as the width of the outlet end of the end gutter. The lead is then fixed as shown in the figure, the side next the wall being stepped into the joints of the brickwork, the other side being turned over the wood roll, and a welt turned as described for secret gutters. The roll prevents the water that passes down from spreading over the slates. The roll should stand above the face of the finished slating to prevent a driving rain, or high wind, getting beneath the edges of the slates. It is always advisable to protect the edges of the slating, especially when in exposed situations, as a high wind will frequently get beneath and strip the whole of the slates off a roof.

Referring again to Fig. 141, sometimes the lead is laid over the slating. This is not

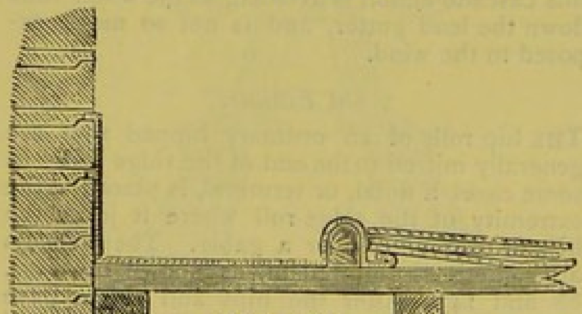


FIG. 141

so good as the other method described, for the reason that wind can get beneath the exposed edge of the lead. Neither is the lead so well fixed, the only protection against its slipping down being the wedging to the wall on the stepped side, and two or three nails driven in at the top end.

In the case of a hipped end to a Mansard roof, as shown by Fig. 142, it is not always necessary to fix a gutter on the lower portion of the roof when a projecting nosing, sometimes called a "Torus roll," is fixed, as any water coming over this roll will drip straight down into the gutter below.

It has been found necessary in some exposed positions to fix this gutter below the curb or Torus, but to do it properly it is necessary to cut off the end of the roll to the width of the gutter above. This is generally objected to; the Torus being intended as an ornament any interference with it would spoil its appearance. But the primary object being to make the roof

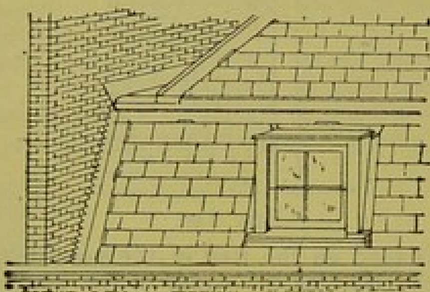


FIG. 142.

weathertight, appearances have sometimes to give way to necessity. The writer has had great trouble in making roofs, similar to Fig. 142, weatherproof. They have been proof against the severest downfall of rain, but high winds will sometimes drive falling rain about in directions never thought of. In one case, similar to Fig. 142, water was running out of a gutter, and over a curb roll with a kind of cascade action. The wind caught this water and dashed it against the dormer, and other places near, where it got beneath the slates and lead work and into the house, where it showed through the plaster work in the attics. When the lower gutter is properly fixed and arranged, this cascade action is avoided, as the water runs down the lead gutter, and is not so much exposed to the wind.

On Finials.

THE hip rolls of an ordinary hipped roof are generally mitred to the end of the ridge roll. In some cases a finial, or terminal, is placed at the extremity of the ridge-roll where it joins the hips or terminates over a gable. These finials are sometimes quite plain, as shown by Figs. 88 and 143. After the hips and ridge have been covered with lead in the ordinary way, and with the ends of the lead worked so as to stand up 2 in. or 3 in. against the base of the finial, which is generally of wood, a circular piece of lead is cut out to the required dimensions, placed in its position, and worked down in such a way as to entirely cover the wood block and the ends of the ridge and hips lead. This is a first-class way of doing the work, but great care must be taken when working the lead. Some men will do a great deal to the piece of lead in the workshop on a horse, and this is a good plan, as the man can walk round it and also be able to hold a dummy, or a large mallet, on the underside, to prevent the lead getting into creases or buckles when bossing down the outside. Care must be taken when working down the lead not to contract it, and so make it thicker than it was at starting, which will make it harder to work and more difficult to remove the tool marks on completion. Another reason for working the lead so as not to thicken it, is, that some parts get thicker than others, with the result that, when working on those thick parts, the thin places will keep stretching, until at last a hole is made, and this sometimes occurs a few inches away from the part being worked upon. If the lead is worked in its position, or partly done before placing it there, and pains not taken to prevent it, a round disc of lead will be cut out of the top by allowing the whole weight of the lead to rest upon the top of the tree of the finial. The top of the tree should have all sharp arisses pared off, and it is a good plan to place a piece of softening between it and the lead, which could afterwards be removed, before it is worked tight home, by lifting off the piece of lead for that purpose.

When the tree, or stem, of the finial is long and slender, an apron piece can be worked to fit the base, and then a piece of drawn lead soil-pipe used to cover the upper portion. When this way is adopted the wood should have a portion cut out, equal to the thickness of the lead, where

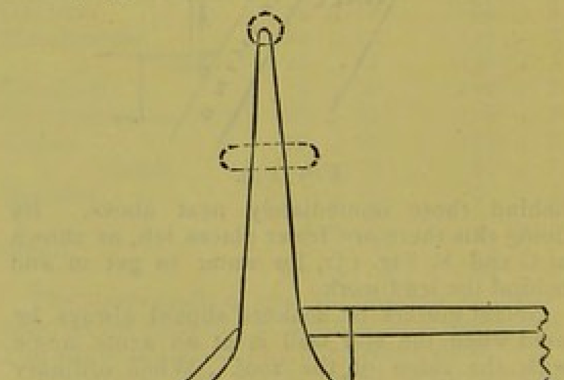


FIG. 143

the end of the pipe laps over the apron piece. This will avoid an ugly looking bump which would otherwise occur at the lap. In some cases finials, similar to the one under discussion have had a small ball fixed on the top end and a larger one lower down, as shown by the dotted lines, Fig. 143. Some I had to cover a few years ago had the balls cut away and separate pieces of wood turned with holes through them to fit the trees. These loose balls were separately covered with lead and the holes lined with pieces of pipe and then dropped on their positions. It is necessary to line the holes through the balls, otherwise wet would get in and rot the woodwork.

Where the finials are dwarfed in height and made thick, so as to look bold, it is a good

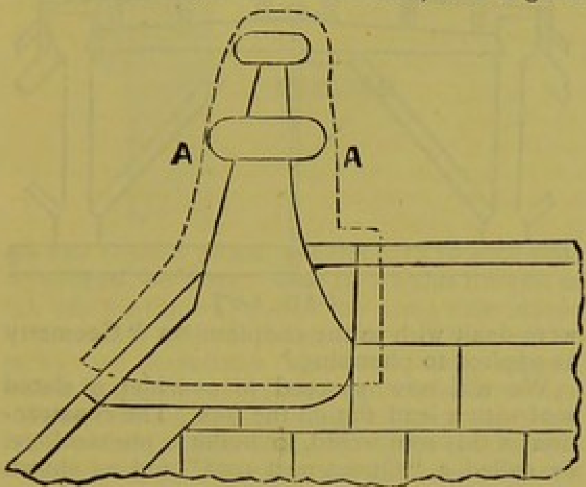


FIG 144

plan to cover the whole with one piece of lead. Great care is required in working the lead for a finial of this kind, and it is best to boss the lead partly into shape in the workshop, and then drop it on the tree, the lead being worked to the shape shown by dotted lines Fig. 144. The plumber should then commence to work the parts A, A, beneath the ball, the top portion being left until the last. This will prevent the

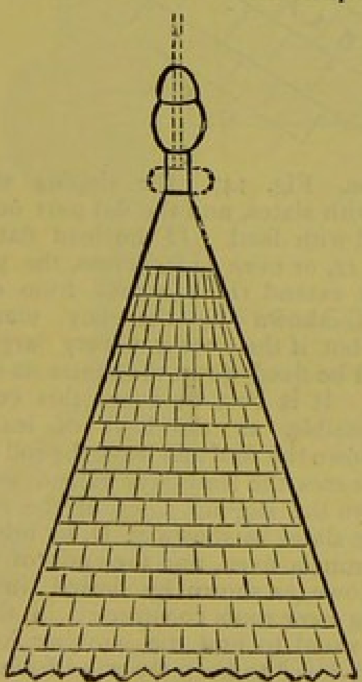


FIG. 145

lead being dragged into holes, or the piece on the top being cut out by the weight of the lead resting on the tree.

The tops of turrets generally have an ornamental finish to them—indeed they look ugly and unfinished unless an ornament is fixed on the apex. As an example, let Fig. 77 represent the elevation of a round turret, or spire, covered with tiles. The tiles for this purpose should be specially made, as each course would require to be smaller than the one immediately below it. But it would be impossible to make the apex, or extreme point, weathertight, unless a capping-tile was fixed, and this capping-tile would require to be a very large one, and should extend some considerable distance down so as to lap over the plain tiles, and then again this capping-tile would require to be specially made to fit the turret and necessitate moulds for making it

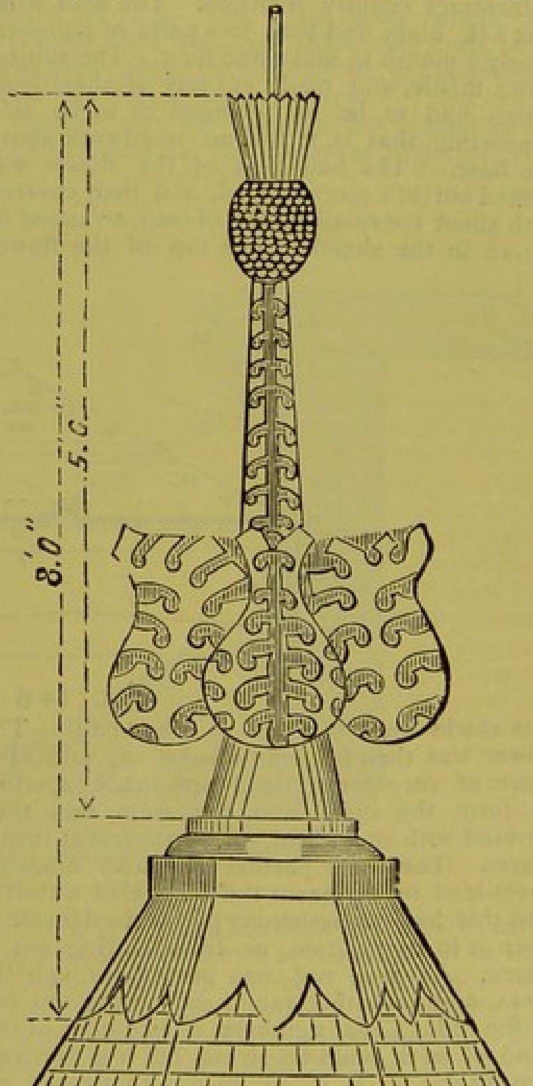


FIG. 146

in. But lead being easily worked to almost any shape by a skilful plumber, it is usual to cover the top end of a finial with that material. Any small ornament would considerably improve the appearance of Fig. 77, as may be noticed by referring to Fig. 145. In this case an acorn or other shaped figure could be turned out of a piece of wood, fixed as shown, and covered with lead. If a weather-vane is to be fixed, a plain block could be covered with lead to form a base, as shown by dotted lines, and the vane would then form an ornamental finish to the turret.

Some architects will make a special feature of a turret. A great many are made for ornament only, or to relieve the monotony of a large expanse of building or roofing, but in some cases a bell may be hung, or a clock fixed, in the lower portion. But when they are fixed for ornament, the finish at the apex is generally elaborated. Fig. 146 is a rough sketch of one the writer made some few years ago from the design of a celebrated architect, who made a special feature of the whole of the lead work on the roof of a nobleman's country mansion. The lead work was 8 ft. high, and took two pairs of plumbers nearly a month to make and fix it. The subject was a thistle, and made entirely of sheet-lead, which had to be so arranged as to be self supporting, that is, it had no woodwork above the base. The ball part of the flower was bossed out of a piece of lead, and then covered with about 100 small pieces of lead, arranged as shown in the sketch. The top of the flower was made and soldered to the ball. The flower was then soldered on the top end of a piece of very strong lead-pipe made tapering, to form the stem, and the stem was then covered with sheet-lead, cut to represent thistle leaves. The lower portion was also made of sheet-lead to represent the foliage of a thistle, and this had strengthening pieces fixed inside to keep it in its position, or from getting out of shape. An iron rod was passed through the stem, and a weather-vane fixed on the top end of the rod. Great numbers of examples of this kind of work could be given, but it is unnecessary to do so. It is very rarely that cases are repeated in practice, as every architect will make his own designs, and these designs require special treatment, which in some cases call for a great amount of ingenuity on the part of the plumber, and, it may be added, that most plumbers delight in having work given them to execute which calls forth their utmost skill. It is not at all unusual to hear plumbers, in their conversations, boastingly speak (with pardonable pride) of the methods they have employed to get over certain difficulties, and of the nice appearance certain works have presented when completed.

On referring back to previous lectures, I find that it will be unnecessary to say anything about lead domes or finials, as the leading points were dealt with in the chapters on "Geometry as applied to plumbing."

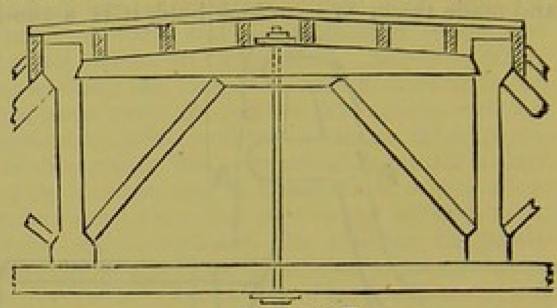


FIG. 147

We will now proceed to consider a slated roof with a lead flat on the top. The construction of this roof would, in builders phraseology, be called a "Queen-post roof," and as shown by section, Fig. 147, the sloping sides are covered with slates, and the flat part on the top is covered with lead. If the lead flat is only about 10, 12, or even 14 ft. across, the pieces of lead may extend right across from eaves to eaves, as shown by the bay marked A, Fig. 148, but if the roof is a very large one a roll would be fixed down the centre as shown in the Fig. It is best to avoid this centre-roll where possible, as the bays of lead often "crawl" down the roof and leave the roll exposed. In some cases the lead bays extend some distance down the sloping sides of the roof, and lay on the slates as shown at D, in other cases a lead apron is fixed, and the ends of the bays dressed down, as shown by dotted lines at E. In looking over roofs constructed in this manner it is usual to find the plumber has made "soldered dots," to keep the wind from blowing up the ends of the bays. This may be considered a very unwise proceeding, as soldered dots never answer the purpose for which they were intended. The expansion and contraction of the lead invariably causes a breakage round the dots. It is a much better plan to omit the

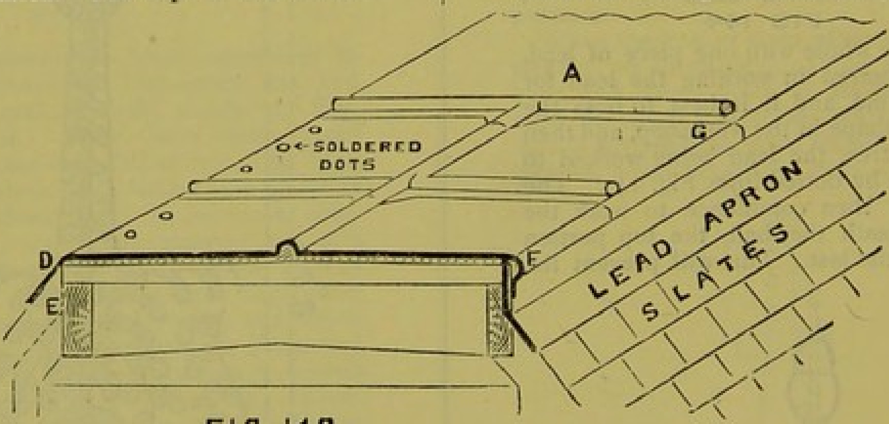


FIG. 148

dots and fix "bale" or secret tacks, as shown by sketch section, Fig. 149, which shows the end of

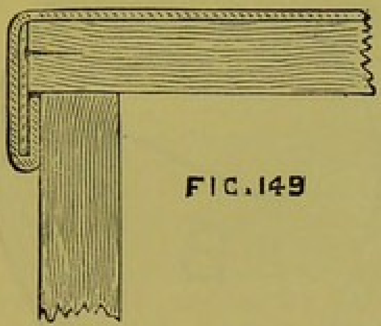


FIG. 149

the bay clipped round, a secret tack being nailed on to thewood work. This tack holds the end of the bay lead down, and at the same time allows it to expand without hindrance. These secret tacks are sometimes made of sheet copper, which is a stiffer metal and can be used of less substance than lead and thus make neater work by avoiding bumps where the tacks are fixed—another way of arranging the dripping eave of a lead flat is to fix a wood nosing, as shown at F, Fig. 148, round which the ends of the bays are worked and left so that the wind cannot get under the edges of the lead. The wooden nosing is sometimes covered with lead before the bays are laid, but more often the lead apron is nailed on first, next the nosing, and the ends of the bays are then worked round it. When done this way the water will get through the laps a

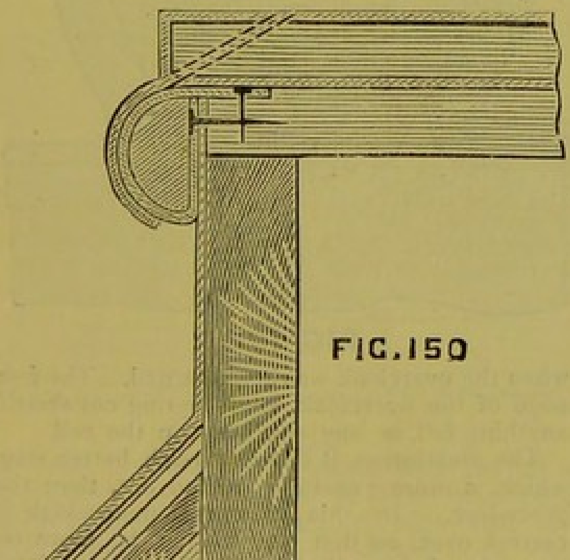


FIG. 150

the ends of the rolls near the nosing, and it is necessary to work a water groove in the undercloak, as described when writing on capillary attraction and illustrated by Fig. 115. In some cases this nosing has been covered, and the apron flashing formed with one piece of lead, in others two pieces of lead have been nailed on as aprons, the wood nosing then fixed, and the top piece of lead folded round it and nailed on the flat, as shown in section, Fig. 150. This is considered to be the best method for constructing this portion of the work.

Referring back to Fig. 148, at G is shown the roll end cut short of the nosing. This should never be done, as the few inches between the roll end and the nosing lays quite flat, and water can pass between the laps of the lead at that point. The writer has seen great numbers of roll ends cut as described, and the woodwork beneath quite rotten from the wet that has got in between the laps. The roll end should always be continued as far as possible, as shown by Fig. 150. In cases where the architect does not wish these roll ends to be seen from below, they should be cut sloping, as shown by dotted lines, Fig. 150.

Another way for covering the nosing at the edge of a lead flat is shown at Fig. 151. The

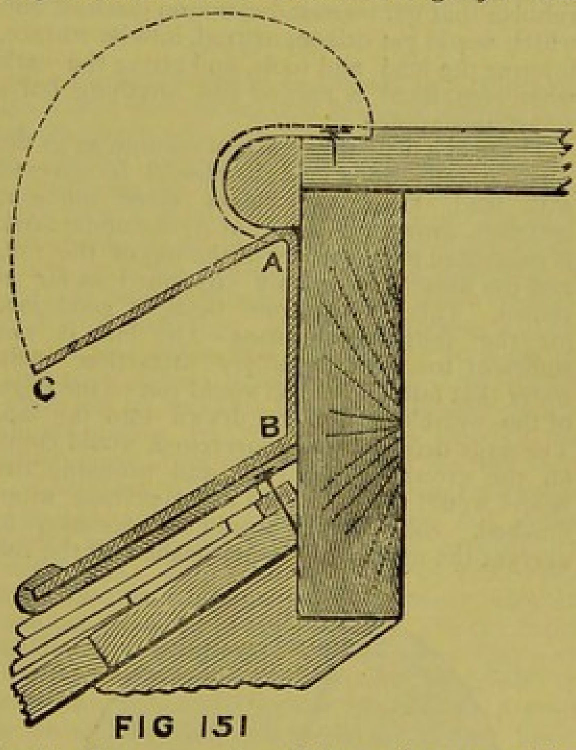
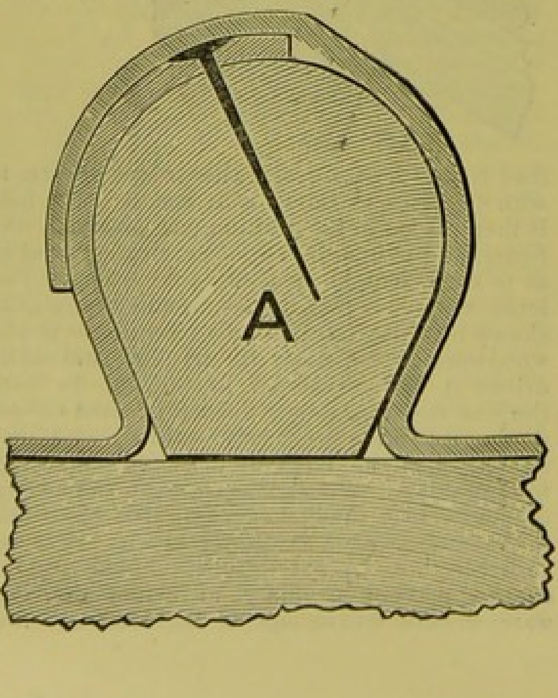


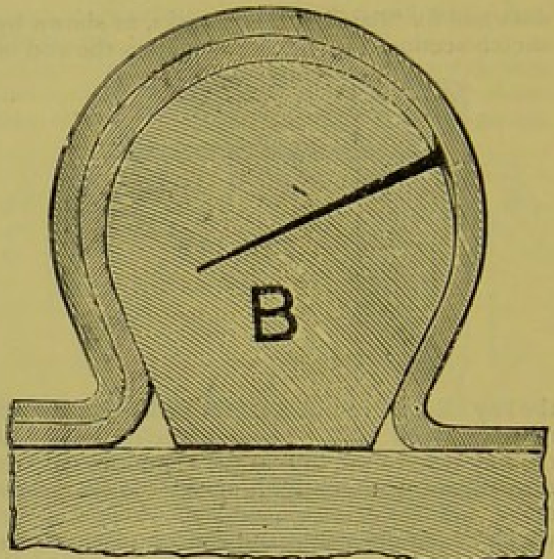
FIG 151

lead is first creased, and the arrises are set in with a dresser, as shown at A and B. The lead is then placed in its position, as shown in the figure, and temporary wooden struts placed so as to keep A tight up under the nosing. The loose edge C is then folded round the roll, as shown by dotted lines, into a rebate cut in the woodwork at the edge of the flat, and nails driven it at intervals of about 6 in., to hold the lead down, so that it will not become hollow on the roll, and so become bruised and disfigured when the ends of the bays are being worked down. Where laps come on the nosing the undercloak should be let into the woodwork in the same manner, as shown at Fig. 115 in an earlier lecture. A water groove should also be cut to prevent capillary attraction drawing water in between the laps of the lead. If the plumber is careful to "fold" the lead round the wood nosing, instead of dressing it round, the lead would be free from tool marks, and thus present a smart appearance. To fold the lead as described, it is a good plan for the plumber and his mate to kneel on the wooden platform, above his work, and place a piece of smooth board, the length of the lead, beneath the part C, Fig. 151, and pull it towards them. If this is carefully done, the dresser need not be used at all, excepting to dress the edge of the lead into the rebate. These remarks apply when turning the overcloaks of rolls on the lead flat. Nothing annoys a good plumber more than seeing a lot of bruises and useless tool marks on the rolls, when he is laying a lead flat, or to see anyone scratch them by walking on them with nailed boots.

The mate, too, should always have a soft broom, and sweep away all grit and pieces of rubbish that get scattered about on the lead and which would get driven, or trod, into its surface, injuring the lead and tools, and giving the work when completed a ragged and anything but a smart appearance.

There is a little difference of opinion as to the way the rolls on a lead flat should be covered with lead. Fig. 152 shows three different methods, drawn full size. At A, the undercloak is continued to the centre of the top of the roll, and the overcloak is only continued as far as shown. This is far from being a good job, for the following reasons—The lap is not sufficient to resist capillary attraction. Any water that falls on the roll would run to the edge of the overcloak and be drawn into the lap. The nails driven into the overcloak would come on the crown of the roll, and probably the heads would show through the overcloak when finished. Extra nailing would be necessary to prevent the undercloak being pushed off the roll





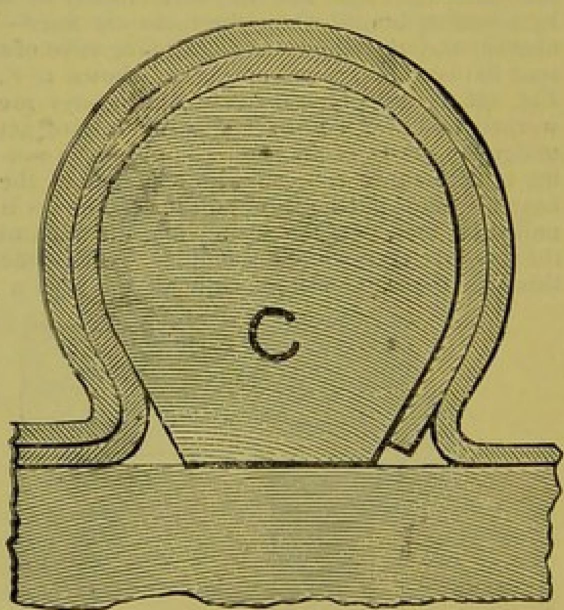


FIG 152

when the overcloak was being turned. The free edge of the overcloak would spring out should anything fall, or any one step, on the roll.

The illustration B shows a much better way, which is more generally carried out, than the preceding. In this case the undercloak is carried over, so that the nailing is more on the side of the roll, and further away from any moisture which would cause the heads to rust and become useless. The edge of the lead undercloak could be rasped or shaved to a feather edge. The overcloak is carried round the roll, and lays about 1 in. to 1½ in. on the flat of the next bay. This stiffens the edge of the overcloak, and offers a greater resistance to its opening out by traffic over the flat, or by the movement caused by the contraction and expansion of the metal. The illustration C shows the undercloak turned right round the wood roll, and is copied from the drawings of an architect, under whom the writer has worked, who always supplies drawings of all details of plumbers' work. In this case it is not necessary to nail the undercloak, and thus the lead is free to move by atmospherical influences.

Wood rolls for ridges and hips are usually made circular, in section, with a slightly flattened base, but for a lead flat these rolls would look dumpy, and where small ones of 1½ in. in diameter are used, the lead could not be tucked under the sides, so as to offer a resistance to be torn up. In practice, the roll shown at B, Fig. 152, is found to answer very well, and to have a good appearance when finished.

Plumbers vary very much in their methods of working down the roll-ends of a lead flat. The usual practice is to turn the overcloak and "set it in" tight, and then place a temporary wooden strut to keep the part that lays on the flat tight up to the roll, near the end. A hand-dummy is then held beneath the part that projects beyond the roll, and the lead worked down by means of a small hand-mallet. When working the roll-end down the lead is contracted, and generally gathers into a thick hard mass which gets full of tool marks, entailing a considerable amount of labour to afterwards get them out. Another way, and which may be considered better, is to set in the overcloak to within 6 in. or 8 in. of the

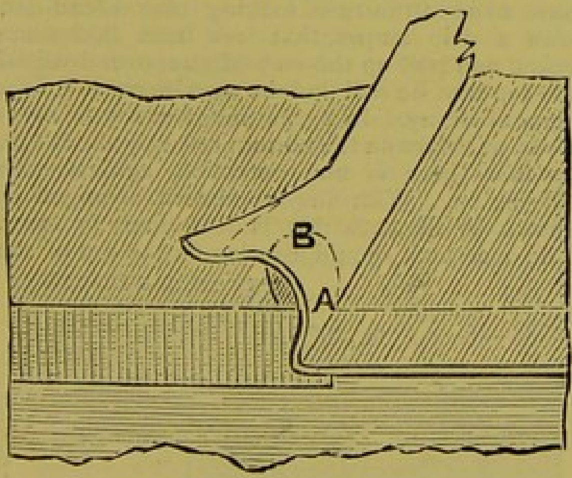


FIG 153

roll-end, then pull up the corner and cut off a piece about 1½ in to 2 in. wide at the outer edge up to nothing at the marginal edge near the drip of the flat, as shown by dotted lines, Fig. 153. Then with a small smooth-faced mallet commence at A and work the lead sideways towards the left until the lead creases round that side of the roll-end; then commence at B, to work that part in the same manner as if a corner was being bossed down. By working the lead this way the superfluity is worked out sideways, very few tool marks are left, not nearly so much labour is required, and the lead retains an even thickness. Several plumbers I know work this way, and undertake to boss a roll-end down, finish it off, turn and trim the tack under three minutes. The roll-end when finished presenting the appearance as shown by Fig. 154. Some plumbers will have a very hard smooth-faced box-dresser, or failing that tool, will take a polished-faced hammer, to finish the

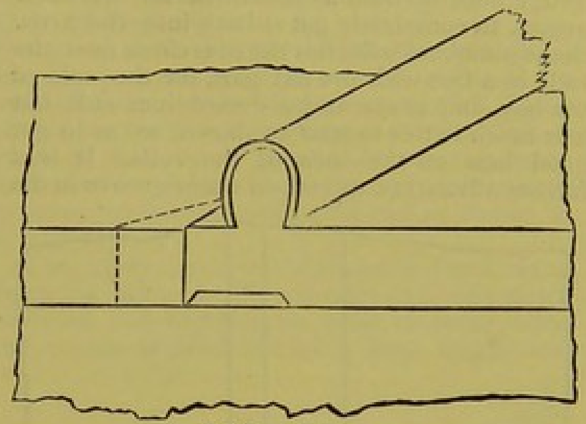


FIG 154

roll-end—will make it as smooth as a piece of glass, and afterwards, by a few gentle taps, take off the sharp arris round the roll-end and leave it slightly bevelled. The tack is shown as turned over the overcloak, but some plumbers will turn a secret tack, that is, turn the tack backwards so as to clip under the undercloak. Some plumbers, instead of cutting off the piece of lead, as described before working down the roll-end, will leave it on, which gives them a great deal more trouble, and afterwards trim it off as shown by dotted lines, Fig. 154. This corner when left on, answers no good purpose and is objectionable by reason of its offering an obstruction to water flowing down the lead bay.

The cross rolls shown on the two nearest bays, Fig. 148, require care in working, but in the hands of a skilful plumber they present no difficulties. The principal point to remember is to use the chase-wedge in a proper manner and not in such a way as to reduce the thickness of the lead in the arris. Instead of dragging or stretching the lead it should be driven in from the outer edges A, B, C, Fig. 155. A steel or sheet iron-plate, as shown by dotted lines, being placed so as to prevent the under lead being bruised; the chase-wedge held, as shown by the arrow, against the edge of the lead overcloak at A, and driven by good strokes with a medium sized mallet. This will thicken the edge of the lead and cause a buckle to rise in the angle between the rolls. This buckle can be gently worked down with a narrow and thick edged chase-wedge and then the outer edge again driven in, repeating these operations until the lead is tight home. A piece of board should be placed on the top of the rolls forming the angle A, for the plumber to kneel upon, and then the angle B worked home in the same manner as the other one described. The piece of board should then be shifted round for the workman to kneel upon and keep the lead from being dragged out of the corners that have been finished until the third one has been worked home. This last corner, shown at C, is not one-half the trouble of the others, and can be folded and driven down by the mallet until it is more than half-way home when the chase-wedge must be used as described for the other angles, to completely get it back into the arris. Some plumbers will trim the overcloak over the rolls in a line with the flat part, on the sole of the bay, and as shown by dotted lines at E, but it is much better to trim as shown so as to get good laps on the tops of the rolls. It is a further advantage to make a water-groove in the

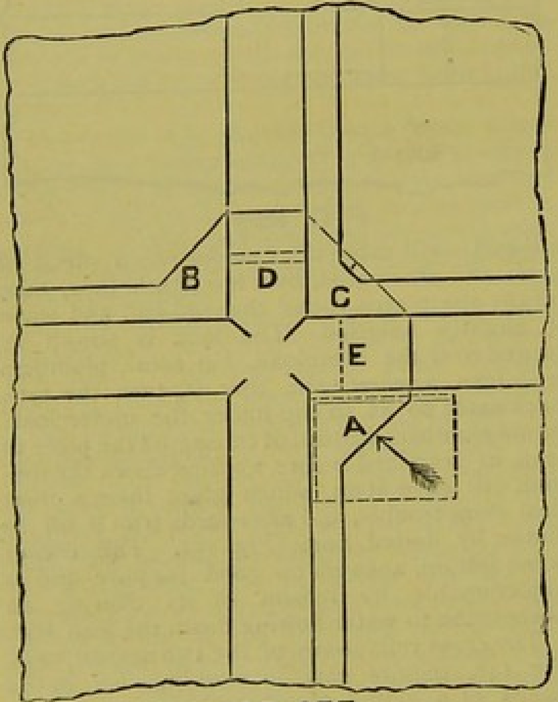


FIG 155

undercloak, as shown by double dotted line at D, to prevent water being drawn between the lead lappings. Young plumbers at their first attempts at intersections of rolls are not usually careful to keep down the corners that have been worked home, with the result that in working one angle they will drag the lead up from the others, thus necessitating their being again worked down. They also get the lead so thin that on attempting to rework the corners they break a hole through the lead. Another common mistake is to have the chase-wedges and dressers too sharp, and so either cut the lead or reduce it in thickness in the arrises. It should be a standing rule that in working sheet-lead no parts should be reduced to less than the original substance, and neither angles nor arrises worked to a sharp edge. It does not necessarily follow that they should be left uneven or slovenly, but should be quite straight, and external and internal angles dressed to the same radii, that is the edges of dressers and chase-wedges should never be sharper than would fit the angles by the sides of the rolls shown at Fig. 152, and external angles should be dressed to the same roundness.

When a drip crosses a lead flat the drip should be at least ½ in. higher than the depth of the rolls, as shown by section, Fig. 156.

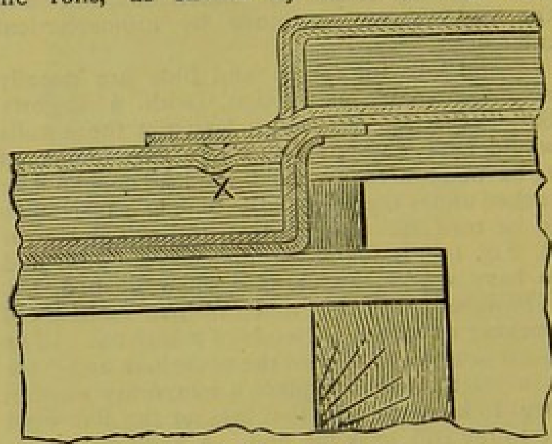


FIG 156

Indeed it would be better if 3 in. drips were made where 1½ in. rolls are used. Fig. 157 is drawn to show what is usually done. In this case the end of the bottom roll stands higher than the drip, so that any water getting in the lap, as shown by the arrow, could pass between the over and undercloaks and get beneath the end of the upper bays. Should any reader have an opportunity of looking over a lead-flat, with a drip across, that has been laid some years, and pull up the end of the overcloak of the top bay, he will find the woodwork at Z in a state of decay. In a great many cases the overcloak at Y lays on the bottom roll only about 1 in. so that there is no protection against rain driving in. With the woodwork arranged as shown by Fig, 156 this is less likely to occur. The overcloak should also lay on the top of the

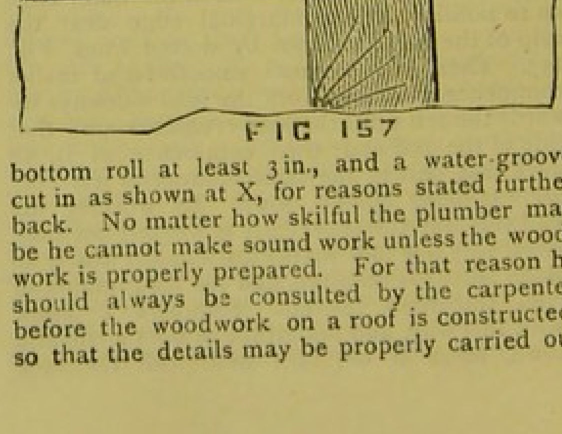


FIG 157

bottom roll at least 3 in., and a water-groove cut in as shown at X, for reasons stated further back. No matter how skilful the plumber may be he cannot make sound work unless the woodwork is properly prepared. For that reason he should always be consulted by the carpenter before the woodwork on a roof is constructed, so that the details may be properly carried out and the various weak points that are so often discovered guarded against instead of the workman blundering along and repeating errors that usually are more the result of thoughtlessness than want of skill as a craftsman.

On large lead flats, similar in construction to Fig. 148 in an earlier lecture, the centre roll is sometimes made larger than those between the bays. Fig. 158 shows a section across one that

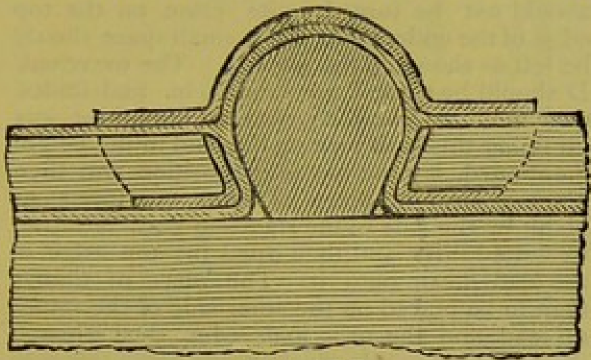


FIG 158.

is often found. When this large centre roll is fixed the end of the bays are dressed up to meet on the top, and then a capping lead fixed and worked down at the sides to lay on the bays as shown by the sketch section. When the flat is laid to a very slight fall the above makes a very good job, but where a good pitch is given to the roof the lead bays will often crawl down and break away from the nailing to the centre roll. Where roofs are constructed so as to have a steep pitch it is much better not to have a centre roll, but to let the lead bays lap over each other at the ridge, the lappings to be arranged so that alternate bays pass over each side of the crest of the roof as shown by Fig. 159. A great many of our old churches, cathedrals, and

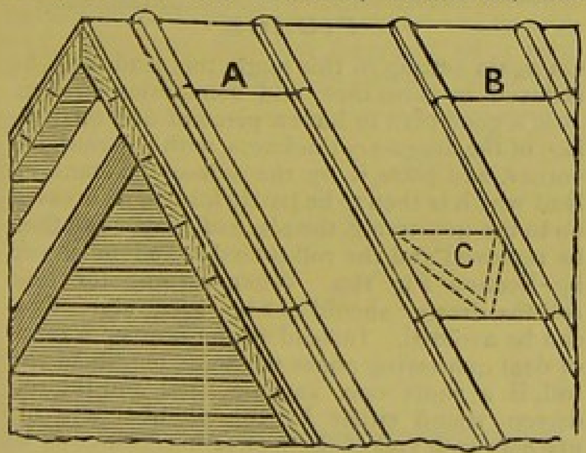


FIG 159.

other buildings have the lead on the roofs arranged in this manner, and the best argument that can be used in its favour is the length of time these roofs will resist atmospheric influences. In a great many cases the lead is lapped over the ridge about 1 ft., as shown at A and B, but in some instances where the roofs have been flatter than shown in the sketch it has been thought necessary to have 2 ft. lappings. At first sight this may appear to be a waste of lead, but it must not be forgotten that these lappings have to be arranged to resist capillary attraction. Where the roofs are very large so that the bays have to be covered with two, three, or more pieces of lead, the horizontal lappings are always a source of weakness by reason of the water, during a rain-fall, being drawn between the lappings. On flat-pitched roofs it has been found necessary in some instances to chase the undercloak into water-grooves cut in the wood-work, and as shown at C Fig. 159.

The lower bays will frequently break away from the nailing at the top edge and slide down the roof, and this is more liable to occur when the pieces of lead are of a long length and

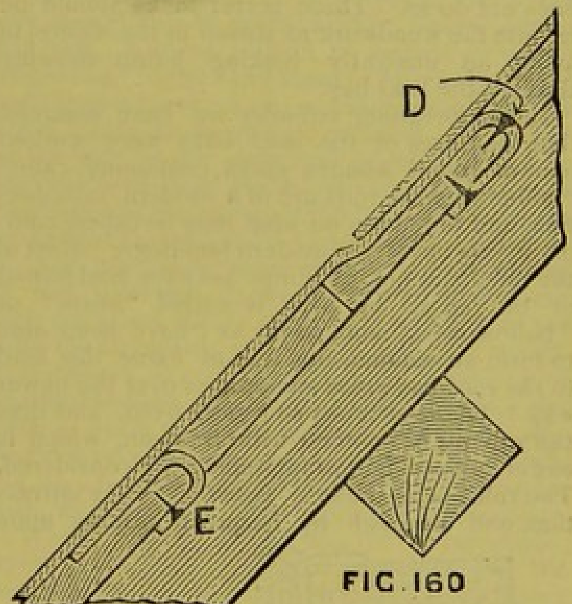


FIG 160

fastened with iron nails. For best work copper nails are found to be better than iron, especially in cases where moisture can get to them which sets up a voltaic action between the iron and lead, and results in the heads of the nails rusting and falling off. The lengths of the pieces of lead should not be longer than stated in an earlier lecture for reasons there given. A further advantage is gained if the top ends of the lower bays can be turned through the boarding and nailed on the other side as shown by sketch section Fig. 160. In some instances this is difficult to do, especially in roofs that are full of inside timbering, or to the top bays that are near the ridging where a man cannot get inside to do the nailing. But in these cases a piece of board can be taken out and the nails driven in on the edge of the boarding as shown at D, when the piece of board can be replaced before the next piece of lead is put in its position. Sometimes "soldered dots" have been made to prevent the lead sliding down a roof, but I think soldering of any kind on a roof always looks patchy and suggestive of repairs. In addition to this soldered dots never last for any great length of time and the lead invariably breaks away from them. Perhaps you are thinking "all the better" as it will make a job for the plumber. But I do not take this view. The better we do our work, and the longer it lasts, the more likely it will be that architects will specify lead in preference to other and cheaper materials which do not last so long as lead when it is properly laid and fixed.

In some cases secret tacks have been "sweated," or "burnt," on the under sides of lead bays, and these tacks then turned through a saw cut in the boarding and nailed on the underside as shown at E, Fig. 160. Sheet-copper has sometimes been used for these tacks, but lead is better, as it expands in an almost equal degree with the lead bay, whereas copper does not do so. These secret tacks should be let into the woodwork as shown in the figure to avoid an unsightly looking bump showing through the lead bay.

In the foregoing remarks we have assumed that the edges of the lead bays were worked over or round wooden cores commonly called "rolls." These rolls are of a modern introduction, and only seen on what may be called, comparatively speaking, modern buildings. Most of the older class of buildings have the lead joined at the edges by what is called "seam" or "hollow rolls," and, so far as I have been able to form an opinion, this way of fixing the lead to the roof has great advantages over the newer way. The lead is not so rigidly fixed, and thus can expand or contract with freedom, which is one of the most important items to be considered. The rolls, being hollow, resist capillary attraction, and although by frequent walking upon

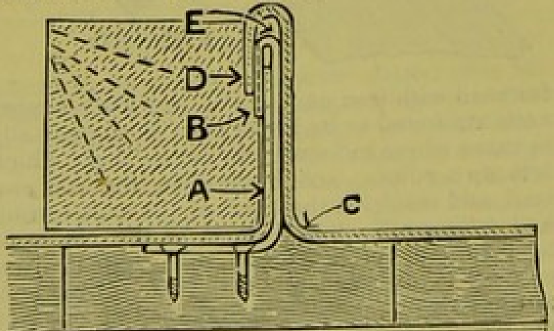


FIG. 161

them, they may in some cases lose their original smart appearance and become flattened and disfigured, they will still retain their power of preventing water passing through them.

"Seam roll" work is not more difficult to do than the ordinary wood roll work, and with a little practice any ordinary plumber can do it. First of all we will refer to Fig. 161. A represents the undercloak turned up about 3½ in. or 4 in. as shown. B is a tack, sometimes made of thin sheet copper, because the thickness of lead would show through the overcloak when the roll was turned, about 6 in. long by 2 in. or 3 in. wide, let into and screwed to the wooden platform on which the lead is to be laid. Sometimes this tack is fixed the other way about, but as shown, is the correct way, as otherwise, when the roll is turned it would show in the angle C. The tack should not be turned quite close on the top edge of the undercloak, but a small space should be left as shown in the sketch. The overcloak D should be turned up about 6 in. and folded over the undercloak as shown. The best way for doing this is to turn up the lead to the height mentioned, lay the bay in its position and then place a straight piece of deal quartering or plank by the side of the stand-up part, as shown by dotted lines, and then dress the top edge of the lead down onto it. The piece of timber then to be placed on the other side of the stand-up lead and the overcloak edge then dressed down over the undercloak, pains being taken to keep the folded edge in a perfectly straight line. A hollow space should be left as shown at E. If this space is not left, but the overcloak turned tightly over the undercloak, when the roll is turned down the lead at F, Fig. 162; will be pulled up as shown by the double dotted lines.

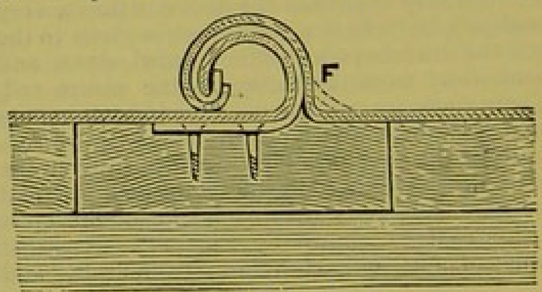


FIG. 162

On again setting in this angle the lead will be reduced in substance and sometimes broken. It is a good plan to have a piece of deal quartering, of the necessary thickness, with one rounded corner, and place it by the side of the stand-up lead which is then to be partly folded, or dressed on to the quartering, the piece of timber can then be removed and the roll folded round as shown by Section Fig. 162. When turning the lead roll the dresser should not be used more than can be avoided. Instead of the dresser a piece of deal quartering about the same length as the roll, if a short one, can be used and the roll driven round either by the plumber and his mate at each end of the quartering, which is to be held parallel with the roll, alternately hitting their ends against it, or by driving the piece of wood with a large mallet.

In very old examples of seam roll work the ends of the rolls are worked over the ridge in the usual way as when wood rolls are used. In other cases where the lead bays abut against a wall at the top end, the rolls are turned up as shown at G, Fig. 163, and the bottom ends turned down as shown at H. In some Scotch towns at the present time the plumbers work the roll ends in this way. In other cases where the roofs have a fairly good fall the roll ends and bays are not turned up against the wall but

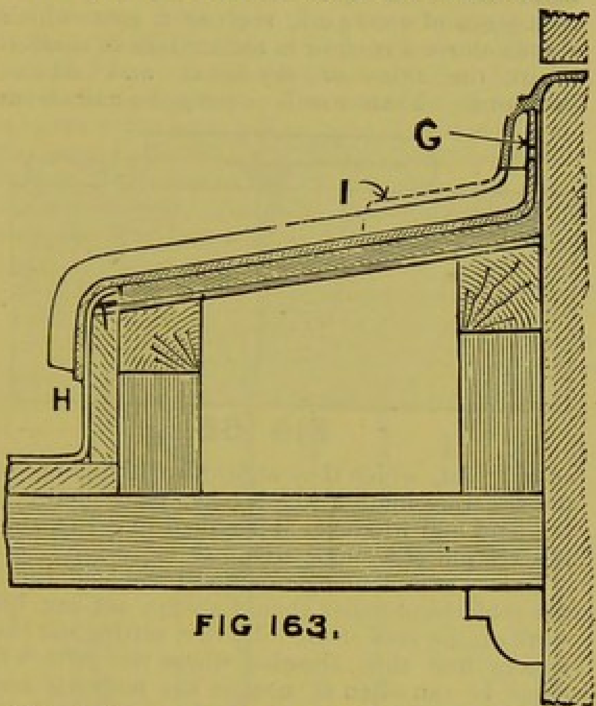


FIG 163.

finished close up to it and a lead apron is then fixed as shown by dotted lines at I, the lead laying on the sloping part from 9 in. to 1 ft. 6in, and is worked over the rolls over which it laps the same distance as on the flat part of the bay. On the roofs of some of the City of London Churches the lead is laid in this manner. In seam roll work of more recent date the roll ends have been finished in a much neater and smarter way. Fig. 164, shows a fragment of a roof, showing the bottom roll end finished quite flat

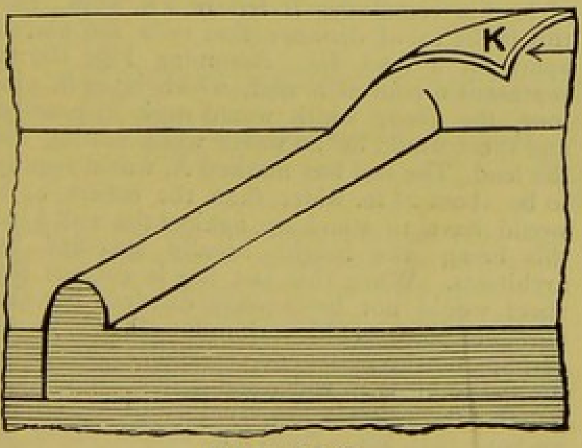


FIG 164.

and presenting the same appearance as when a wooden roll is used as a core. This can be done quite easily, but the plumber has to take more time over it and be careful not to make any bruises which he cannot afterwards get out again. The undercloak should be partly made its proper shape before turning the overcloak and a piece of lead left on as shown by dotted lines at L, Fig. 165. The overcloak should be

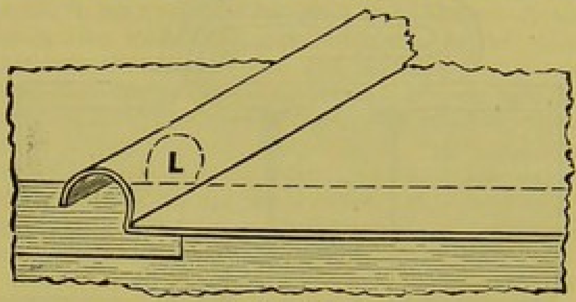


FIG.165

worked out sideways as explained by Fig. 153, in the last lecture. The head, or top end of the roll should also be partly worked before laying the bay. A corner should be bossed up in the undercloak in the same manner as for wood rolls and then a piece cut out of the stand-up part to allow it turn easily without buckling. The part of the welt on the overcloak which is folded to clip the under lead should be cut off even with the wall, and the corner of the lead which stands up against the wall should be folded as shown at K, Fig. 164. This corner should then be worked in the direction shown by the arrow and the lead stretched slowly and by degrees during the time the straight part of the roll is being turned. It is difficult to explain in writing the whole of the proceedings to be taken when working the ends of seam rolls, but perhaps, the reader who has had no experience in this branch of plumbing may be able to gleam some little information from what has here been written on the subject.

When working cross rolls, or intersections, more difficulties present themselves, but the student plumber would learn more in one hour's practice than in reading several pagesof description of the process..

On Flat Welts.

When covering the perfectly upright parts of roofs with lead, some little difficulties present themselves, and water will often find its way between the upright lead-joinings. For this class of work wooden rolls are only of partial utility. When the rolls are laid on a horizontal or sloping surface, whatever rain falls upon them runs off again onto the parts that are at a lower level, but when these same rolls are placed upright whatever rain falls upon them will run downwards, and a portion be drawn between the lead lappings, partly by capillary attraction and partly by gravitation. In these cases it is always advisable to have seam rolls or substitute for them—what is commonly called double welts. These welts are similar to seam rolls to a certain extent, but instead of being hollow they are dressed down quite flat. They are also much smaller and take a less quantity of lead. Fig. 166, is a section of a double welt after it is folded. The Figure is drawn full size, so that it is not necessary to give any dimensions. For these welts the lead is turned up and the tacks fixed in a similar manner as for a seam

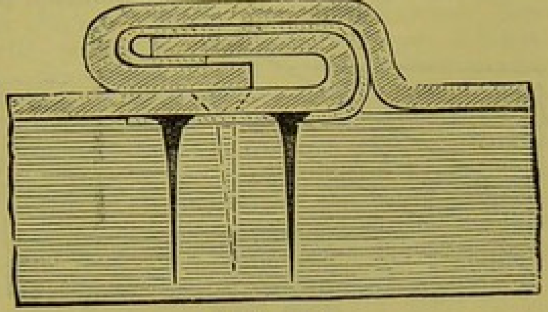


FIG. 166

roll, as shown by Fig. 161, excepting that the lead is not turned up so high. The tacks are sometimes fixed 1 ft. to 2 ft. apart, but in some cases a strip of lead has been nailed on and turned with the welt its whole length. By this means the lead is more firmly fixed, the welt looks bolder and there are no swellings or bumps in the welt, which occur when the tacks are put on at intervals. Fig. 167 represents a section of a triple welt. In this case an extra fold is given to the edges of the lead where they are turned to form the welt. This is not much practised. For work on horizontal or nearly flat roofs, welts are not so good as wood or hollow rolls. It is not at all unusual for roofs to sink a little in places, and a settlement of ¼ in. would in some instances retain a pool of water to that depth. If this pool was near a flat welt water could pass through the folds and so get beneath the lead and rot the woodwork. Where welts are used on flat roofs and the ends of the bays have to stand against an upright wall the ends of the welts should be prepared before fixing them. This is a simple matter, the edges to

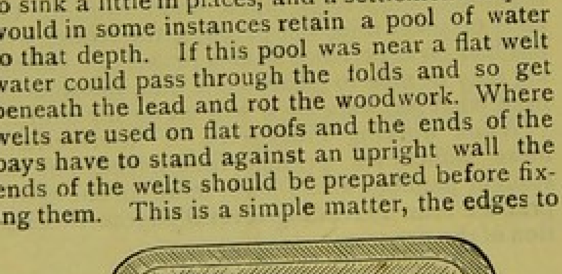


FIG. 167

form the welt could be folded separately and a packing of thick lead placed inside, after which the ends of the bays could be pulled up, the pieces of packing lead removed; and on placing the bays in their position the undercloak and overcloak edges could then be slid sideways and so lock into each other, when they could be dressed so as to tightly clasp together.

In some instances when fixing lead by means of double welts the tacks are omitted and the lead nailed as shown by the dotted lines, which represents a nail in Fig. 166. This is not at all a good plan, as should the nails get loose, or the holes in the lead become larger by the movement of the lead, wet could be drawn in, when the evil would be aggravated by the woodwork beneath becoming rotten.

Single welts are generally used to cover the nail-heads when a piece of lead has to be nailed to a piece of woodwork, such as a post, which stands above a roof, or in some cases to wooden shafts, the sides of sky-lights and similar positions. There use is to keep the nails from

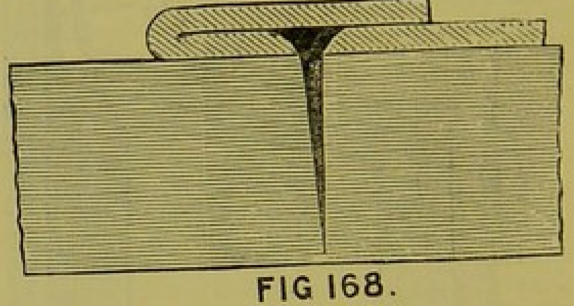


FIG 168.

coming out, which they almost invariably do by the shearing motion which takes place between the lead and whatever it is nailed to. Fig. 168, is a section of a single welt.

Before commencing to cut out the lead for a flat roof the plumber should always set out his work on the roof itself. By first setting out the spaces and thus showing where the rolls will come he can often economise his material and avoid cutting it to waste. It is usual to cut out all lead for bays to a width of 3 ft. 6 in., which is half the width of ordinary lead in sheets, although some makers have mills for rolling sheets 9 ft. wide. For wood-rolls of the size shown by Fig. 152 B, in an early lecture, 3¼ in. is required to be turned up to form the "undercloak," 6¼ in. for the "overcloak," including an allowance for 1¾ in. to lay on the flat by the side of the rolls with an extra ¼ in. for trimming. The 3¼ in. added to 6¼ in. makes 9½ in. Deduct this from 3 ft. 6 in., the width of the half-sheet of lead, a remainder is left of 2 ft. 8½ in., and this is the usual distance that rolls are placed apart on a lead flat. Assuming Fig. 169 to represent a plan of a roof, which is 22 ft. 3 in. long, the above width would work in exactly, and there would be no waste when cutting out the lead. The last bay marked A, would require to be about 2½ in. wider than the others, as it would have to stand up against the wall 6 in., this being the height usually specified by architects. When this last bay is cut out the sheet would not be equally divided, but the narrower piece would work in for other bays, or perhaps for the gutter and cesspool. Supposing the flat to be 17 ft. wide, and deduct from that length 1 ft., which is the usual width for gutters, we have 16 ft. left. Now, lead should never be laid in larger lengths than 7 ft. or 8 ft., so the length of the bay should be equally divided, thus making two portions each 8 ft. long. Bays divided in the direction of the water current over them are joined by means of rolls, but bays divided across the current have to be joined by means of drips. In an earlier lecture it was advised that these drips (see Figs. 156 and 157) should not be less than 3 in. deep. So for setting out the length of the bays A, B, C, D, we add to the above 8 ft., 4 in. for dressing down into the gutter, and 4 in. for turning up at the drip. This 4 in. includes for 1 in. to dress into the rebate above the drip as shown at Z, Fig. 157. The total length of the lead for these bays will thus be 8 ft. 8 in. For the bays E, F, G, H, the lead should be 2½ in. longer, as the top ends have to stand up 6 in. against the wall. An extra ½ in. is useful at the drip for working, and also for trimming the

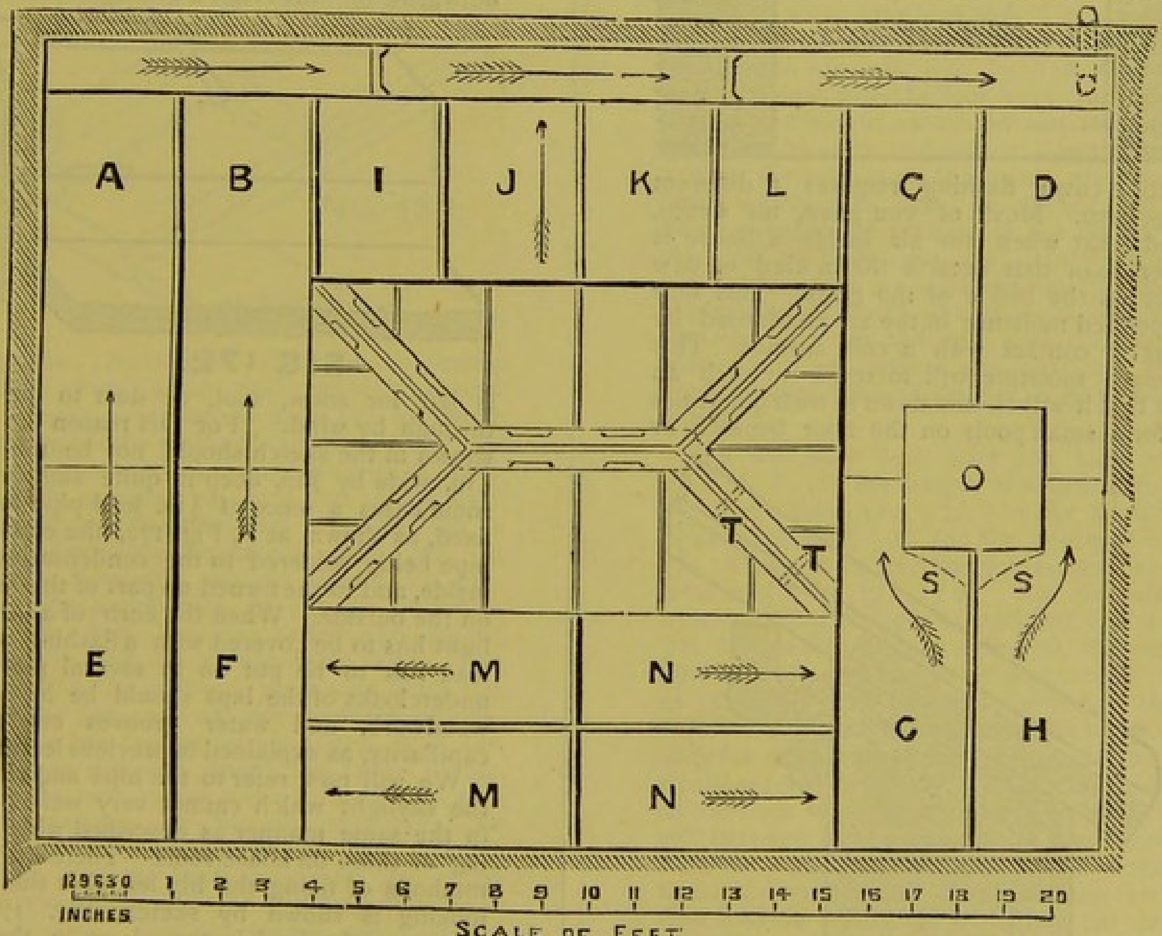


FIG. 169

edge to a straight line when finished. The plan Fig. 169 is drawn to scale, and on measuring the bays I, J, K, L, they will be found to be 4 ft. long. This length added to 4 in. for the drip into the gutter, and 6 in. to stand up against the skylight makes a total of 4 ft. 10 in. for the length of these bays. The widths will be the same as the others that have been described. The bays M, N, are generally arranged so as to fall towards the skylight, the roll ends cut about 8 in. or 9 in. short at the lowest ends, and soldered seams wiped from the roll ends to and up the stand up part against the skylight, to allow water to pass away. It has already been stated that soldering on a leaded roof looks patchy, in addition, when large pieces of lead are soldered together, they generally break or crack near the soldered parts. To avoid soldering, and also to make a much better job, it is best to construct drips in a line with the ends of the skylight, and arrange the wood platform, so that the water will flow away in the direction shown by the arrows. O is a trap-door for access to the roof. The raised curb round the opening should stand at least 6 in. high, and the trap-door should be covered with light lead not exceeding 5 lb. per superficial foot, or a further improvement would be to cover the door with sheet copper on account of its lightness, it being so difficult to open these trap-doors from the inside when they are covered with heavy lead. The trap should be bolted on the inside, to prevent midnight prowlers getting into the house, and also to prevent a high wind blowing the door away. Fig. 170 is a section, drawn to a larger scale, of the trap-door. The lead that stands up against the wood curb should not be nailed to it, which would fix the lead too rigidly, but a flashing should be fixed and nailed on the top edge as shown. The wood cover should be made to hang down all round the curb at least 1½ in., and the lead should be dressed down, turned inside, and nailed as shown in the section. Copper nails are best for this purpose, and they should not be too large, or they will split the wood, and if too long will pass through the outside lead. All trap-doors should fit moderately tight to prevent snow or dust drifting through them.

The skylight shown on the plan next claims our attention. The lead should stand up against the curb, as explained for the trap-door,

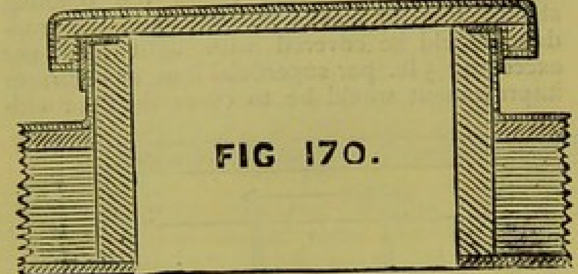


FIG 170.

but the cover flashing requires a different arrangement. Most of you have, no doubt, noticed that when the air inside a house is warmer than that outside that a kind of dew gathers on the inside of the glass. This dew is suspended moisture in the air condensed by coming in contact with a cold surface. This condensed moisture will increase to such an extent that it will stream down in such quantities as to form small pools on the floor beneath, or

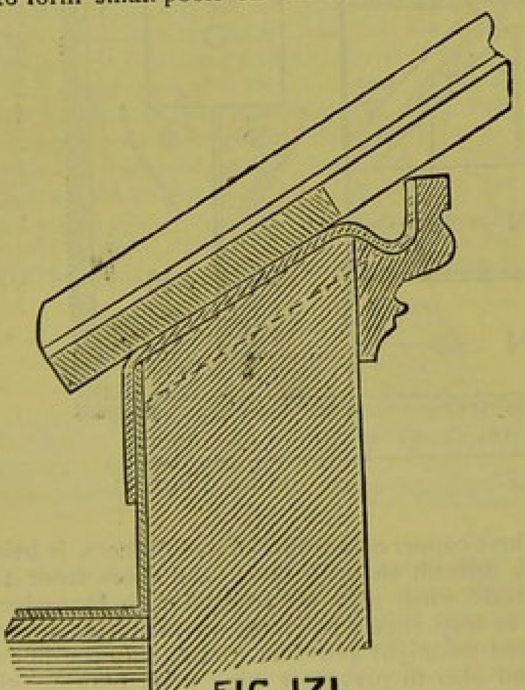


FIG 171.

run down the inside linings of the skylight, and leave dirty-looking streaks. The curb flashings of skylights should be so arranged as to catch this condensed water, and convey it outside onto the roof.

Fig. 171 is a fragmentary section, which shows how this should be done. If the wood curb is narrow, the lead flashing is carried beyond it and a wooden moulding fixed to support and hide it from view, the edge of the lead being turned up as shown in the sketch. If the curb is a broad one the lead is generally turned up even with the inside face of the skylight linings, in which case the wood moulding is not always fixed.

Fig. 172 is a small perspective view, showing a small water groove cut into the curb and the lead chased into the groove for the water caught by the turned up lead to run outwards. The dotted lines Fig. 171 represents the bottom of the water groove. In some cases the skylight is blocked up about ¼ in. for the water to run outwards, but this is not a good plan, as a space

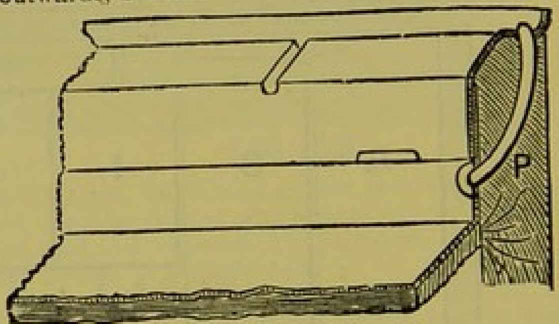


FIG 172.

is left for snow, soot, or dust to be driven through by wind. For this reason the groove shown in the sketch should not be too large—½ in. wide by ⅜ in. deep is quite sufficient. In some cases a piece of ½ in. lead-pipe has been fixed, as shown at P, Fig. 172, the ends of the pipe being soldered to the condensation gutter inside, and to the turned up part of the lead flat on the outside. When the curb of a large skylight has to be covered with a flashing, and the lead has to be put on in several pieces, the undercloaks of the laps should be let into the woodwork, and water grooves cut to stop capillarity, as explained in previous lectures.

We will now refer to the hips and ridging of the skylight which cannot very well be fixed in the same manner as described when speaking of those on house roofs. There are various methods of fixing the hip lead, but the neatest looking is shown by sketch, Fig. 173. In this case the lead is turned up in the usual way and, at distances of about 2 ft., secret tacks about 2 in. wide are sweated or burned on the under side. The rolls are rebated, where the tacks will come, to the same depth as the thickness of the lead tacks. The lead is then placed in its position on the roll, the tacks folded round and nailed to the roll, thus forming a fixing as shown in the figure, after which the sides of the lead covering are pressed down and caused to clip tight round the roll, the angles are then set in and the roll-end worked down in the usual way. The edges are then trimmed straight and so as to lap over the puttying round the edge of the glass. The wings or sides of the hips are then pulled up sufficient for the glazier to fix and joint up the edges of the glass, after which the plumber will dress down the lead and turn the loose end of the tack, which should be left long enough for the purpose, as shown at R. It is not necessary to fix the ridge lead in the same manner as described for the hips as it is fixed on a horizontal instead of an inclined line and consequently will not be so liable to slip down.

Now we have this problem before us it may be interesting to turn away from constructive roof work for a short time and dwell upon its

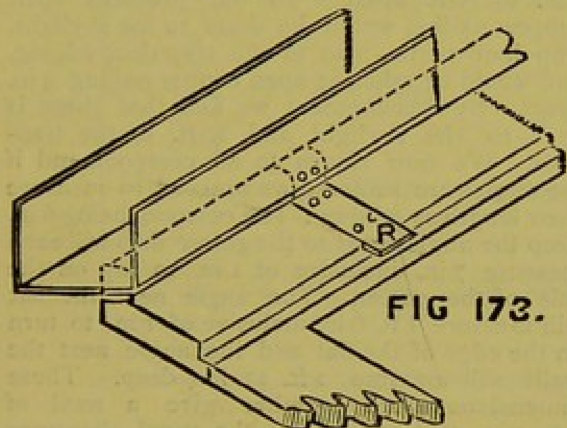


FIG 173.

mensuration. Nearly the whole of the details have been given in this and previous lectures and it is only necessary to have the following information for the whole of the quantities to be taken out so that the exact amount of lead that will be required to cover the roof, shown by Fig. 169 can be calculated. As the plan is drawn to scale, the superficial area can be measured. The rolls are as shown by Fig. 152 B. The socket-pipe is 4 in. in diameter, out of 7 lb. lead, has two bends and passes through 9 in. wall into a rain-water head. The cesspool is 1 ft. 5 in. deep, measured from the edge of the flat, and has four soldered angles. The gutter has two drips 3 in. deep, and the side next to the wall stands the same height as the side next to the flat at its deepest end but 3 in. above the flat at its highest or shallowest end. The drips on the flat are 3 in. deep, and the lead stands up all round next to the walls, skylight, and trap-door to a height of 6 in. The flat, gutter and cesspool are covered with 7 lb. lead. Cover flashings out of 5 lb. lead, and averaging 6 in. wide, are fixed in 7 ft. lengths all round the flat, skylight and trap-door, and this door is covered with 5 lb. lead. The hips and ridge of skylight are covered with 6 lb. lead, and the wings are 5 in. wide when trimmed off. The ridge of the skylight is 4 ft. above the curb line.

The flat and gutter has a fall of 1 in. in 10 ft., and all wall-flashings are fixed with lead wedges, weighing about eight to the pound, at distances of 1 ft. apart. The dotted lines at S, S, Fig. 169, show feather-edged pieces of board nailed on under the lead so as to tilt it and prevent a little pool of water laying near the curbing of the trap-door in the angles formed by the roll.

To proceed with our mensuration. There are several ways for measuring the amount of lead necessary for the roof, but the least confusing method to pursue will be to measure it in sections. Most Quantity surveyors will begin taking their measurements at the top of a building and work downwards, so we will begin at the highest point, namely, the skylight. The piece of lead for the ridging will be 6 ft. long by 1 ft. 3 in. wide. The four hips will measure, inclusive of 4 in. for working down over the roll end, 6 ft. 10 in. by 1 ft. 3 in. The ten tacks are each 1 ft. 5 in. by 2 in. The curb of the skylight measures a net length of 36 ft. 6 in., and to this length add six 4 in. laps or passings, makes a total length of 38 ft. 6 in. by 6 in. wide. We will now deal with the four bays marked M, N. To the net length, which measures 11 ft. 4 in., add 4½ in. at each end to turn down the drips, and for the roll across the centre, which is 9½ in., from which it is usual to deduct 1 in. (this being equal to the portion of the flat on which the roll is fixed) we get a total length of 12 ft. 9½ in. For the width we measure from the skylight to the wall and find it to be 5 ft. To this add 8½ in. for the roll, and 6 in. on each side to turn up against the wall and skylight curb respectively, and we get a total width of 6 ft. 8½ in.

We will now deal with the bays marked E, F, A, B, the net length of which is 16 ft. To the above dimension add 6 in. for standing up against the wall, 9 in. for the centre drip, and 4 in to turn down into the gutter, and we get a total length of 17 ft. 7 in. For the width we measure from skylight to wall and find it to be 5 ft. 6 in., which added to the roll, the stand-up against wall, and curb of skylight makes a total of 7 ft. 2½ in. For the bays marked G, H, C, D, it is usual to take the quantity found as necessary for the previous four bays, and then make deductions of twice 5 ft. by 2½ in. for the drips at the ends of the bays and 4 ft. by 2½ in. for the roll between bays L and C. We will now deal with the trap-door, and first of all deduct the space it stands upon. On measuring the top we find it to be 2 ft. 9 in., but from our practical knowledge we know that it sails, or projects, beyond the curb at least 1½ in. all round (this will be noticed by referring to Fig. 170, which is not drawn to the same scale as Fig. 169), so that the size is really 2 ft. 6 in. by 2 ft. 6 in., but we must also deduct the amount taken up by the roll and drip, which makes a superficial area equal to 3 ft. 3 in. by 3 ft. 2½ in. If this area is deducted we must then add the amount of lead which stands up against the curb on the four sides of the trap-door. We already know the net length of one side is 2 ft. 6 in., but we get a lap or passing on each side equal to the lead required for the roll or drip or a total of 12 ft. 11 in. by 6 in. wide to go all round the curb.

In practice the curb flashing to the trap-door would be put on in two pieces, so that we should get two laps of 4 in. each, which, added to the net length, or girt of the curb, would give a total of 10 ft. 8 in. by 6 in. wide. To cover the door the piece of lead would have to be 2 ft. 9 in. added to twice 5 in. for the edges (as shown by Fig. 170), or a total of 3 ft. 7 in. by 3 ft. 7 in. The bays I, J, K, L, will measure 14 ft. 7 in. by 4 ft. 10 in.

We will now pass to the gutter and cesspool, the net length of which is 22 ft. 3 in. Add to this dimension for three drips, taking an average of 8 in. each, 9 in. to turn up at the highest end and 1 ft. 5 in. at the lowest, we get a length of 26 ft. 5 in. For the width we take a medium or average as follows: The drip at the highest end is 3 in., two other drips across the gutter are also 3 in. each, and by referring to details given further back the fall was described as being 2 in.

So now we have—

1 in. to lay on the flat
3 in. drip next the flat
1 ft. 0 in. width of gutter
9 in. turn up against the wall

2 ft 1 in. the total width of the lead at highest end of gutter.

Then we have—

1 in. to lay on the flat
11 in. drip next the flat.
1 ft. 0 in. width of gutter
1 ft. 5 in. turn up against the wall

3 ft. 5 in. the total width of the lead at lowest end of gutter.

If we add the two totals together, and divide them by two, we get a mean width of 2 ft. 9 in. for the gutter.

In the above dimensions we have taken the cesspool with the gutter, this being the usual practice, but as the cesspool is 6 in. deeper than the gutter we now want the inside girt of the cesspool, which will be found to be 4 ft. by 6 in. the depth, assuming the cesspool to be 1 ft. long.

We now come to the cover flashings, and measure all round the walls for the net length, which will be found to be 78 ft. 6 in. To this length add for 4 in. passings 7 ft. apart and an extra one at each drip. This makes a total of 20 in number, or a length of 6 ft. 8 in., which added to the net length makes a dimension 85 ft. 2 in. by 6 in. For the lead wedges we take the number of feet in the net girt of the flat, which is equal to 79 wedges in all. It is usual to put tacks on all cover flashings to prevent them being blown up by the wind. These tacks are generally put on at all laps, and also an extra one in the centre of each 7 ft. length of flashing, the tacks being of lead 1 lb. per foot super heavier than the flashings, and cut out 5 in. by 3 in. The number of tacks can be found by adding the gross lengths of the flashing round walls, skylight, and trap-door together, dividing the length by seven and multiplying by two we thus get a total of 39 tacks.

Wherever copper-nails are used, an extra on iron clout nails is charged, and where driven in close together the nails are measured as so many feet run of close copper nailing; or if placed wider apart they are measured as being so many feet run of open copper naillng, 1 in., 2 in. or 3 in. apart. In our problem open copper nailing would be done to the skylight, trap-door curbs, also to the trap-door edging, and would be taken as open copper nailing 3 in. apart. By measurement we find that there is 27 ft. to the skylight and 20 ft. to the trap-door. We now return to the cesspool, and if the angles are soldered we proceed to measure their length as follows: The cesspool being 6 in. deep the angles next to the gutter drip will each measure 7 in. inclusive of 1 in. to lay on the sole of the gutter. The angle next the flat will measure 1 ft. 6 in. inclusive of 1 in. to turn on the edge of the flat and the angle next the walls will measure 1 ft. 11 in. deep. These dimensions added together give a total of 4 ft. 7 in. soldered angles, the usual allowance for solder being 1 lb. per foot run. The socket-pipe will be found by setting it out, and then measuring it, to be 2 ft. long. Add extra for labour to two 4 in. bends and a 4 in. soldered joint to the bottom of the cesspool.

Below is the form in which the lead would be booked by a surveyor. The first column is the number of any pieces of lead or repetition of any single piece or article. The second column is for the sizes or dimensions, and the third column for the squared up dimensions.

Milled Lead on Flat, Skylight, &c.

No. of Pieces.	Size.		Squared-up.		
	Ft.	in.	Ft.	in.	
	6	0			
	1	3	7	6	6lb. lead ridging
4	6	10			
	1	3	34	2	Add hips
10	1	5			
		2	2	4	Add tacks
4					Extra to labour to roll ends
2					Extra labour to intersections of hips & ridges
	38	6			
		6	19	3	5lb. curb flashing
	12	10			
	6	9	86	7	7 lb. lead on flat

Milled Lead on Flat, &c.—Continued.

No. of Pieces.	Size.	Squared-up.	
	Ft. in.	Ft. in.	
2	17 7 7 3	254 11	Add
2	5 0 2	1 8	Deduct 7lb. lead
	4 0 3	1 0	Ditto
	3 3 3 2	10 3	Ditto, trap door
	12 11 6	6 6	Add round trap door
	10 8 6	5 4	5lb. curb flashing to trap door
	3 7 3 7	12 10	Add cover to trap
	26 5 2 9	72 7	7 lb. gutter
	4 0 6	2 0	Add for cesspool
10			Extra labour to roll ends
1			Extra labour to roll intersection
	85 2 6	42 7	5lb. cover flashing
79			Lead wedges
39	5 3	4 1	6 lb. lead tacks
	27 0		Copper nailing 3 in. apart to sky curb
	20 0		Add to trap door
	4 7		Soldered angles
1			Extra labour to cesspool
1			Socket pipe 4in. diameter out of 7lb. lead with two bends and soldered joint to cesspool

The quantities having been squared-up we then proceed to collect them as follows :

Add lead.

7 lb.	6 lb.	5 lb.
Ft. in.	Ft. in.	Ft. in.
86 7	7 6	19 3
254 11	34 2	5 4
6 6	2 4	12 10
72 7	4 1	42 7
2 0		
	48 1	80 0
422 7		
12 11	less deductions	
409 8		

Deductions.

7 lb.	6 lb.	5 lb.
Ft. in.		
1 8		
1 0		
10 3		
12 11		

	Ft.	in.		lbs.		lbs.		Cwt.	qr.	lbs.
Then—	409	8	×	7	=	$2867\frac{2}{3}$	or	25	2	$11\frac{2}{3}$
	48	1	×	6	=	$288\frac{1}{2}$	,,	2	2	$8\frac{1}{2}$
	80	0	×	5	=	400	,,	3	2	8

Roll ends.	Intersections.
4	2
10	1
14	3

Lead wedges.	Open copper nailing.
	Ft. in.
79 pieces.	27 0
	20 0
	47 0

Soldered angles to cesspool.	Extra labour to cesspool.
4 ft. 7 in.	1.

4 in. socket-pipe with two bends and soldered joint to cesspool.
1 piece, 2 ft. long.

After abstracting the quantities, they should be made out in bill form, ready for pricing out, as follows—

Cwt.	qr.	lb.	
25	2	12	Milled lead on flat gutter, &c.
2	2	9	,, ,, hips, ridging, &c.
3	2	8	,, ,, flashings.
		14	Extra labour to roll ends.
		3	,, ,, intersections
		1	,, ,, cesspool.
			79 lead wedges.

Ft.	In.	
47	0	Run copper nailing 3 in. apart.
4	7	Soldered angles to cesspool.

One 4 in. socket-pipe out of 7 lb. lead, 2 ft. long two bends, one soldered joint.

If the above items are then priced out, the estimate can then be made up and submitted to builder or other client.

We will now return to our lead roof work construction.

It frequently occurs that a trap-door for access on to a roof is constructed on the sloping sides, and if they are covered with slates lead flashings are necessary for keeping out the rain. Before proceeding to explain the details of the leadwork, I should like to explain that trap-doors as usually fixed, are very far from being good arrangements. First, they are very difficult to open, the person generally having to stand on portable steps to reach them. Secondly, they are usually laid over the opening, and simply bolted inside; so that after drawing the bolts and the trap is partially raised, it will slide down the roof. They have been known to fall into the street when the house has not had a parapet wall to prevent it. Thirdly, they do not usually form a ready means of access to the roof in a case of the house being on fire. And, fourthly, a leakage generally takes place near them when rain is falling. But as they are so often fixed we will deal with them.

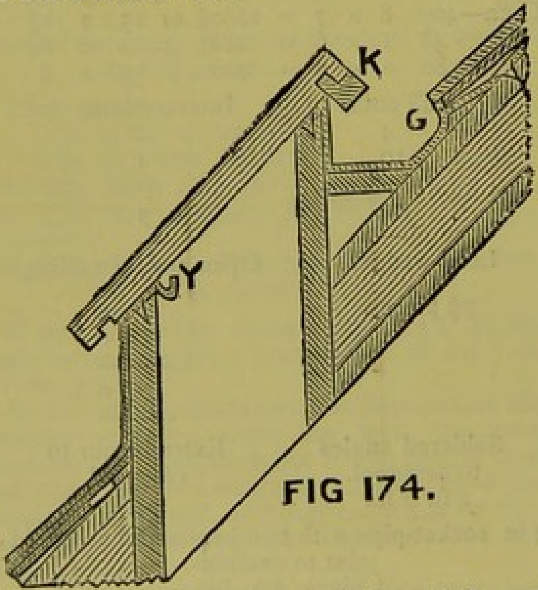


FIG 174.

One great cause of leakage is through the curb not being raised high enough above the sides of the roof, so that any rain falling at a higher level will stream down and wash over the curb, and pass beneath the trap cover. Fig. 174, which is a fragmental section, will explain how the curb should be fixed to prevent this, the usual way being as shown by Fig. 175, the arrow denoting the defect. The same remarks apply to skylights when fixed under similar conditions, but in the case of skylights the bottom, or apron flashing should be turned up inside, as shown by Fig. 171 and at Y, Fig. 174, to catch the condensed water that at times runs down the under side of the glass.

Fig. 176 is a plan of a skylight, showing the arrangement of the flashings. A is the apron which is continued beyond the side flashings, so as to clip round them, and form a tack, as shown at B, B. The side flashings C, C extend beyond the apron, over which it laps, and the lower ends are turned under the apron, as shown by dotted

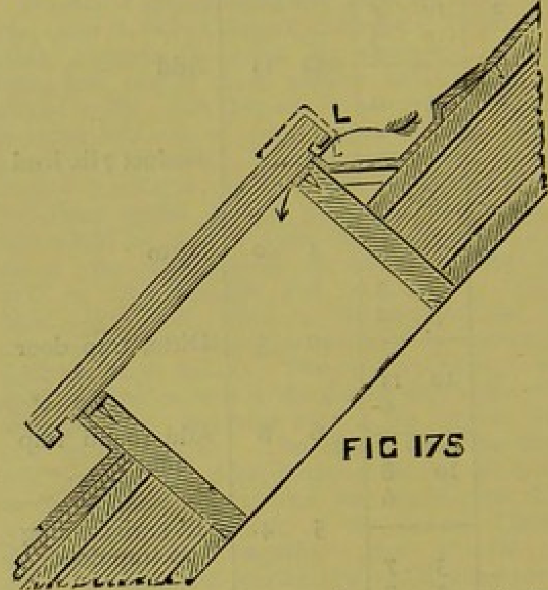


FIG 175

lines at D, D to form tacks to prevent the bottom edge of the apron slipping down the roof. The edges of the side flashings are turned as tacks over the ends of the skylight gutter, as shown at E, E. The gutter F is generally covered with lead of the same thickness as the other gutters on the roof, but the side flashings

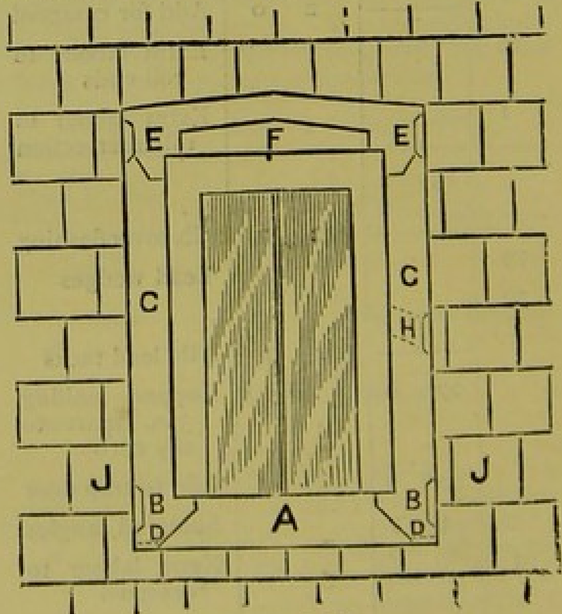


FIG. 176.

and apron are usually of lighter lead, and the same substance as any other flashings on the same roof. The gutter lead is usually nailed on the top edge of the curb; but, where the skylights are very long, the gutter lead should be trimmed off near the top edge of the curb, and a flashing put on. The gutter lead is continued up the roof over a tilting fillet, and beneath the slates, as shown at G, Fig. 174, in the same manner as for ordinary roof gutters. In the case of a large skylight, which requires rather long lengths of side flashings, an additional tack would be fixed, as shown at H. This tack should be slightly sloping downwards, as shown, and as explained in an earlier lecture, and illustrated by Fig. 124. In cases where a great deal of rain-water will stream down the roof into the skylight gutter F, Fig. 176, this water being discharged out of the gutter ends, will sometimes get beneath the side flashings and into the roof. For this reason it is advisable to fix soakers on the sides of the skylight, and a flashing nailed on the curb, so as to lap over the soakers. When soakers are fixed the lead apron should be worked round the sides

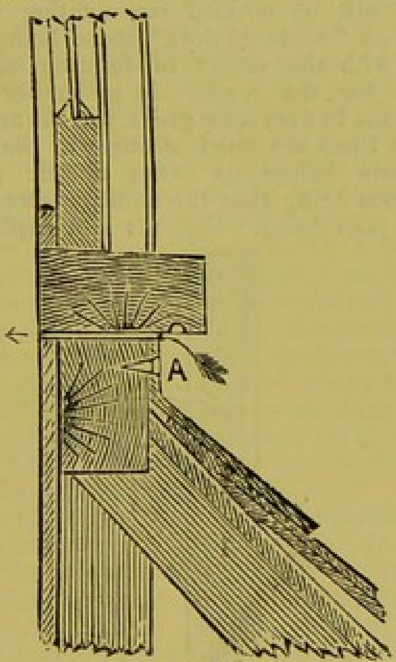


FIG 177

of the skylight and beneath the course of slates, marked J, J. When skylights are hinged, so that they may be opened for ventilation, a weather fillet can he fixed, as shown at K, Fig. 174, but if this fillet was fixed on the skylight, shown by Fig. 175, it would probably be broken off on raising the skylight. A common and bungling way sometimes practiced for keeping water out of the head of a skylight is to nail on a flashing, as shown by dotted lines at L, Fig. 175; but this very rarely answers the purpose for which it is intended, and frequently this lead is pushed off on opening the skylight. The foregoing remarks apply to trap doors and skylights in an equal degree.

The best means for access to a sloping roof is to fix a dormer which may be either internal or external, that is, the dormer may be constructed beyond the inclined surface of the roof as shown by a window, Fig. 142, or it may be recessed. Dormer doorways frequently leak and, like all other details of plumbers work, want very carefully arranging. We will deal with an ordinary

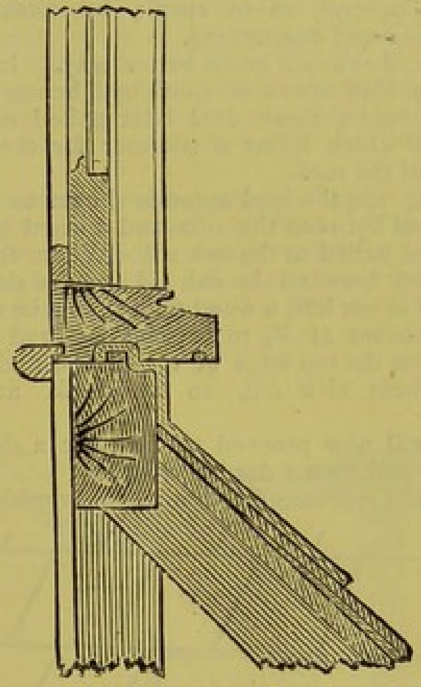


FIG 178

dormer first, and as the apron flashing is the first piece of lead to fix we will draw distinctions between the common way of fixing this piece of lead and what is done by the best tradesmen. Fig. 177 shows a section of the dormer sill and

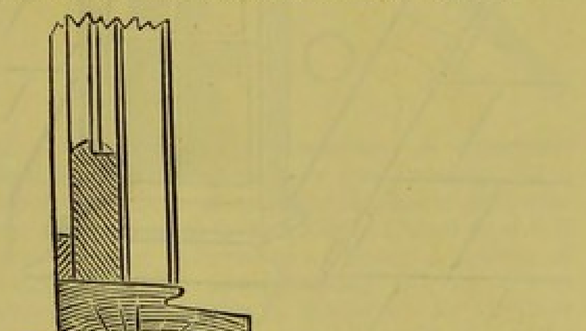


FIG 179.

the lead nailed on as very frequently done. In this case a driving rain will beat up against the part A, and water be driven through as shown by the arrow. The nails will also eventually be drawn out by the shearing motion that takes place between the woodwork and the lead which slides sideways, so to speak, by alternately expanding and contracting.

Fig. 178 shows a much better way. In this case the lead apron is continued beneath the sill and over a small deal fillet nailed on the undersill which forms a trimmer for the jack rafters of the roof.

In Fig. 179 the lead apron is shown as being continued between the sills and turned up inside, and nailed to the oak sill. Where the upright neck between the oak sill and the slope of the roof is not left, a wood fillet should be nailed on as shown at X, to prevent the lead apron resting on the top edge of the slates, and thus make them kick out, so to speak, at the bottom.

We will now proceed to describe a dormer window and then a dormer doorway.

Fig. 180 represents a view of the window, the

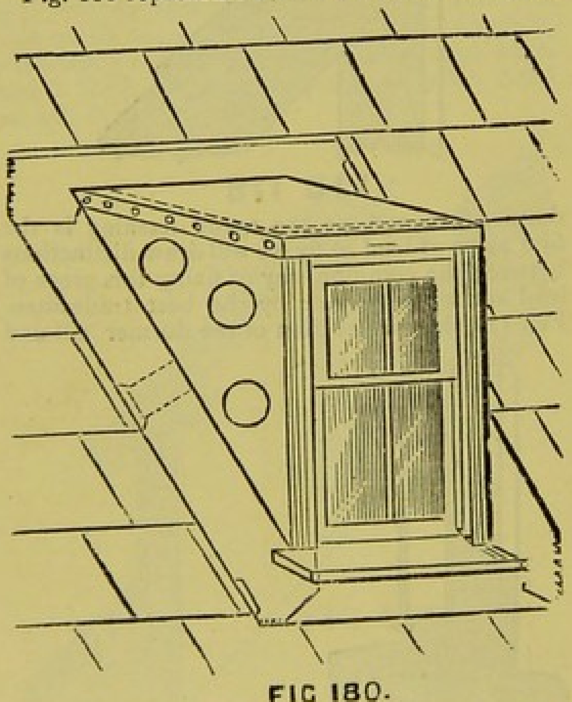


FIG 180.

apron of which was shown in section by Figs. 177, 178, and 179. After the apron the next piece of lead to fix is the cheek. The bottom edge is usually laid on the slates a distance of 6 in., and the top edge is nailed as shown by the dots near the top edge of the dormer, but the fixing is much stronger if the top edge of the lead is turned into a rebate cut into the woodwork on the top and nailed as shown. The front edge of the cheek should be turned on the front of the dormer so as to cover the joint between the sash-frame and the side boarding, it is usual to nail the front edge of the lead and then turn a single welt to cover the nail-heads as shown by Fig. 168. The nailing should be into the sash-frame, some little distance from the edge, so as to not split it off, The nails should not be too near together for the same reason, and they should not be too long so as to pass through the woodwork and interfere with the movement of the sash-weights. In some cases the single welt is omitted and a deal architrave nailed on to the sash so as to cover the edge of the lead and the nails. It is usual to fix a lead tack under the lead that lays on the slates, this should be fixed sloping, as shown, for reasons that were given in an earlier lecture. In the sketch, Fig. 180, the window-sill is shown with the ends projecting beyond the side cheeks of the dormer as usually done. These are great sources of leakages, and the wet generally gets in at these places. The sills should never project beyond the sides of the dormer, as, in addition to the foregoing reason, a lot of useless time has to be spent in working the lead cheek to fit over them. On again referring to the sketch three small circles will be noticed representing what are known as "soldered dots," these being usually made with the object of forming additional fixings for the lead. In an earlier lecture objections to dots were given, but the arguments against them are much stronger in the case we have now before us. One of the principal objections being that the nails, or screws, have such a poor fixing. Fig. 181 will explain this.

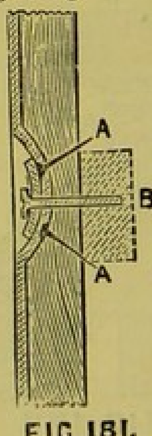


FIG 181.

The ordinary way for making a dot is to cut a sinking in the wood, work the lead into the sinking, drive in two or three nails with the points slanting in different directions, as shown at A, A, and then fill up the hollow space with solder. Sometimes the nails are only partly driven in so that solder may get behind the heads and thus prevent them pulling through the lead, rendering the fixing perfectly useless. Another method is, instead of nails, to use a tinned copper washer, and pass a screw through as shown at B, but this is a very poor fixing and perfectly useless unless a wooden block is fixed as shown by dotted lines, for the screw to pass into. A much better way for this purpose is to burn, or sweat, as it is sometimes called, a secret tack on the back side of the lead, pass the tack through a slit cut through the woodwork, turn the tack down and nail it on the inside as shown by the fragmentary section Fig.

182. In addition to this being a better fixing, the lead cheek can expand and contract

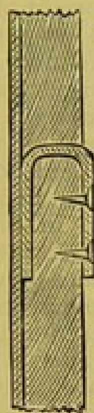


FIG 182.

with a certain amount of freedom without breaking away from its fastenings. Where the dormer cheeks require large pieces of lead to cover them, the lead should be put on in two or more pieces. If the laps are horizontal the under or bottom piece of lead should have the top edge passed through a slot cut in the boarding, as shown by sectional Fig. 160, but if the joinings are vertical or upright they should be welted together as shown by Fig. 166. In this latter case it will be necessary to fix a flashing to lay on the slates 6 in., and stand up 4 in. or 5 in. against the dormer cheek to which it shonld be nailed, and then the cheek lead to lap over it. Where secret gutters or soakers are used the lead cheek would lap over them, but the bottom edge of the cheek should pass below the edge of the slates, or small tacks should be fixed, for holding the free edge of the lead from being acted upon by a high wind

The lead for dormer tops is generally used 1 lb. heavier than that on the cheeks. If 6 lb. is used for the cheeks the tops should be 7 lb. The lead on these places should be well fixed, if not, a high wind will roll it up like a piece of paper. Soldered dots are sometimes used for this purpose and the edges of the lead left projecting

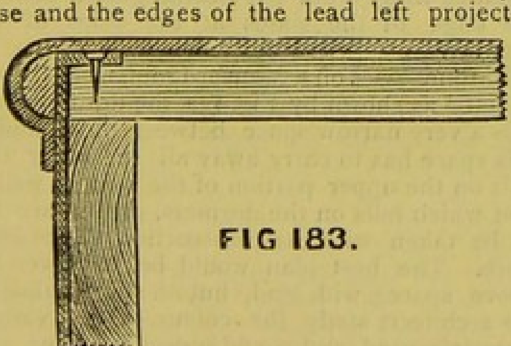


FIG 183.

beyond the front and sides to form dripping eaves, but the objection to dots has been before described. Another way for firmly holding the edges of the lead is to dress them down and turn a secret tack, as shown by Fig 149. In some cases a nosing is fixed and the lead worked over it, as shown by Fig 183. This makes a neat finish, holds the edges from being blown up by the wind, and yet allows the lead to expand without breaking. In cases where the rain-water would stream down the front and over the window, a small groove can be cut in the woodwork on the top of the dormer and the lead chased into it, as shown by the double dotted line, Fig 108, so that the water would run down the sides; or the dormer top could be constructed with a fall from the front edge to the sloping roof.

Dormer doorways require slightly different treatment to dormer windows. The latter generally have sashes made water-tight, but the doorways frequently leak at the top edge of the door. The way to treat this part of the work is shown by Fig 184, which is a vertical section

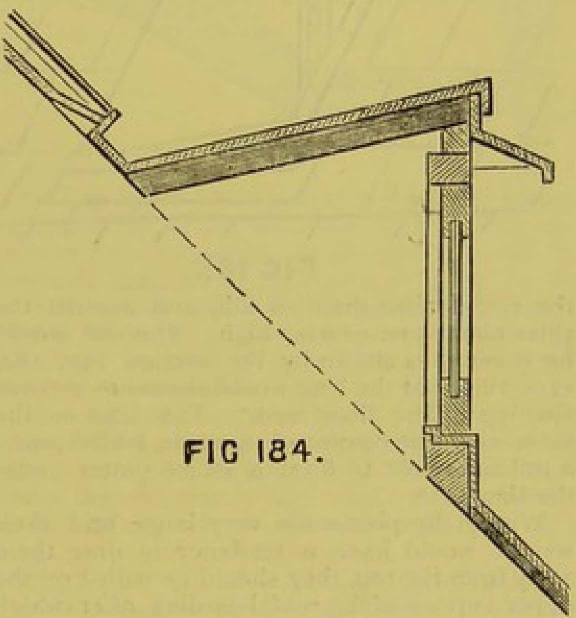


FIG 184.

of a common kind of doorway. A triangular deal fillet is nailed on over the opening and a piece of lead fixed to cover the fascia and also the fillet, so as to form a kind of hood or shield over the part referred to as being a source of weakness. The upright sides of the frame should have a groove in the rebate for the door to prevent capillarity, and the sill should be covered with lead, so that whatever water streams down in the side joints of the door would be caught and conveyed outside. In the section the wooden sill is shown as not projecting beyond the door-frame. When done this way it is much easier to make this part water-tight than when the sill projects, as shown by Fig. 180. The writer cannot see any use for this projecting sill, and presumes it is fixed more from custom than either appearance or utility.

Internal doorways are sometimes fixed and form a convenient access to a roof as they have a floor on which any one can step or stand when getting on to the roof without risk of falling or injuring the slates. Fig. 185 is a sketch showing a doorway of this kind in the sloping side of a roof.

An apron should be fixed to lay on the slates at least 6 in., as shown at A, and the floor B should be covered with lead, the lead standing up at

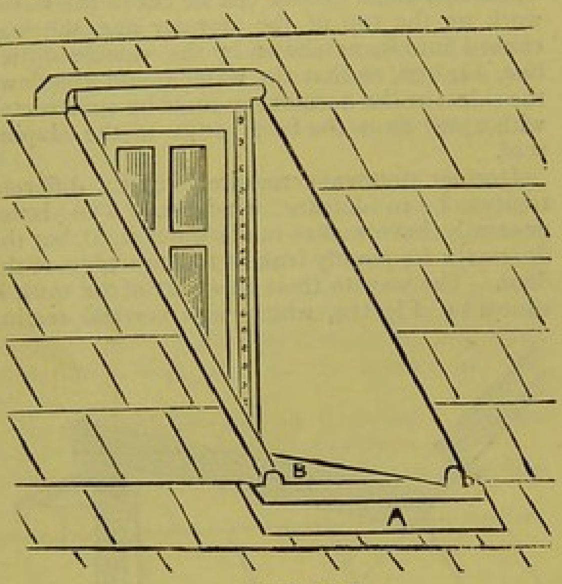


FIG 185.

the end against the door sill, and against the sides about 5 in. or 6 in. high. The sill would be covered as shown by the section Fig. 184, excepting that the lead would answer as a cover flashing to the floor lead. The lead on the sides would be continued upwards, folded round a roll and made to form a secret gutter under the slates.

Where the pieces are very large and their weight would have a tendency to drag them away from the top, they should be nailed on the upper surface of the roof boarding after which the roll should be nailed on and covered with lead which should hang down over the sides and also be folded to form a secret gutter as shown in section by Fig. 186. It is not at all

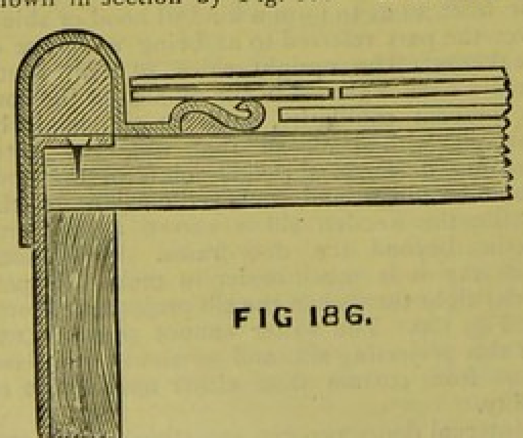


FIG 186.

a good plan to lay the top edge of the lead on the slates when it would have its free edge exposed to the wind or a driving rain. Neither is it a good method to nail the top edge of the lead on to the roof boarding and then fix the slates over it so as to leave their edges exposed in the same manner as described for the lead.

The ends of the upright pieces of lead should be returned, nailed to the door frame and a single welt turned over the nail heads as described for the dormer window Fig. 180. In some cases these upright edges have been worked into the rebate of the door frame, but it is difficult to keep the lead straight and true so as to make the door fit moderately tight to keep rain from driving in through the joint.

The door head will next receive our attention. The water that streams down the roof immediately above the doorway should not be allowed to run down and over the door nor yet to fall like a cascade and splash about on the floor near the door. A hood could be fixed as shown by Fig. 184, to protect the door, but this would not get rid of the other evil. An eaves gutter could be fixed with ends open so as to discharge on to the roof at the sides of the doorway or the ends could be stopped and a pipe fixed from the gutter to discharge onto the floor. Another method would be to construct a gutter as shown in section by Fig. 187. In this case the ends of

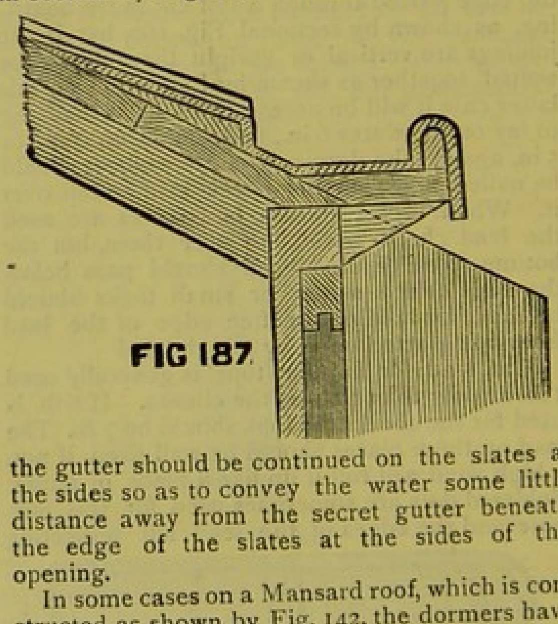


FIG 187.

the gutter should be continued on the slates at the sides so as to convey the water some little distance away from the secret gutter beneath the edge of the slates at the sides of the opening.

In some cases on a Mansard roof, which is constructed as shown by Fig. 142, the dormers have only a very narrow space between them, and as this space has to carry away all the water that falls on the upper portion of the roof, as well as that which falls on the dormers, great care has to be taken with the construction of the lead-work. The best plan would be to cover the above spaces with lead, but on some buildings the architects study the colour of the various materials used, and would object to some portions of the roofs being the colour of lead, and other and similar portions that of slate. Where the roof is entirely covered with lead the problem is easy enough, but when slates are used to cover the roof, and lead to make various portions water-tight, without being too conspicuous, the problem becomes more intricate. The best method to be pursued in this case is to use soakers, as ordinary flashings are useless, for the reason that the water will get beneath the part that lays on the slates, and so pass into the roof. In some cases where cheeks are fixed so that their bottom edges lay on the slates, it has been found necessary to use soakers as well, where the dormers come nearly close together, the part on the slates being left simply for the sake of making the whole of the work rhyme, so to speak, and not because of its actual necessity in all cases.

Where roofs are covered with tiles and lead used for the weatherings, a little ingenuity is sometimes required to make the work look neat. As an example, the apron to a chimney, or dormer, looks ugly, by reason of the edges of the tiles standing so high above the lead apron at the ends. This can be best explained by means of a sketch; see K, Fig. 188. A neat way to avoid this is to nail on two deal fillets, one thicker than the other. The top fillet to form a ground to support the lead close to the chimney, and the other for the top edge of

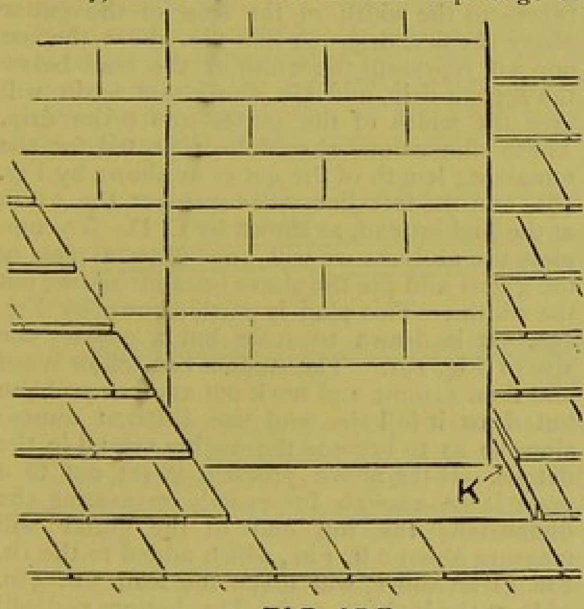
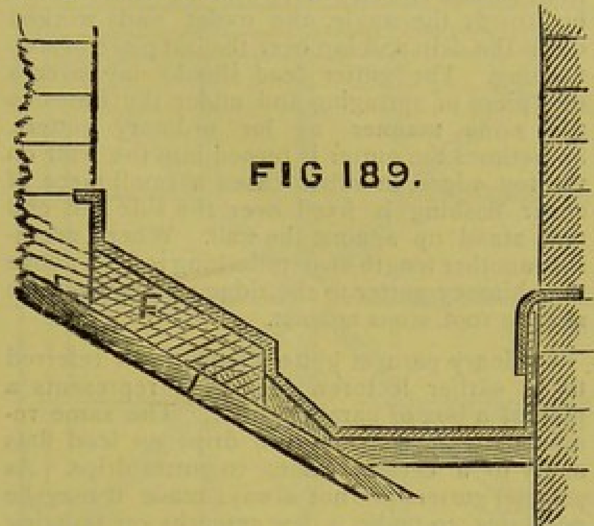


FIG 188.

the heading cour:e of tiles to lay on, and thus bring them up level with those at the sides. When the chimney or dormer comes a short distance above a gutter, the tiles can be left out, and the space boarded up even with the surface of those at the sides. The section, Fig. 189, will make this more clear. The piece of board is shown at F, and should have a thickness equal to the springing, plus two thicknesses of tiles. The dotted lines shows the tiles at the sides, and also the springing. I may here say that I prefer to have a second springing nailed on beneath the ordinary one, as shown in the section. In all the illustrations that have been given, the springing has been shown as generally done in practice, but as last illustrated is much the best, as the "setting in" of the lead below the springing is not necessary. In some cases the lead will slip down and form a buckle over the edge of the springing. This is often found in old work. In addition, water will get in at the laps, pass along this buckle, and so get into the roof.

FIG 189.



In Fig. 189 the lead gutter is shown as laying up the slope of the roof and turned into the joint of the brickwork. It should have had an apron flashing fixed from the chimney to lay over the gutter lead. As illustrated the gutter lead is fixed too tightly and would eventually break or be dragged out of the joint between the courses of bricks.

It frequently occurs that a chimney will project from a party or gable wall into the roof. In these cases the step flashing is fixed below the chimney in the usual way as shown at A, Fig. 190. Some plumbers will boss up a

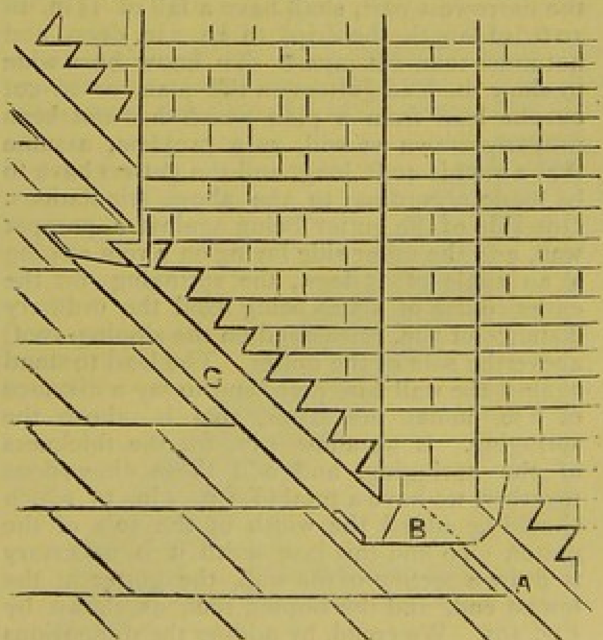


FIG 190.

corner at the top end, but this is not necessary. The apron B should then be fixed, a corner being bossed up to fit the internal angle, and the part that lays on the sloping roof should lap over the top end of the lower piece of step flashing. A side flashing is then fixed as shown at C. A small gutter should be made to fit behind the chimney, with a corner bossed up to fit the angle, the outlet end worked down the drip and lap over the last piece of step flashing. The gutter lead should lay over a thin piece of springing and under the slates in the same manner as for ordinary gutters. Sometimes the gutter is turned into the wall on the top edges, in other cases a small piece of cover flashing is fixed over the side and end that stand up against the wall. Where necessary another length of step flashing is fixed above the chimney gutter to the ridge or whatever the sloping roof stops against.

Ordinary parapet gutters have been referred to in earlier lectures. Fig. 111 represents a plan of a box or parallel gutter. The same remarks which were made on drips on lead flats apply to a certain extent to gutter drips. As parallel gutters are not always made it may be advisable to make a few remarks on tapering gutters. In the first place a plan of a roof showing a tapering gutter cannot properly be made until it is known how wide the lead should be shown on the plan. And then again, when plans are made for the plumbers guidance, he could not from those plans always know how wide he should cut out his pieces of lead for the gutters, especially when the plans have been prepared in a haphazard way, and the width of the gutter not worked out in a proper manner. Architects, in their specifications will sometimes stipulate that the gutters shall not be less than 1 ft. wide at the narrowest part, shall have a fall of 1¼ in. in 10 ft. of length, the drips to be 2 in. deep, and not more than 8 ft. apart. To know how wide to show the lead gutters on the plan, or to cut out the lead from a plan which has not been properly drawn we will, as a problem, assume that a roof is 40 ft. long, and the gutters have to be made according to the above stipulations. One side of the gutter being against a parapet wall, and the other side laying on a roof sloping at an angle of 45 degs., the springing for the eaves course of slates being fixed the ordinary distance of 3 in. (measured on the sloping roof) above the sole of the gutter. The lead to stand against the wall 6 in. high, and to lay a distance of 6 in. under the slates, that is, above the springing. If we allow 1 in. for the thickness of the springing, and add these dimensions together, we have a total of 1 ft. 4 in. to which should be added the width of the sole of the gutter. To find this last width it is necessary to draw a section of the wall, the gutter at the lowest end, and the sloping roof, as shown by Fig. 191. We could, by adding the dimensions together get to know how wide the lead would be at the highest end, but as we wish to know the widths at various intermediary distances we will work it out step by step. Now a fall of 1¼ in. in 10 ft. is equal to ⅛ in. to each foot. As the drips are 8 ft. apart the fall from the first drip to the lowest end is eight times ⅛ in. or 1 in. If we now draw a line 1 in above A, B (which represents the sole of the gutter at the lowest

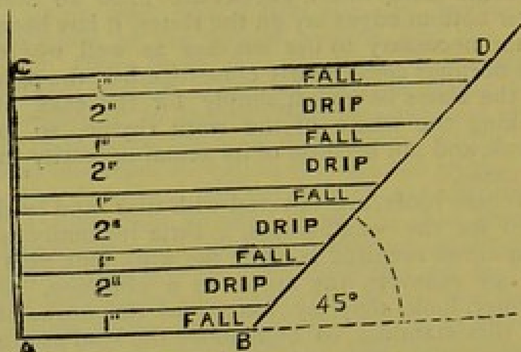


FIG 191.

end) and parallel with it the length of that line represents the width of the sole of the gutter below the first drip. We then draw a line parallel with the last one, but 2 in. above it to represent the width of the sole of the gutter above the first drip. A line 1 in. above the last one will represent the width of the lead below the second drip, and 2 in. above that again will give the width of the gutter above the drip. These dimensions should be repeated for the remaining length of the gutter as shown by Fig. 191, and the last line will represent the width at the highest end, as shown by C, D. To complete the problem we will now draw a plan of the gutter and use the above lines for setting out the widths. This plan is partly shown by Fig. 192. It is drawn to scale but a quarter the size of Fig. 191. The student can follow it out and then assume and work out another problem but draw it full size and use different dimensions so as to become thoroughly versed in the details. If the above problem is set out to a scale large enough for exactly measuring the dimensions the top end of the gutter will measure about 2 ft. 1 in., which added to the 1 ft. 4 in. given above, will make the lead 3 ft. 5 in. wide at the highest end. The bottom end will measure 1 ft. which, added to the 1 ft. 4 in., will give 2 ft. 4 in. as the width at the lowest end. If the 3 ft. 5 in. and 2 ft. 4 in. are added together and divided by two, we have a mean width of 2 ft. 10½ in. The net length of the gutter, plus the turn up against the two ends and an allowance of 8 in. for each of the four drips, will give a total length of 43 ft. 8 in. If the above dimensions are squared up, we find that the superficial area of the lead used for the gutters will be 125 ft. 10½ in. Multiply this by the weight per foot of the lead used, and we then know the total weight of the lead in the gutters.

Some architects will describe in their specifications the lead to lay under the slates a distance of 9 in., but this is a waste of material, as 6 in. is quite enough. Other architects will specify the lead to lay up the sloping roof to the same vertical height as that side which stands against the wall, meaning thereby that a horizontal line projected from the top edge of the stand up lead against the wall onto the sloping roof, will show the distance the lead has to lay up the roof. But this does not always work out well in practice. As an example, let the line E, F, Fig. 193, repre-

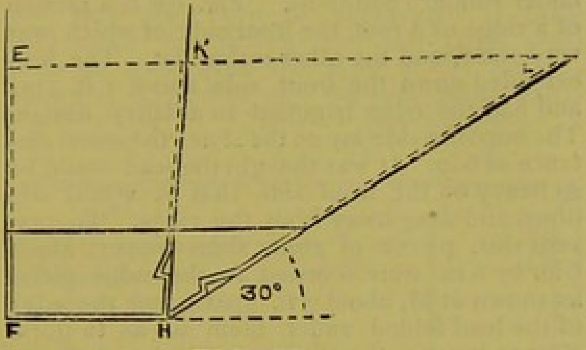


FIG 193.

sent the face of a parapet wall, F, H the sole of the gutter, H, K the slope of a roof which is nearly upright, and H, L the slope of a low-pitched roof. In one case the lead will be only 3 in. under the slates, and in the other it will be about 11 in. On the face of the argument, this appears to be a good plan, as the gutters will hold more water, should they become choked with snow or any other obstacle, than if one side was lower than the other. But it is a useless provision, as long before the gutters became full of water, it would have leaked or passed through the drips, assuming them to be of the ordinary height. To carry the above argument to its logical conclusion, all gutters should stand up at the sides to a level line carried all round, in which case the lower gutters would be a considerable depth. In the example shown by the last figure, the dotted lines represent the lead continued upwards for the lower gutters, and a glance will show the waste of materials.

All gutters should have wooden racks laid in the bottom. There are several reasons for this. They protect the lead to a certain extent from the effects of the sun's heat rays. They save the lead from being worn from walking over it by chimney sweeps or workmen. In the winter time the racks would act as strainers during a fall of snow, allowing the water to run away as the snow became melted by the warmth of the house. This is a much better plan than sending men onto the roof to pitch off the snow into the street, or a backyard, using for the purpose common iron shovels, which they dig into the lead, frequently making holes through it. When snow must be removed from a roof, wooden shovels should be used. These can be made out of pieces of deal board, cut to the required shape.

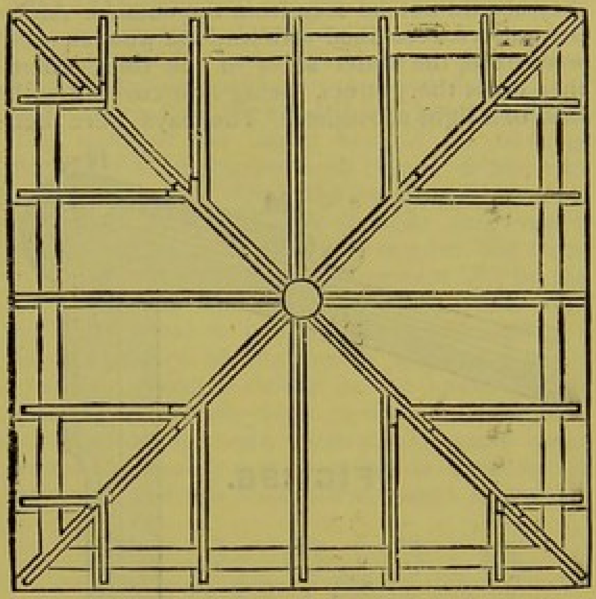


FIG 194

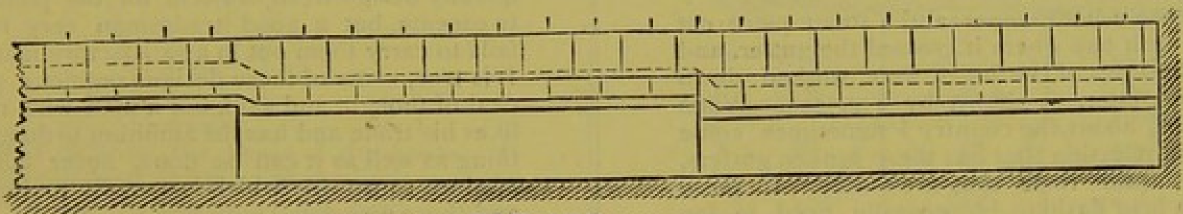


FIG 192.

In some kinds of architecture the gutters on roofs are arranged so that they cannot be seen from below, or yet have parapet walls, the gutter being sunk into the roof. Fig. 194 represents the plan of a lead covered roof on a clock tower that was so arranged, and Fig. 195 is a section across the gutter. The gutters

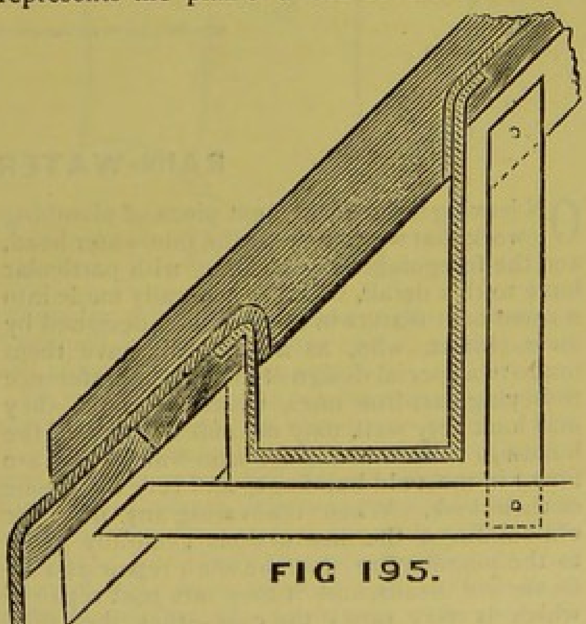


FIG 195.

were continued all round the roof, had drips and a fall towards two opposite corners and rain water down pipes fixed inside the tower so that they should not be seen from the outside. After the gutters were lined with lead the wooden rolls were fixed, the under sides of the rolls, where they cross the gutters, being first covered with lead of a light substance. The bays were then

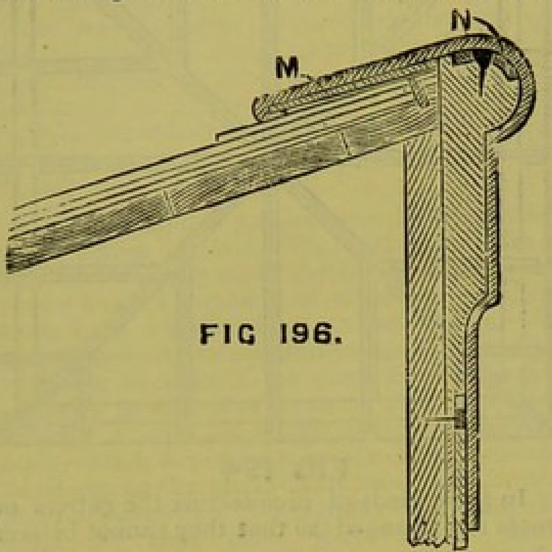


FIG 196.

laid in the usual manner and a small piece cut out of each bay where it crossed the gutter, and then the sides of the holes were worked down into the gutter, as shown by Fig. 195. When travelling about the country I sometimes come across a mansion that has these sunken gutters, but let into roofs that are slated. In these cases a lead flashing is generally fixed to lap over the slates on the lower side of the gutter It is necessary that these flashings should be well fixed, otherwise the wind can get under the free edge and eventually lift the lead off its position. There are various ways of doing this —not only in the above positions, but in others under similar conditions. Fig. 196 is a section of a ridge of a roof, the front side of which was very steep, and the other rather flat. The lead extended down the front side about 1 ft. 3 in., and had the edge trimmed to a fancy design. The opposite side lay on the slates the usual distance of 6 in. It was thought the lead would be so heavy on the front side that it would slip down and drag away from the ridge. To prevent this, pieces of stout sheet-copper, about 6 in. by 6 in. were screwed to the ridge piece, as shown at M, about 3 ft. apart, and the edge of the lead folded under them so as to form clips to prevent the above occuring, and also to hold the edge of the lead from being blown up by the wind. Secret tacks were also sweated on, as shown at N.

Several more lectures could be given on roofing and external plumbers' work, but what has been written will cover most of that which is found in everyday practice. Extraordinary cases frequently crop up, and architects frequently design fresh subjects for the plumbers to execute, but a good tradesman very rarely fails to carry them out in a satisfactory manner. It is true, some of these designs require a great deal of thought and skill, but a man who really likes his trade and has the ambition to do everything as well as it can be done, never fails to produce something which is a credit to himself and those associated with him.

RAIN-WATER HEADS AND PIPES.

ON leaving the roof the next piece of plumbing work that we come to is the rain-water head, and the foregoing remarks apply with particular force to this detail, which is generally made into a prominent feature in any building designed by an architect, who, as a rule, will have them made to a special design of his own in preference to buying cast-iron ones, which, although they may look very well, may not suit the style of the building. Lead heads for rain-water-pipes are found in most old buildings, and very nice some of them look. When renovating any of these old buildings, the instructions generally given to the plumber are that he shall repair and refix the old heads, and if they are past repair—which is very rarely the case—that they shall be reproduced exactly like the old ones. At a country mansion where the writer was fixing new soil-pipes outside the house, he had to make lead-heads to match the old ones, and fix them over the top ends of the soil-pipes, so that they should look like rain-water-pipes, and thus disguise their real use. It is not my intention to illustrate any of these old heads, or to give designs for new ones, but simply to dwell a short time on a few details in connection with them. In the first place, lead-heads never wear out, they sometimes get knocked about by ladders, or distorted by workmen standing upon them. They sometimes break away from their fixings, thus showing want of thought on the part of the men who fixed them. Some heads, according to their size, weigh a great deal. I have seen them weigh over 1 cwt. The usual method of fixing them is to have the back lead project beyond the sides some distance, to form lugs or tacks, and wall hooks driven through these tacks into the joints of the brick walls, or into wooden plugs driven into dowel holes cut into the stone, when the walls are built of that material. Now it stands to reason that even ½ cwt. hung on four, or perhaps six wall hooks, must eventually break away from the wall. The evil is aggravated if these wall-hooks are driven into the tacks some distance away from the sides of the head as shown at N, N, Fig. 197, the tack being partly

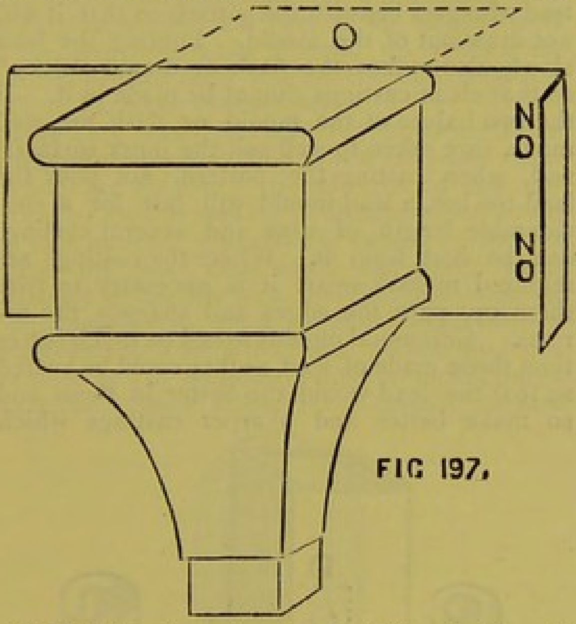


FIG 197.

unfolded to show the heads of the hooks. If the piece of lead which forms the back is made large enough so that when the head is made the back will stand up 3 in. or 4 in. higher, it can be folded back as shown at O by dotted lines, let into the wall, wedged with lead wedges, and then pointed up with cement. In the case of fixing the lead on the face of a stone wall a raglet, or chase, could be cut for the back lug of the head to turn into, and then the chase filled up by pouring in molten lead in the same way that lead flashings are "burned," as it is commonly called, to stone walls. This is not difficult to do. A piece of dry deal should be cut as shown by Fig. 198, the lower portion of

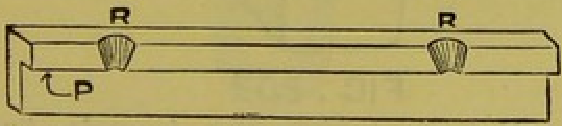


FIG 198.

the face to be recessed equal to the thickness of the lead so that the upper portion will fit tightly against the wall above the chase in the stone. The edge P should be placed even with the top edge of the raglet and struts placed to hold the piece of wood in its position. Pouring holes, or channels, should be cut as shown at R, R. One can be used as a pouring hole and the other will act as an air vent. When burning flashings to stone walls the length of the piece of wood should not exceed 2 ft. If a longer length of burning is attempted it is necessary to have more men to pour at the same time as the lead will not run freely, in the chase cut in the cold stone, for any long distance. Care should be taken not to have the molten lead too hot or it will melt the lead flashing, or the "turnin" of the head if one is being fixed. The ends of the raglet beyond the burning stick should be stopped with clay or a piece of common putty. When the burning stick is removed the lead will look straight and even if properly done, and will not require any trimming beyond cutting off the runners left by the pouring holes. As the lead shrinks when cooling it is usual to use a blunt hand-chisel and hatch the face of the run-in lead to cause it to swell out and fit tightly in the stone. This hatching is usually done to what is commonly called a herring-bone pattern. In some cases a caulking tool or a staving iron is used to set up the face of the lead, but in some cases this

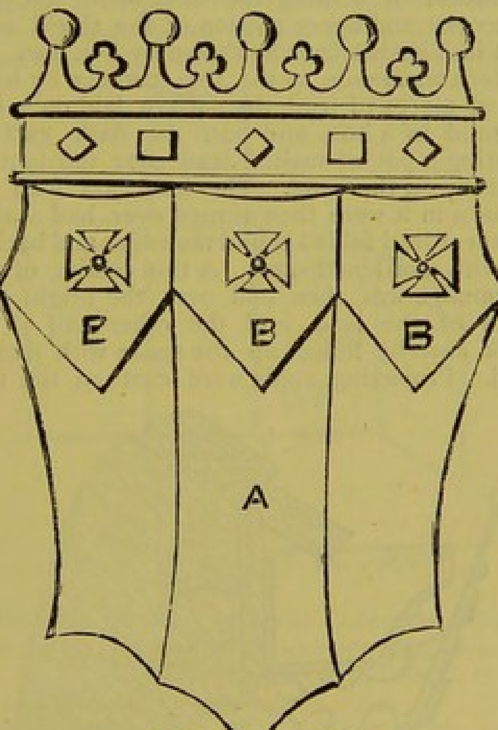


FIG 199

causes the edges of the stone raglet to become "stunned," as stonemasons call it, so that they will afterwards crumble away.

In country mansions we frequently see lead shields substituted for rain-water heads. The shields being fixed to hide the connection of down-pipe with the gutter, and also act as an ornament. Fig. 199 is a sketch illustrating several that the writer fixed some 12 years ago at a nobleman's mansion. The body A was made out of a piece of 8 lbs. lead, blocked and worked on a piece of oak cut to the pattern. The piece B was also blocked in the same manner and fastened on to the body by means of the crosses

C which were cast in a leaden flask (made for the purpose), and had lead tags to them as usually cast on leaden clacks for jack pumps.

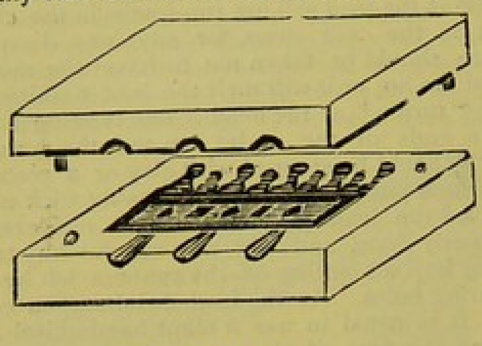


FIG. 200

Holes were made through the two pieces of lead forming the body of the shield, the tags of the crosses passed through and rivetted on the back side. This being carefully done so as not to bruise or scratch the faces of the crosses. The crest and upper portion of the shield were cast in a leaden flask as shown by Fig. 200. A pattern was made in the first instance by hand out of pieces of lead, the pattern laid on a bed of sand in a box, and half the flask cast by pouring a pot of melted lead over the pattern as it lay on the sand. The half flask with the pattern in it were then turned over, had a strip of sheet-lead folded round the edges and backed up with moistened sand. A thin coating of soil or smudge was then laid over the bright portions of the lead, and the other half of the flask cast by filling up the space with melted lead. Projecting studs were cast on the first

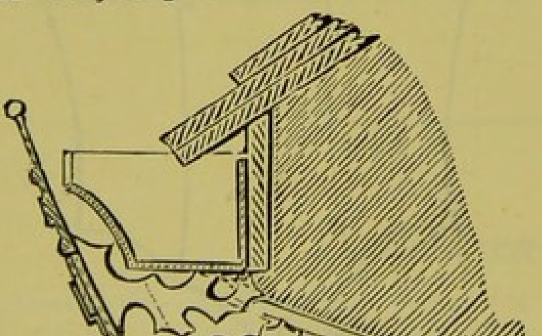


FIG. 201

half of the flask so that on making the second half sinkings were cast for the studs to fit into. By doing this the two halves fit exactly in the right positions, and the two outsides of the pattern come opposite each other. Should any reader attempt to make a lead flask for casting any small lead articles he will find it an advantage to have a very large ladle and pour the melted lead into the pattern as quickly as possible. In some cases I have had a pot full of melted lead and upset it on to the pattern. If the lead is poured slowly, the pattern, it of lead, will twist and wind out of shape by the unequal expansion which takes place when the melted lead comes into contact with the pattern. The lead also gets beneath the pattern so that it will not draw out of the mould. Pouring the lead slowly also makes the flask or mould "flaky" so that clean castings cannot be made in it. If the two halves of the mould or flask are well made, care taken to well soil the inner surfaces, and, when casting the pattern, not pour the lead too hot, a lead mould will last for a considerable length of time and several castings can be had from it. Where the castings are required to look smart it is necessary to trim them up, pare the edges and sharpen the arrises. Gun-metal moulds would be much better than those made of lead, as they could be heated so that the lead would run better in them and so make better and sharper castings which

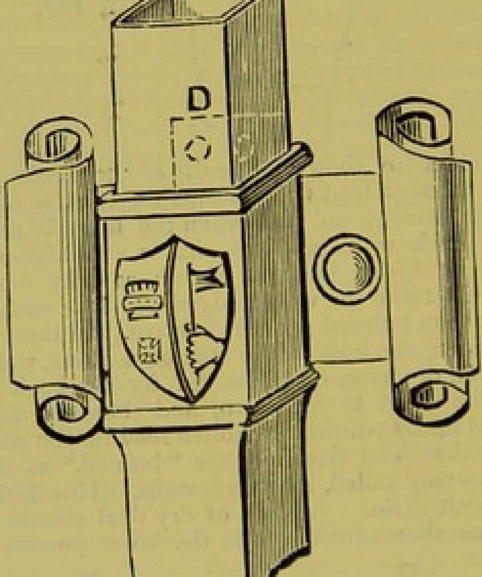


FIG. 202

would require less trimming afterwards. But gun-metal moulds are costly and cannot be made by the plumber in the same manner as those of lead and which answer their purpose fairly well.

On each side of the shield, shown by Fig. 199, lead foliage was fixed, the pattern being as shown by Fig. 201. This last figure also shews a section of the shield and the double bent-pipe from the eaves gutter under the soffit of the projecting eaves of the roof to the walls of the house. The pattern of the foliage was cut out of a piece of sheet-lead, and then a flask or mould made as described above, the flask being afterwards used for casting as many as were required. The rain-water-pipes were of lead, the sockets being quite plain.

At another job in the north of England, ornamental lead-heads were made, the down-pipes were of lead, square in section, and the sockets were ornamented, as shown by Fig. 202. So that the weight of the pipes should not drag down and distort the large projecting and scrolled ears the back part of the socket end of the pipe was made to stand up about 4 in., and flat-headed nails driven through into the wall, as shown by dotted lines at D.

It is very rarely that soldered joints are made to leaden rain-water-pipes when they are fixed outside the building. In addition to the unnecessary cost of making joints, the pipes would not look so well, especially if fixed in positions where the sun's rays would fall upon them. Some the writer has seen, and that had soldered joints, looked—to use a colloquial expression—as crooked as a dog's hind leg. When the pipes are fixed in 6 ft. lengths, and plain socket joints made, each joint allows for a certain amount

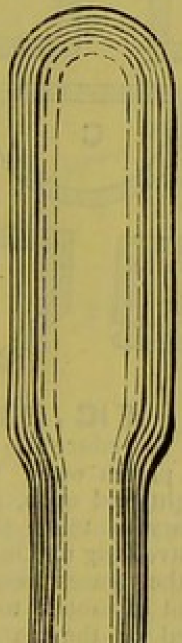


FIG. 203

of expansion to take place without forcing the pipes out of a straight line; but care should be taken not to allow the spicket end of the upper pipe to rest in the bottom of the socket on the lower pipe. About ¼ in. to ½ in. space should be allowed for the free expansion of each length of pipe.

When plain drawn lead-pipe is used, it becomes necessary to open the top end of the lower pipe for the spicket end of the next length o socket into. This is usually done by means of a hand dummy, but it is a much better plan to have a wooden mandril, made as shown by Fig. 203. The smaller portion of the mandril should be a trifle smaller than the size of the inside ot the pipe, and the upper portion a little larger than the outside size of the pipe. The mandril having its smaller end placed in the end of the pipe, and driven in with a good sized mallet, will enlarge the pipe, and form the required socket. Three or 4 ins. in depth is quite sufficient where the pipes are intended to be quite plain. In some cases the sockets are ornamented by means of a bead turned on the top of the socket and sometimes another bead is soldered on the bottom edge to make it look smarter. Strong lead ears being cast and soldered onto the back of the socket between the beads for nailing to the wall and suspending the pipe. There are large numbers of examples of sockets, as shown by Fig. 204. This is a very old design, but it has been used a great deal in later years on houses of modern construction. For country mansions sometimes the family coat-of-arms is planted on, as shown by Fig. 202, and the ears are scrolled, as shown by the same illustration.

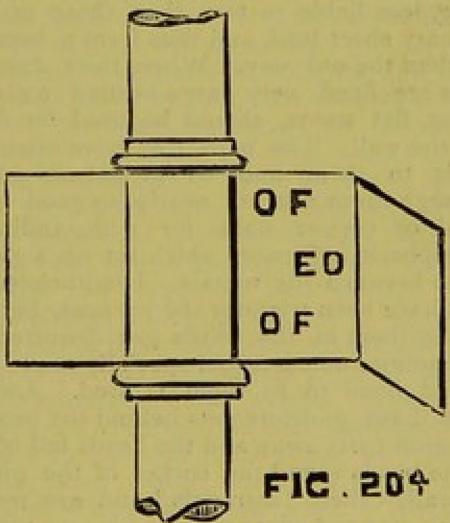


FIG. 204

In Fig. 204 the ears, or tacks as they are sometimes called, are shown as usually made, and are 9 in. or 10 in. high, and project about 9 in. on each side.

These tacks have two thicknesses of lead. Flat-headed wall-hooks are driven through the under thickness into the joints of the brick walls, and then the other half of the lead is folded, so as to fit tight up to the pipe, and cover the heads of the wall-hooks to hide their unsightly appearance, and also to protect them from the weather, which would soon cause them to rust away—where lead and iron are in actual contact in the presence of moisture a Voltaic action is set up, in which case the iron will eventually entirely rust away. The right hand tack is shown as only partly folded, so as to make clear what is intended, and also to show the position of the wall-hooks. These should be driven in as close to the pipe as possible, as shown at F, F, and not some distance away as at

E, so that the weight of the pipe will not drag it away from the wall, and tear the tacks away from the hooks. When driving in the hooks, a foul blow with the hammer will sometimes bruise the pipe, but this can be prevented by holding a small iron plate near it when driving

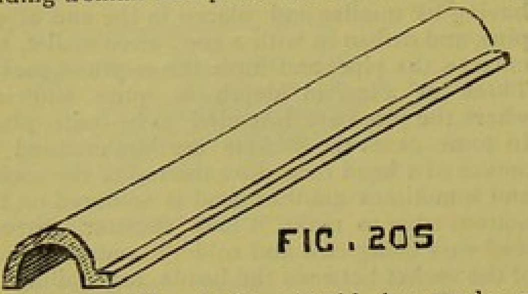


FIG. 205

the hooks. The tacks should be made of thicker lead than is usually the case.

Several master plumbers have, these last few years, introduced cast lead-ticks of about 3-16th in. to ¼ in. in thickness, and of an ornamental design. In some cases the people who fixed the pipe can be known by the design of the tacks. These thick tacks are a great improvement, as being less liable to tear than those made of ordinary sheet lead, and thus form a better fixing than the old way. When thick cast lead-tacks are fixed, very large-headed nails with strong, flat stems, should be used for driving into the wall. The nails can have ornamental heads to them and be of galvanised iron, although these are not nearly so good as gun metal or copper nails for withstanding the atmospheric influences which set up a galvanic action between the metals. Lead-headed iron-nails have been tried for the purpose, but when driving them in, the heads get distorted with the hammer unless a tool specially made with a cupped head to fit them is used. And then again if any moisture gets behind the heads the iron soon rusts away and the heads fall off.

The beads round the socket of the pipe are generally called "astragals" and are made in various ways. A piece of ½ in., ¾ in., or 1 in. pipe, sawn down the centre is sometimes folded round the socket and soldered with fine solder and copper bit or blow-pipe. In most large plumbing shops a set of cast iron astragal moulds is kept for casting astragals of various sizes. Fig. 205 is a sketch of one of the most common

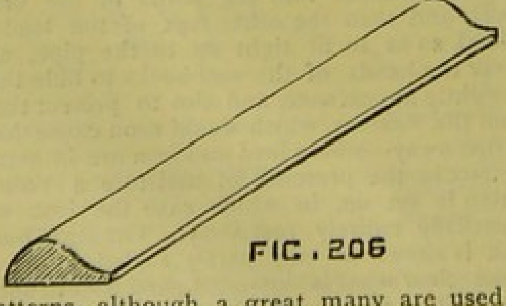


FIG. 206

patterns, although a great many are used as shown by Fig. 206. These astragals are only intended as ornaments and do not add to the strength of the pipes or fixings. Plumbers will frequently design a neat astragal and cast them themselves.

In most cases plain round drawn lead-pipes are used for rain-water leaders. Some pipe makers have dies and mills for drawing pipes of a square section, but if any other design is required, they have to be made by hand out of sheet lead. In Fig. 207 A is a section or end view of a round fronted pipe with a right angled back made to fit in an angle of a building. B is a pipe of a rectangular section. C has a flat back and round front; D is a rectangle, with rounded corners, and E is a semi-octagon in section. To make these pipes it is always advisable to have a wooden block, a foot or two longer than the pipe; for folding the strips of sheet lead round and working up the arrises to a straight and moderately sharp edge. In some cases the plumber will strike lines where the lead should crease to form the angles and then run the point of a sharp-pointed shave hook over

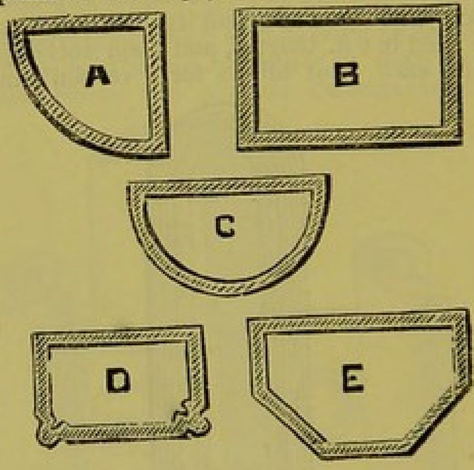


FIG. 207

the lines, so as to reduce the thickness of the lead at those places when the lead can be folded up straight and even, and so that it is scarcely necessary to touch the outside with a dresser, thus avoiding making any tool marks, which in the other cases require some considerable amount of labour to work out again. The lead worked on the mandril is much the best, and makes the strongest work, but in the absence of a mandril the latter method may be adopted, but the inner angles should be shaved about ⅛ in. wide on each side, and soldered down with coarse solder, either by means of a well-tinned and pointed copper bit or a blow-pipe, with gas as the heating agent, as shown by Fig. 4, or the spirit lamp shown by Fig. 5. It is not necessary to leave a large amount of solder in the angles, but care should be taken that the solder flows down to the bottom of the scoring, and thus leave the angles as strong as if the lead had not been reduced by the shave-hook. The pipes have a soldered seam on the outside at the back. When it is necessary to change the direction of a down-pipe to avoid a window, to pass round a string course, or over the plinth or projecting base of a building the pipe has to be bent. In the case of round pipes this is easy to do, but where pipes are used of the sections shown by Fig. 207, it becomes almost a necessity to cut the pipes, make elbows and solder the mitres. I need not dwell upon this, as the method was explained in earlier lectures, and illustrated by Figs. 95 to 99. Square or rectangular pipes may be excepted from the list, as it is possible to make a bend in those pipes, as shown by Fig. 208. For this purpose it is best to use a length of round pipe; make the bend in the

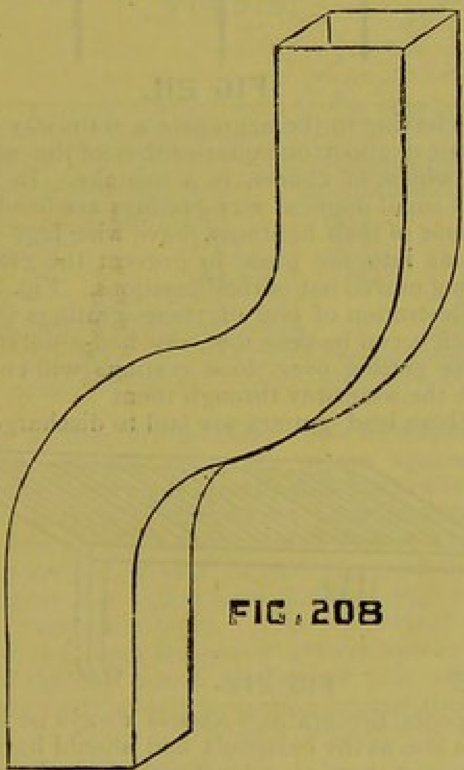


FIG. 208

ordinary way, and then raise the parts intended for the external angles from the inside by means of a hand dummy, the outer faces being then dressed flat between the angles, and the arrises worked up nice and true, and so as to take out all tool marks. To make a 4 in. square bend, which must not be confused with an elbow, it will be necessary to use a 5 in. round pipe. For a 3 in. square pipe a piece of 4 in. round pipe would have to be used. Any other sizes the student can work out for himself by remembering that the outside girt of the round pipe must equal that of the square pipe when made.

Rain-water-pipes are frequently made with ornamental fronts, and to special architectural designs. Some of these have to be chased into the pattern cut on a wooden mandril. Where a large quantity is required, it is best to have a wooden pattern made, with which make a print in a bed of nice clean loamy sand, and then cast a mandril or mould with "hards," which is composed of lead and solder, and is generally made by cutting all the joints and solder out of the old lead brought home from the various works. The lead can be chased better on this than on one made of wood, it being heavier, not so springy, and will keep the sharpness of the pattern or mouldings much longer. The moulded fronts of rain-water-pipes are sometimes cast by the plumber, who will make a print on his casting frame, will then cover the frame with lead, and draw a strike down in the same manner as when casting small sheets of lead. There are machines for drawing sheet-lead through dies, and thus form certain shapes in the same manner that zinc is drawn to form tubes, guttering, &c. In most of these cases it is necessary to solder on the back sides of the pipes afterwards, and in some instances the sides are soldered onto the front by wiping the inside angle down in the same manner that cistern bottoms are soldered.

When rain-water-pipes are fixed on an external face of a wall, and with an inclination, instead of being vertical, they should always be blocked out some little distance. If this is not done dust and other matters will accumulate on the pipe, or between the pipe and the wall, and afterwards get washed down by rain, thus making a lot of unsightly, black-looking streaks on the face of the bricks, stones, or whatever materials the walls are constructed. Some architects specify that all rain-water leaders, whether lead or iron, shall be fixed clear of house-walls for the reason that the water from a leaking pipe will soak into the walls, and frequently pass through them. When walking through a house, it is not at all unusual to see the colour taken out of the wall-papers, or painted decorations spoilt by a leaking rain-water-pipe fixed outside. Even when the pipes are in good order they sometimes get choked with leaves or birds' nests, with the result that, when raining, water will escape at the joints and stream down the walls. When the pipes are fixed inside the house the evil is aggravated. In this case lead-pipes are the best, and they should have soldered joints. Lead-pipes, when fixed outside, last longer if the joints are socketted, and not soldered, especially when they are exposed to the heat from the sun, which causes them to expand and become distorted out of a straight line.

To prevent anything getting into down-pipes to cause a stoppage, gratings should always be fixed over the inlet ends, but this will be referred to later on.

When rain-water-pipes are fixed in a slanting direction, on a front of a house, they always look unsightly, and are liable to have a stoppage take place in the bends or elbows. For these reasons architects will frequently have an open trough or gutter fixed in a horizontal direction to convey the water from the bottom end of one pipe to the top of another. Fig. 209 will illustrate what is meant. In some cases these troughs are quite plain, and are fixed on a projecting moulding, or string course, the whole width of the building, and where there are gables the pipes from the gutters between them will be made to discharge into the trough from which a pipe is fixed at some convenient position to convey the water to the ground level. In other cases these troughs are made to an ornamental design, and in addition to the top edge being turned into the wall for a fixing and

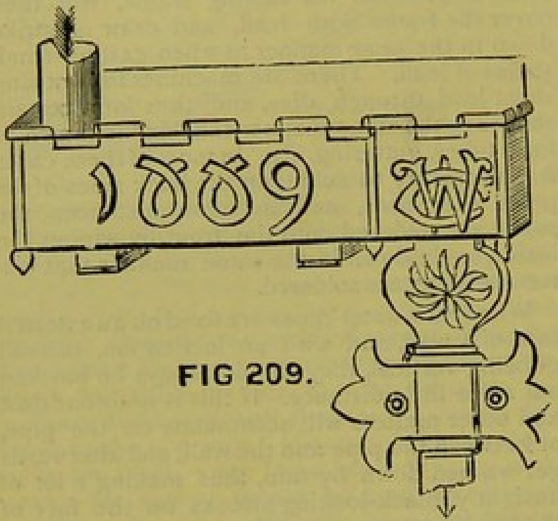


FIG 209.

to keep rain-water from getting behind; stone corbels are built in the wall under the trough for support, as shown by Fig. 209. As the bottom of the trough will sometimes sag down between the corbels it is a much better plan to make the corbel the whole length of the gutter so as to support the bottom its whole length.

To return to gratings; these should always be fixed over the inlets to rain-water-pipes, especially on slated or tiled roofs. Remnants of the material used on roofs will frequently become detached and fall into the gutters. Where these materials are of an absorbent nature, they get charged with moisture, which will, on becoming frozen, expand, and cause pieces to fall away and eventually choke the down-pipe. Birds will frequently build their nests in down-pipes. Leaves and other matters will drift onto a roof and, during a rainfall, float into the pipes, thus choking them up.

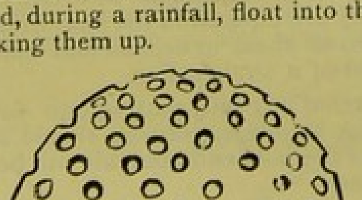


FIG 210.

The gratings for heads or open gutters, as shown by Fig. 209, should be plain flat pieces of perforated sheet metal with pieces cut out for the socket, or down-pipes, to pass through. In some cases these pipes have been made to discharge over the gratings, but this is not a good method. For gutter-gratings it is a common practice to boss up a piece of lead in the shape of a hemisphere, or dome, a trifle larger than the socket-pipe in diameter, and then bore a few holes through with a gimlet or small augur, as shown by Fig. 210, the number and size of the

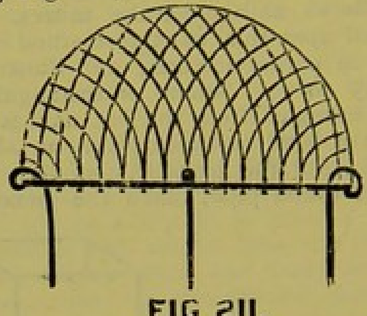


FIG 211.

holes having in the aggregate a waterway equal in area to about one quarter that of the socket-pipe which, of course, is a mistake. In other cases small domical wire-gratings are fixed and, because of their lightness, have wire legs made to pass into the pipes to prevent the gratings getting moved out of their positions. Fig. 211 is an illustration of one of these gratings. At a glance it can be seen that, say half-a-dozen tree leaves getting over these gratings will entirely close the waterway through them.

Where lead gutters are laid to discharge into

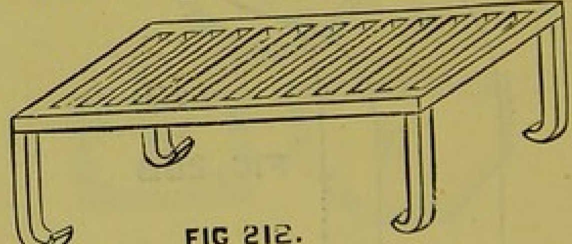
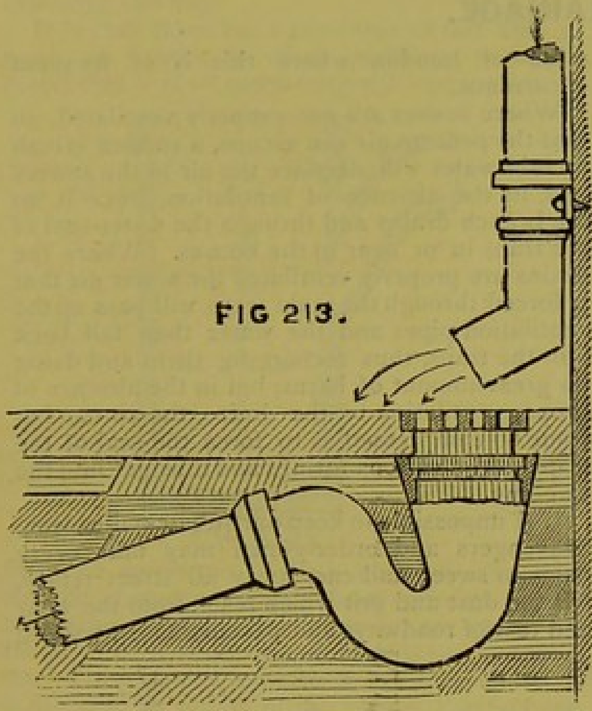


FIG 212.

cesspools the gratings should always be of the same size as the cesspools and should have legs to support them at a level with the sole of the gutter, as shown by Fig 212, so that when walking through a gutter there shall be no pitfalls to stumble into. By keeping the gratings level with the gutter bottom there are no sunken places left for leaves and such matter to drift into. The grating also acts as a grid, under which snow-water can drain away when a thaw sets in. Straight barred, cast iron gratings are better than those which have a woven mesh, and are made of light wrought iron wire, both on account of strength and resistance to galvanic action between the lead and iron. The light galvanised iron gratings last but a very few years. The writer has seen them quite useless after a couple of years exposure.

Where the rain-water is not required to be stored for use, but is run to waste into the sewers or drains, the down-pipes should never be used as drain ventilators. In the first place it is difficult to believe, although some people find it very easy, that water can pass down a pipe and air can pass up the same pipe at the same time. When a great influx of water into the sewers displaces the air in them, the air cannot very well escape by means of the rain-water leaders so

FIG 213.



long as they are fulfilling their legitimate purpose. Another and grave reason against connecting these pipes directly with the sewer drains is, that cases of illness have been attributed to the bad air that escaped out of them. There are very few houses that do not have windows or dormers at a higher level than the top ends of the rain-water-pipes. Even when there are no windows, there are nearly always spaces in the roof through which smells can pass and once in the roof the only protection against their entry into the rooms is generally a defective, hollow, lath and plaster partition.

All rain-water-pipes (where the water is to run into a sewage drain) should be made to discharge beneath the grating of an interceptor trap, and, if possible, into a trap into which the waste-water from a bath, sink, or washhand basin is emptied, so that there shall be little or no risk of the trap becoming devoid of water. Where the pipe discharges over a grating, in very few cases will the water be found to pass directly through it, on the contrary, it will splash some distance beyond, and on running back provided the surroundings are paved, and with a declination towards the trap, will bring with it a quantity of grit and any light matters that will float, and thus either silt up the trap or clog the grating with pieces of paper, leaves, and other matters, that, in spite of a free use of a broom, are generally found laying about. And then again, rain-water from a roof should be sent into the drains in a good stream, and not be broken up into mere driblets by passing it through a grating. Rain-water is not, as a rule, a good medium for flushing drains, that is, under ordinary conditions, but it can be made the most of by carefully planning the way it shall enter into them. Fig. 213 shows one of the most common ways of fixing a gulley-trap and rain-water leader, and the arrows show where most of the water goes. Even when a light shower of rain is falling, the water will rebound off the shoe at the bottom end. When a shoe is not used the water will rebound off the gulley-trap grating and make the adjoining wall quite wet. The evil is aggravated if the grating has only very small apertures through it.

Fig. 214 represents the proper way to connect

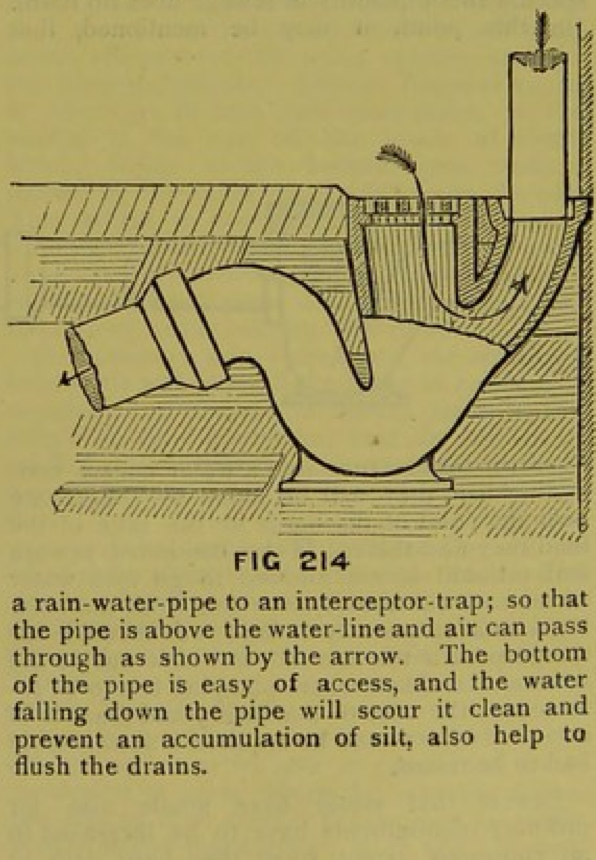


FIG 214

a rain-water-pipe to an interceptor-trap; so that the pipe is above the water-line and air can pass through as shown by the arrow. The bottom of the pipe is easy of access, and the water falling down the pipe will scour it clean and prevent an accumulation of silt, also help to flush the drains.

RAIN-WATER DRAINAGE.

IN most towns rain-water is run into the sewers with the object of getting rid of it in the cheapest and quickest manner, and also for it to be a valuable auxiliary for keeping them clean. These are open questions and may be looked at from different points of view. Looking at it broadly and to commence at the final disposal of sewage and rain-water combined, the cost is much more than if sewage only had to be got rid of. If the combination was simply run into a river, or any other natural water course, it would not be a difficult undertaking; but this would be a very improper thing to do as it would not be wise to convert a natural water course into an open sewer. In some cases water is taken from a river or brook for domestic uses, and it is not at all pleasant to think that this water may be charged with sewage. On the other hand, the statement may be made that with a stream running at a fairly good speed a small quantity of sewage does no harm. On this point, it may be mentioned, that wherever sewage runs into a water course containing fish, they will be found to congregate near the point of discharge for the sake of the food they find there. If the combined sewage and rain-fall is not allowed to go into water streams an alternative is to put it on the land, but a smaller quantity of land would suffice for the purpose if the rain-fall was kept out of the sewers. In cases where pumping has to be resorted to, the cost of machinery and plant is in excess of what would be required if sewage only had to be raised.

Sewers that would have ample size for ordinary requirements have to be increased to an enormous extent when they have also to receive rain water. A sewer of a certain size may have only a few inches in depth of sewage running through it, but after a rain-fall, this same sewer may be running full bore, and in low-lying districts the sewage, &c., may eventually flow through the branch drains and flood the basements of the houses. There are several parts of London where this is of frequent occurrence.

Where sewers are not properly ventilated, so that the pent-up air can escape, a sudden inrush of rain-water will displace the air in the sewers and, in the absence of ventilation, force it up the branch drains and through the water-seal of the traps in or near to the houses. Where the drains are properly ventilated the sewer air that is forced through the main traps will pass up the ventilation-pipes and the water then fall back into the traps, thus recharging them and doing no great amount of harm; but in the absence of proper ventilation to the drains, the air can become so compressed as to force the seal of the traps to the various fittings and thus get into the dwelling.

It is impossible to keep our streets quite clean. Scavengers and orderly-men may take every pains to sweep and cart away all street refuse, but the dust and grit which result from the wear and tear of roadways and pavements get washed into the sewer at every fall of rain. In some cases the sewer-men have to dig out, hoist to the surface, and cart away an enormous quantity of silt which has been washed into the sewers by the rain. We frequently find the branch drains from street gulleys choked with sand washed into them by a rain-fall.

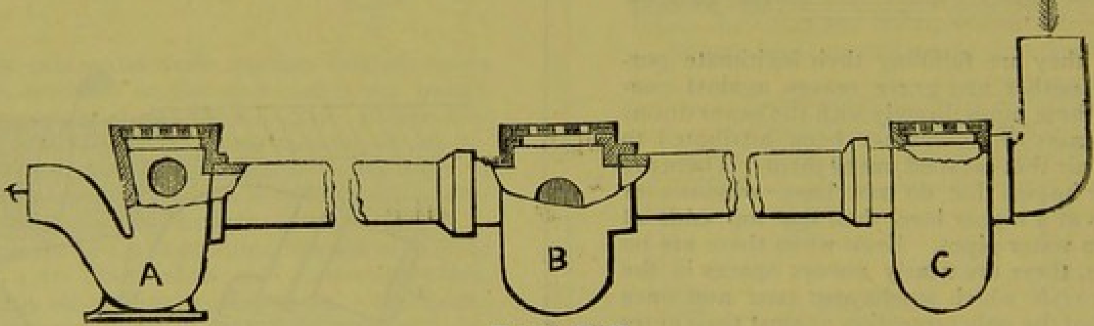


FIG 216.

It is becoming more the custom than it used to be to fix specially constructed street-gullies, as shown by Fig. 215, with a deep pocket for all solid matters to lay in, which can be readily scooped out as occasion requires, and thus avoid having the sewers silted up with such matters.

Some makers of sanitary fittings have gulley-traps with iron trays in the bottom, as shown by dotted lines, the trays having rods and bow handles for lifting them out for emptying.

I think the plain trap best as the trays sometimes get jammed in by pieces of gravel and such matters getting round the edges. Neither do these trays receive the attention they should, from the men who empty them, with the result that a layer of sand gets underneath the trays and in time the capacity of the gulley-trap becomes reduced. This would be otherwise if all the sediment was scooped out of the trap before replacing the tray.

It is very rare that a provision of this kind is made in houses or their premises, with the result that it is of more frequent occurrence to

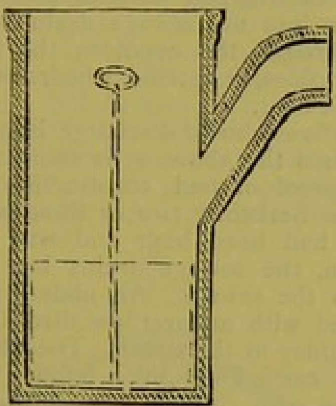


FIG 215

find the rain-water drains choked than the sewage drains. Drains from garden paths and large expanses of pavement are generally found to be in a chronic state of being stopped up. These drains are also a frequent cause of complaint, by reason of the smells that escape from them, and which is generally found to arise from the water having evaporated out of the trap, thus allowing drain air to pass outwards. It should be a standing rule, that all rain-water drains near houses, should discharge into a gulley-trap into which the waste water from a sink, bath, or similar fitting is emptied. The constant use of such fittings would prevent the water-seal of the trap being broken by evaporation. And then again, all rain-water branch drains should be easily accessible from either end so that there would be no difficulty in removing any obstruction. Fig. 216 will explain this more clearly. A is an interceptor-trap, placed to receive discharges from a sink. B, a pocket for catching silt and with an open grating for receiving rain-water from a court-yard or similar place. C, a similar fitting to B, but with an inlet arm for receiving a rain-water-pipe. In places where there is a likelihood of these gratings being used for throwing down dirty slops, those over B and C should be omitted and solid covers laid over the openings. In these cases the pavement should be laid with a fall to the open grating over A. On referring to the figure it will be seen that on the removal of the gratings or covers, easy access is had for passing a cane or flexible rod through the drains. Where of necessity rain-water drains have to be laid at some considerable depth beneath the surface, it is advisable that as much pains shall be taken in their construction, and similar means of access to them be provided, as when laying sewage drains. This matter will be referred to at a future time.

With an ulterior object in view, I should like to refer again to the causes of rain-water-pipes and drains becoming choked. If we go onto the roofs of an old house we generally find an accumulation of heterogeneous matter, which is almost indescribable, but consists a great deal of such as the following: Dead leaves, pieces of stick, materials for building birds' nests, childrens' playthings, dead birds, bedroom slops, old rags, soot, crumbled mortar, matters wafted up from the streets (I once saw a lady's veil lifted by the wind off her bonnet in the street and deposited in a gutter), pieces of slate and tile, &c. Where the gutters are rather hollow and full of mud, some kinds of moss will grow on the accumulation of mud and decayed matters. Flower-pots are frequently found in gutters of houses. It stands to reason that a small shower of rain will wash some portion of these things into the down-pipes and drains in such a way that if the least stoppage occurs, such as a piece of stick across a pipe, the other materials will cling round it, and eventually form a solid plug which will prevent the water running through the proper channels. Another frequent cause of stoppage in iron rain-water-pipes, is the scaling of the rust off the inside of them, which, falling to the bottom, gets wedged tighter by the other matter falling on the top. This, added to other details given in earlier lectures, and in "Plumbing Practice," is a great argument in favour of leaden rain-water-pipes which, when well made and properly fixed, will last as long as the building will stand.

On opening a rain-water drain, the scourings from roofs will generally be found to have caked together, and sometimes fibrous material will help to so bind it together that no amount of rainfall will remove it, and mechanical means have to be resorted to for removing the obstruction.

Enough has been said to show the evils of improperly constructed rain-water drains, and also of adopting what is commonly known as the "combined system" of sewerage in which the rain-water is discharged into the sewers. This latter is an engineering problem which is rather beyond plumbers' work. But it is necessary to have some knowledge of the subject, so as to be able to come to a sound conclusion in cases where the necessity arises, and also to take certain precautions in towns where the combined system is in use. It may be added this system is more common than the "separate system," in which the rain-water and sewage drains are quite distinct.

STORING RAIN-WATER.

IN towns rain-water is sometimes caught in cisterns and butts, and used in the household for various purposes. But it is so difficult to get this water quite clean, that is, clear and free from suspended matters in addition to those which are dissolved or in solution, that the practice is not very common. At country mansions it is usual to run all rain-water into a large cistern inside the roof, or store it in an underground tank. Although the water which runs off country mansion roofs is much cleaner than that caught in towns, by reason of the atmosphere being freer from soot and other impurities floating in the air, it is still very unsuitable for common use. For laundry work it is very useful, but if it is not clarified and all suspended matters removed it is sometimes discarded for a cleaner kind of water, which may not be so suitable by reason of its hardness. A heavy downfall of rain will sometimes fill a tank, which, although the water may be very dirty and unsuitable for use, it would be thought a pity to run to waste so that the tank might be cleaned out, the result being that these tanks are rarely cleaned, and are often found to be in a filthy, stinking condition. Where these tanks are fitted up on bedroom floors, which is a common practice, the bad air which hovers round them must find its way into the bedrooms. At a house at Chislehurst, the children were ill, and it was suspected that a very foul rain-water tank near the nursery was the cause.

Where rain-water is stored in underground tanks the evils are almost as bad as when the tanks are fixed in the house, as the bad air in them will frequently pass through the rain-water drains and pipes up to the house. Wherever storage tanks are used, they should have large-size overflow-pipes from them. When fixed upstairs inside a house neglect of this may lead to a flooding of the rooms below. The overflows from tanks are a common source of evil, and one is continually coming across stupid ways in which they are arranged. Near Reading, the other day, when testing the sewage drains with smoke, it was found that the overflow from a tank next to a young ladies bedroom was in direct communication with the drains, and this is only one of several cases that could be cited.

Underground rain-water tanks are generally found to have overflows discharging into the sewage drains. These tanks have been found to have sewage in them. It stands to reason that during a temporary stoppage in the sewage drains, the sewage will run up any branch drain and, as in the above cases, find its way into the underground tank. A trap fixed in the overflow will not keep back sewage, although it would to a certain extent keep drain air from passing into the tank. But these traps will sometimes get empty during a long dry season, when the drain air can pass through, into the tank, and up the rain-water-pipes. This was found to be the case at a gentleman's house at a south of England watering-place. Smoke was driven into the sewage drains, and after passing through the overflow, the tank, and rain-water-pipes, it entered a bedroom window on the attic floor.

All overflows should discharge into the open air and then the above evils could not occur. Another proof of bad construction was discovered in Berkshire two or three weeks ago. A house had been built and was ready for occupation, the sewage drains laid and connected to the sewers. An underground tank constructed with an overflow discharging into the side gulley in the street. The whole of the work was carried out by a builder under the supervision of a clerk of works, and on completion it was thought that everything should be tested by a sanitary engineer. On propelling smoke into the sewage drains, the underground rain-water tank became filled with smoke; but how it became so was a mystery. The drains were further tested by attempting to fill them with water, but they were so defective that it was found impossible to do so. On exposing the whole of the drains for sewage and rain-water, they were found to be so defective—in some cases laid in the same trench—that smoke passed out of one into the other. The pipes were so arranged with regard to position, as well as being badly put together, that there is not the least doubt sewage would have eventually found its way into the tank in the same manner as the smoke did. The writer has found cases where waste water drains have been connected with those leading into rain-water tanks.

The above evils, which are only a few out of several that could be given, point to the necessity of always appointing some competent person to arrange and supervise the carrying out of all drainage for either sewage or rain-water. Also to the necessity of a proper plan of drains being always left in the house, with the drains marked in different colours and an index to show their various uses. This would help to save any confusion, and lessen the liabilities to make those blunders that are almost daily being discovered.

Drains are frequently found to have been properly laid and all details well carried out; but some time after their completion some Jack-of-all-trades has been called in to do some small matter, perhaps to fix a wash-hand basin, or some gardener has undertaken to fix a small fountain, and with the limited knowledge at their command, these men proceed to mutilate the drains and thus upset or nullify all the pains originally taken in their arrangement.

RAIN-WATER FILTRATION AND STORING.

TO avoid converting storage-tanks into quasi cesspools, it becomes a necessity to remove all objectionable matters out of the rain-water before being stored. There are several ways for doing this. If the necessary attention could be given during a rain-fall this would be a very easy matter; but as rain falls at all times, during the night time as well as the day, it would be a difficult matter to be always in attendance. There is a patent apparatus in the market (shown by Fig. 217), which, so far as I

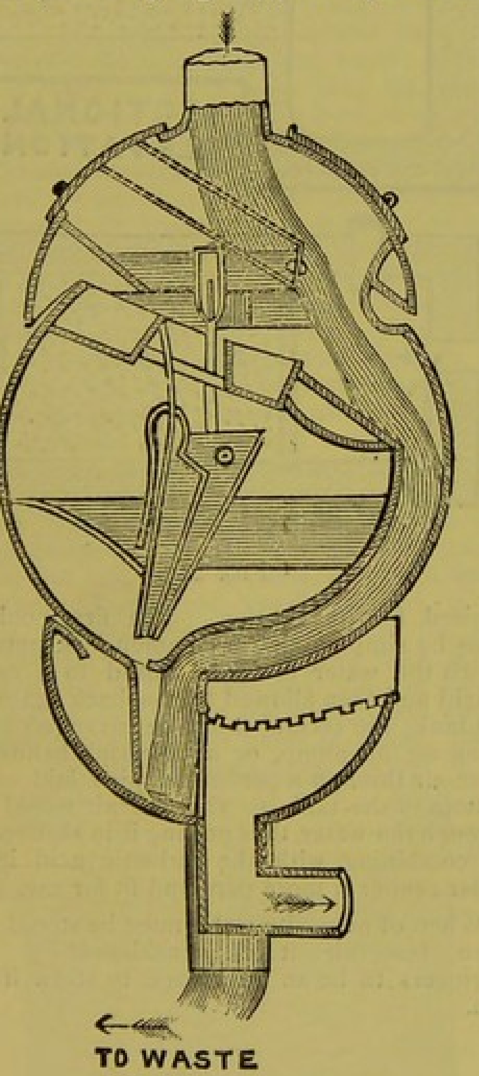


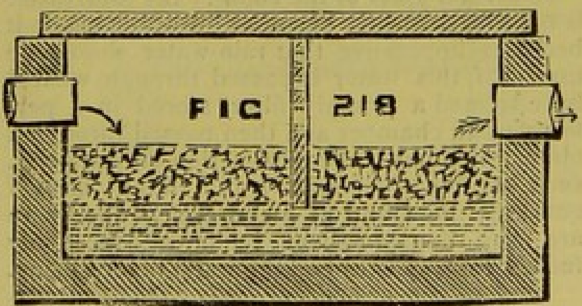
FIG 217.

can judge, answers the purpose very well. As it is the first part of the rain-fall which floats light articles down the pipes, a grating is fixed in the apparatus to catch them. In addition to the pieces of floating matter that have to be arrested there is a certain quantity of dust, which is soon converted into mud by the rain, and which should not be allowed to go into the storage tank. The apparatus is so constructed that this muddy water is allowed to run to waste during the first part of the time rain is falling. After a time the roofs get washed clean, to a certain extent, and the water comes, comparatively speaking, quite clean when the tumbling chamber cants to the other side and directs the water into the drain leading to the storage tank.

There is no doubt the apparatus answers its purpose very well indeed, and a little attention at times to remove whatever has been deposited on the grid is all that is necessary for its efficient working.

If all rain-water could be caught in a large tank and time allowed for suspended matters to float or sink, as the case may be, and then the clear water racked off into the storage tank, that would be all that was necessary for ensuring a clean supply, fit for laundry, but not for drinking, purposes. But as this would require attention, it would not be found to work well in practice.

Filters are sometimes made for rain-water to pass through, and in which most of the impurities are left behind. Fig. 218 is a sectional elevation of one of the commonest that is found, but they appear to be badly constructed. In the first place, all the incoming water falls onto the filtering materials. These are soon covered with leaves and such like refuse, which eventually clog up all the water passages through the filter. A slate division is usually fixed across the centre, but it is found necessary to pierce holes for the water to pass through during a heavy rain fall, in which case the filter is entirely useless, excepting as a partial strainer. These filters have sometimes a layer of sand in



the bottom and coarse gravel on the top. In other cases the writer has seen them with a body of gravel and a floor of bricks loosely laid on the top, so that leaves and such matters could be swept up and taken out with a shovel; but all muddy matters get washed into the gravel below the floor. Rain-water charcoal-filter chambers have been constructed, but charcoal in not a proper material to use for this purpose.

Charcoal in itself has no purifying properties, but as a medium for conveying oxygen to the impurities in the water it is very valuable. As the oxygen enters into combination with the impurities in the water, the charcoal loses its propeities and cannot regain them until it has been thoroughly dried and exposed for the purpose of taking up more oxygen.

And again, the charcoal must be very tightly packed so that all the water may come into actual contact with it. If the charcoal is too tightly packed the water could not pass through the filter quick enough during any ordinary rain fall. Charcoal blocks of a very large size could be made, but to keep them in perfect order they should be taken out after every rain fall, scrubbed clean and thoroughly dried, when they would again be useful for their intended purpose.

As a primary filter a chamber constructed as Fig. 219, which shows plan and sectional elevation, is considered by the writer to answer all ordinary requirements. In this chamber all the incoming water enters the first division, which has a deep pocket for mud to settle in. A slate diaphragm is placed as shown at A, but this does not quite reach to the bottom of the second division. In the space between the slate and the bottom a grating is fixed to keep leaves and floating matters from getting into the filtering medium, which can be either fine gravel or small broken flint. By this arrangement all mud and leaves can be periodically scooped out through a movable cover placed over the inlet chamber. The size of the filter should be governed by the amount of water that may have to pass through it, and be arranged so that the incoming water shall pass through at as slow a rate of speed as possible. by which means all solid matters will be left behind, whereas, if the filter is made too small the rush of water will keep the suspended particles in motion and drive them through.

In certain parts of the country the local water is unfit for domestic purposes, in which cases it becomes imperative that rain-water should be used. If this water is passed through what I have termed a primary filter, stored in a perfectly clean chamber and then passed through a filter, which has a chemical action on the water, such as the "Spongy Iron" filter, it will generally be found fit for drinking. If there are any doubts about its fitness the only further remedy is to boil the water before using.

Rain, like any other water used for domestic purposes, should always be stored in a covered chamber to prevent the growth of vegetation and and also the development of living organisms. Another great advantage would be gained if the stored water could be kept in motion or means

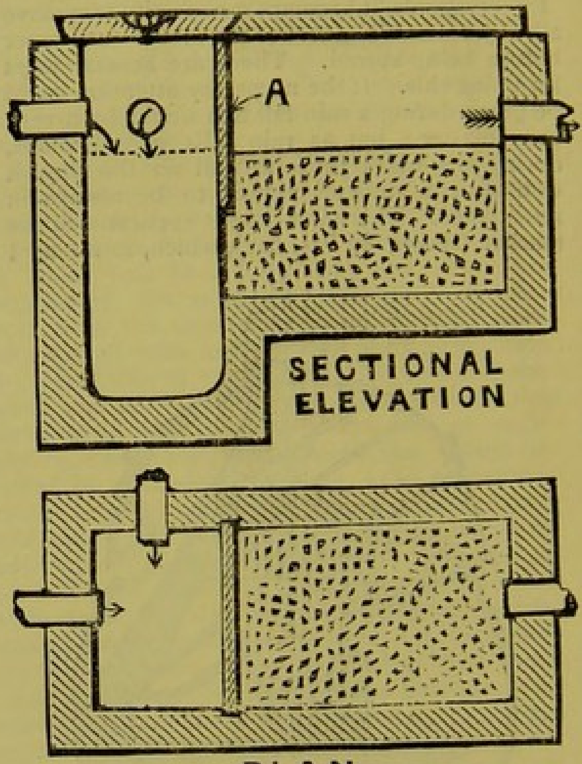


FIG. 219.

devised for its æration. The first could be done by simply fixing a common jack pump by which the water could be raised to a certain height and then allowed to flow back again into the tank; the second could be arranged for by using an air-pump, or a powerful bellows, to force air through a perforated pipe laid on the bottom of the tank so that the air would pass through the water, thus putting it in motion, and by combining with the carbonic acid in the water render it more pure and fit for use.

When of necessity water must be stored in an open reservoir it is considered by some engineers to be an advantage to stock it with fish.

TRAPS.

TRAPS are specially made water-chambers used by plumbers, which, while allowing water or liquid sewage to pass through, prevent the escape of bad air, or the gases which are generated by the decomposition of sewage, out of the drains or pipes used for the conveying of sewage or slop-water from the house or building. They are also used to prevent the air from sewers passing into the house drains and other purposes to which we shall refer at a future time. Not only bad air but certain disease germs can pass from sewers through untrapped drains. We are told by eminent men that nearly all sewers contain the germs of contagious diseases which pass into the sewers from people who are suffering from those complaints. We are also told that these germs can and do pass through traps, but a certain time is required for this to take place. In a house that is occupied by people, water is being so constantly sent through the drains that the water in the traps is frequently changed, so that should any germs be in the act of passing through they get washed away by the current. For this to take place, the traps must not be too large, but of such a size that ordinary discharges will entirely displace the contents of the traps and leave sufficient water behind to charge them again. I do not wish to convey to you that these germs walk or swim through the water. If the traps are charged with sewage and animal matters and a typhoid germ, for instance, should get into those matters, the germ would be under favourable conditions for multiplying, so that given sufficient time the trap may become full of typhoid germs both in the house as well as the sewer end. So you see the necessity of having the traps small and also of frequently changing the water in them. Other

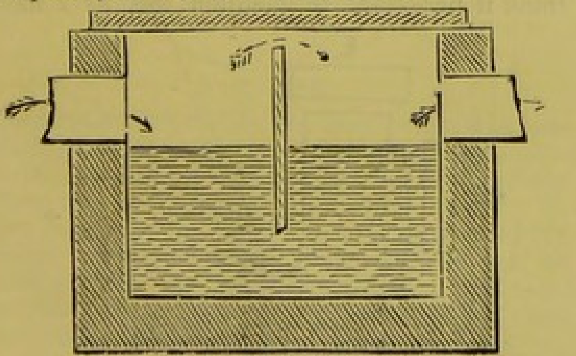


FIG. 220

reasons showing the advantages of small traps will be given further on.

We will now proceed to consider the various kinds of traps that are used and take them in order beginning with those fixed to cut off direct communication between the sewer and the house drain. One of the earliest kinds used for this purpose is shown by Fig. 220, and consists of a brick built chamber with a stone fixed across the centre, the bottom edge of the stone being some few inches below the water retained in the body of trap. The sizes of these traps vary according to the whim of the man who makes them; sometimes being 2 ft. long by 1 ft. broad, and sometimes 5 ft. long by 2 to 3 ft. wide. At a house in South Kensington one was found which was the above size and 5 ft. deep. The dipstone dipped into the water about 2 ft. On opening the trap the stench that escaped was quite as bad as if from an old cesspool. It was also found to be acting as a very good sewage separator, all the solid matters being retained and the liquids only passing away. The house had been built only about twenty years, and from the appearance of the trap one was led to suppose that all the solids from the W.C.'s had been accumulating in the trap for the whole of that time, excepting those portions which had become decomposed, mixed with the water and carried through with the current. In the centre of a childrens' playground I found one of these traps which had leaked all the water through the bottom, thus allowing drain-air to pass outwards for the children to inhale. In Chelsea, when inspecting a new house for a purchaser, a dipstone-trap was found, and the fingers could be passed between the dipstone and coverstone, as shown by the arrow Fig. 220. This trap was perfectly useless for keeping drain-air from passing. A smoke test applied to drains which are trapped by the above means frequently betrays defects round the coverstone. These stones have frequently to be taken off, for removing the solid matters that invariably accumulate in the traps, and do not get properly bedded down quite air-tight after-

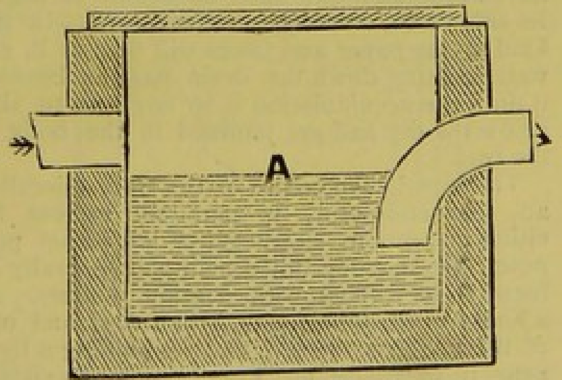


FIG. 221

wards. In spite of the progress of sanitary knowledge there are people who still believe in these traps, and at the present time there are new houses where they are being made. In one of them the writer was called all sorts of hard names and roundly abused for his "fads," because he suggested a better kind of trap. For fever breeding it is difficult to imagine anything more favourable.

Another kind of brick-built trap is shown by Fig. 221, and is held in high estimation by a certain class of people. These traps are always becoming choked by solid matters which float on the surface ot the water at A, until by their weight they sink below the water and float in a body into the dip-pipe, thus choking it. At a house in a London suburb several of these traps were found. In each case the coverstones were left loose so that the gardener could scoop out the solids whenever a stoppage occurred. Further remarks on this trap are unnecessary.

At the time when brick-drains began to be disused and pipe-drains introduced, other, and better kinds of traps were invented. One of the first was of the shape shown by Fig. 222, on looking at which, it will be seen how much superior it is to the old-fashioned brick-built trap. Ordinary builders fix large numbers of these traps, but no sanitary engineer of repute ever uses them now for the following reasons: In the absence of a base to them they rarely get fixed properly; sometimes the outlet is fixed too low so that the water in the body does not reach up to the throat so as to form a dip. The writer has discovered this by means of a smoke test, the smoke passing through the trap. In other cases he has found them tilted the other way, with the result that too much dip has been given the trap, so that solids and fæcal matters

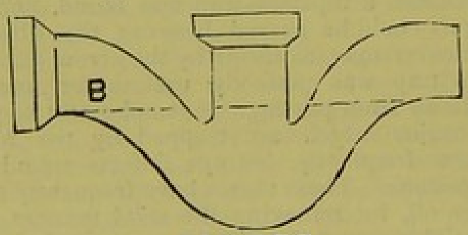


FIG 222

have accumulated to such an extent on the inlet side that a blockage has occurred. In this kind of trap paper and fæces will float at B, any water coming down the drain passjng beneath it until the accumulation is so large as to sink below the dip and get jammed in the body of the trap.

The pipe in the centre of the trap, miscalled an inspection-pipe, is perfectly useless for either inspection, cleansing, or any other purpose. On opening this pipe it will generally be found to be choked with floating matters. At a house in St. John's Wood the writer had one of these pipes opened, and on holding a light near it to make an examination a violent explosion of the gases inside took place which alarmed all who were near. This incident proving the pipe to be worse than useless. Amateur sanitary engineers have had pipes fixed from the centre of the trap to the roof of the house to ventilate (?) the drains. In one case a pipe and air inlet-valve had been fixed for the same purpose, but how they were going to get air through the water in the trap is a mystery that I cannot solve. Another objection to this kind of trap is its capacity. A 6 in. trap will hold nearly 3 gals. of water. Assuming that only ordinary discharges of water are passing through the trap, the contents will be stirred up, instead of being entirely displaced. Whenever you have an opportunity for doing so, throw a piece of crumpled up paper into the trap and watch how long it will stay there, in spite of any water discharges that may be sent through the drains. It may be added this is a very good test, and there are very few drain-traps made through which a piece of paper can be driven by ordinary discharges. Fig. 223 is another kind of trap which is often used for disconnecting house drains from sewers. This trap is not to

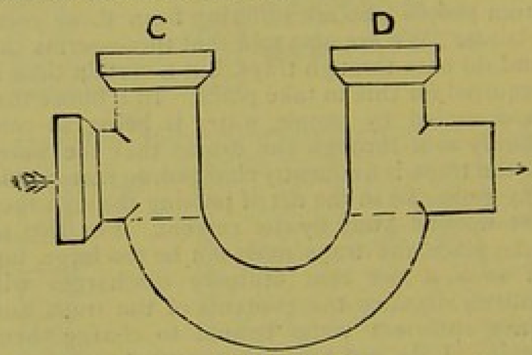


FIG 223

be recommended on account of its capacity which prevents it being thoroughly cleansed, and the contents entirely changed by ordinary water discharges through it. In the absence of a base, or foot, it is sometimes found to be improperly fixed in the same manner as described for Fig. 222. It is very rarely that stoppers are sent out with the trap by the makers, for fixing in the ends at C and D. I think it necessary to mention this as I have

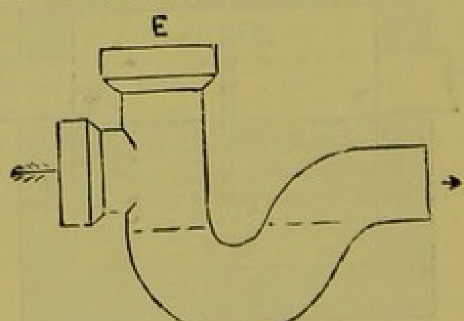


FIG 224

found these traps fixed in manholes and the ends left open. In these cases, sewer air can pass out of the open end at D and enter at C, so that the traps have been entirely useless for their purpose.

Some few years ago, an improved kind of

trap was introduced, the shape being as shown by Fig. 224. This trap is a great improvement on the others that have been described, in that it holds a considerably less amount of sewage and is much better flushed by ordinary water discharges. The opening at E can be used either for cleansing purposes or for admission of air to the drains for their ventilation. This trap has no base. The inlet and outlet ends being at the same level prevents it being so well scoured by water flushes, as others, which will be described later on, and which have smaller capacity in the body of the trap.

Figs. 225 and 226 are two other drain-traps, used for the same purpose as those that have been described. The raking inlets are claimed

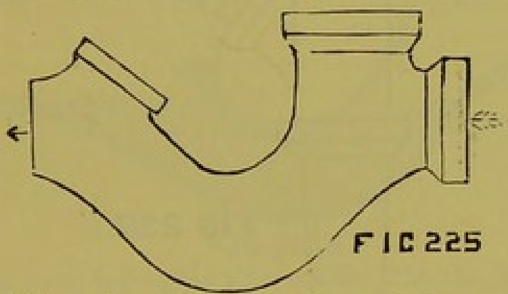


FIG 225

as being advantageous, and no doubt are so, when large quantities of sewage are being sent through, as the current has not to pass round such sudden turns, as in some of the other traps. Every turn or bend in a pipe forms a check to the velocity of flow of the water passing through, so the easier the bends, that is those

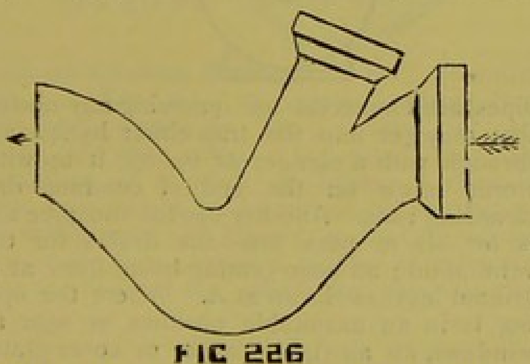


FIG 226

made to a large radius, the more water will pass through in a given time. But when small quantities of sewage pass through traps of the above form they will not displace floating matters on the surface of the water on the inlet sides of the traps, as described for Fig. 222. It will be noticed that the above traps have no bases, which is a disadvantage, especially when they are being fixed by careless workmen.

Fig. 227 is spoken of as being a very good trap, by reason of its holding, comparatively speaking, a small quantity of water. The inlet end of the trap is a considerable height above the water in the body, so that the current of sewage or water will fall onto any floating matter, immersing it and thus driving it through the trap. This trap has no base, and no doubt would get very foul in the part F. Traps should never have any parts or corners that cannot be kept clean by the scour of the water that passes through them.

When selecting a trap for fixing in a main drain so as to cut off direct communication between any common sewer or a cesspool, the following points should be taken into consideration. The trap should have a base or foot, so as to minimise the risk of a careless workman fixing it out of level. The evils of this have been mentioned. The trap should not have corners,

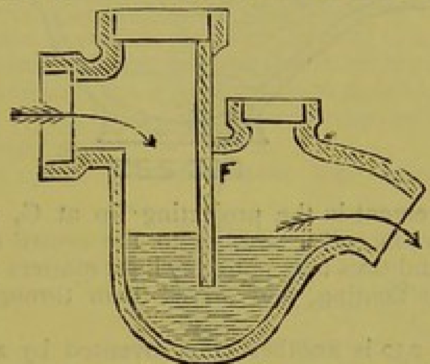


FIG 227

where an accumulation of solid sewage and fatty matters can take place, but one should be chosen which has the whole of the internal surface exposed to the friction of passing water or liquid sewage. The trap should be as small as possible, consistent with the duty it has to perform, so that a less internal surface has to be kept clean and a lesser quantity of water displaced for changing the contents than with larger traps. The inlet to the trap should be higher than the outlet for reasons that have been given. The dip, or water seal, should not be less than 3 in., especially if, when ventilating the drains, an air current is made to pass over the water in the trap and carry a part away by evaporation. This applies more especially to houses that are only occupied a portion of the year.

With these rules before us, we will refer to Fig. 228, which has most of the necessary advantages that have been mentioned. This trap has

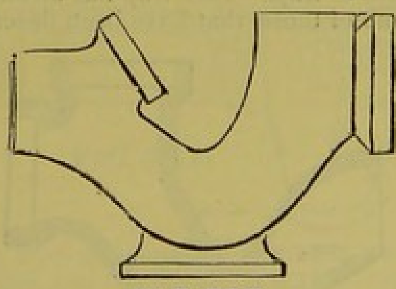


FIG 228

a long raking outgo which could be made shorter and thus reduce the internal surface, and also the quantity of water it will hold. On speaking to the patentee on this matter he explained as his reason for having the long outgo, that it would prevent rats passing through; he said "rats will dive through the water of a trap, but would not walk through." I have known rats to pass through the water in a trap, but if this particular form will prevent them I am not prepared to state with any authority.

Fig. 229 is considered to have an improved

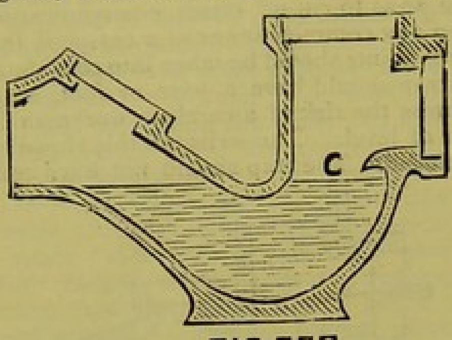


FIG 229

arrangement in the projecting lip at G, which conveys incoming sewage to the centre of the trap, and thus falls onto any light matters which may be floating, and drives them through the trap.

Fig. 230 is another trap invented by a man who has given a great deal of thought and written a great deal on sanitary questions. This trap is preferred to others by a great many engineers, and was one of the first made with what is now considered to be necessary improvements on the old kinds of traps.

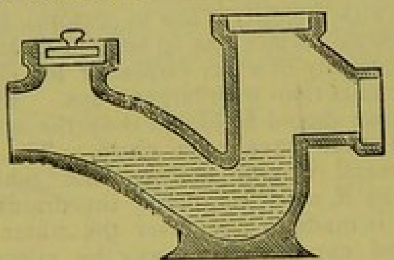


FIG 230.

Fig. 231 is another kind of trap invented by one of our leading sanitary engineers, which has all the essential points requisite to constitute a good form of trap. This trap has an advantage over some of those that have been described, in

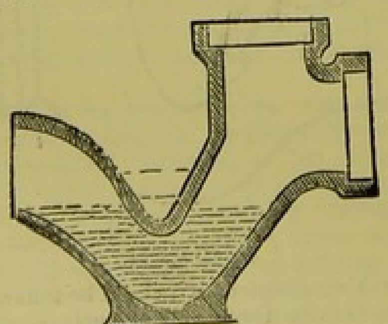


FIG 231.

that the body of the trap is smaller than the inlet and outlet, so that when water is passing through the reduced passage it travels at a higher rate of speed, and thus exercises a greater cleansing or scouring force on the internal surfaces, and literally pushes the contents through into the drain.

Some of the traps that have been described are at times fixed a considerable distance beneath the surface and pipes from the top of the trap to the ground level, as shown by Fig. 232. These

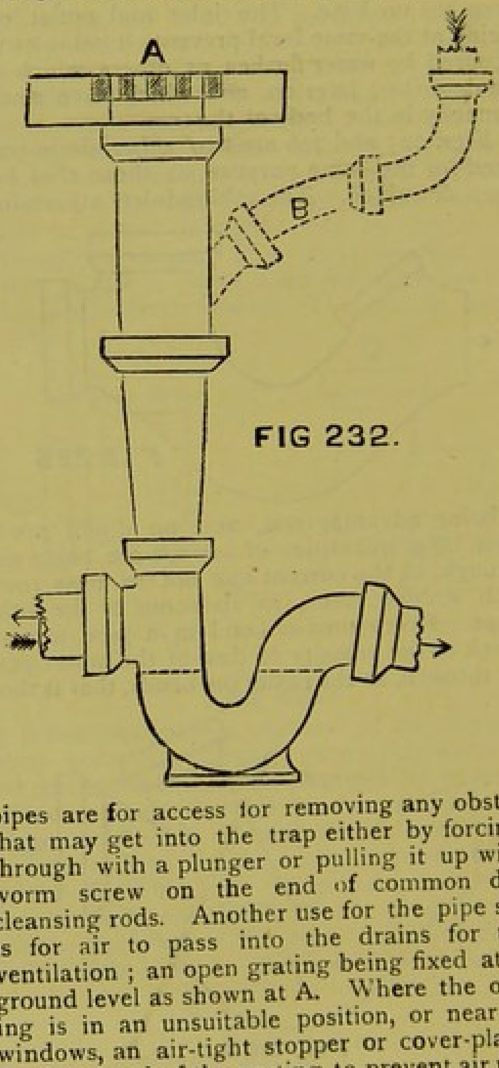


FIG 232.

pipes are for access for removing any obstacle that may get into the trap either by forcing it through with a plunger or pulling it up with a worm screw on the end of common drain cleansing rods. Another use for the pipe shaft is for air to pass into the drains for their ventilation ; an open grating being fixed at the ground level as shown at A. Where the opening is in an unsuitable position, or near any windows, an air-tight stopper or cover-plate is fixed, instead of the grating, to prevent air passing outwards from the drains when discharges are being sent through. In these cases a branch drain is laid in, as shown by dotted lines at B, to some less objectionable position or for a mica valve to be fixed so that air can pass inwards but not outwards. The mica valve (which will be dealt with at a future time) should not be fixed over the pipe shaft as it would then be useless as an access-pipe.

The pipe shaft is only fixed in places where economy has to be practised. Where not tied by this consideration, sanitary engineers have a "manhole" or "access chamber" built round or over the trap, not only for getting at the trap for any purpose but also for examining or cleansing the drains. This cannot easily be done with some k'nds of traps, but others of a special construction have to be used. Some of the traps that have been described, notably Figs. 224 to 231, can have channel or U-shaped pipes fixed to the inlet ends of the traps, and thus partly meet the requirements of the cases. Nearly all makers of sanitary good's have these channels. There are several patent traps with channel inlets, in the market, made for fixing in manholes to cut off direct communication between house drains and sewers. One that is thought well of is shown by Fig. 233. In this trap the water way through

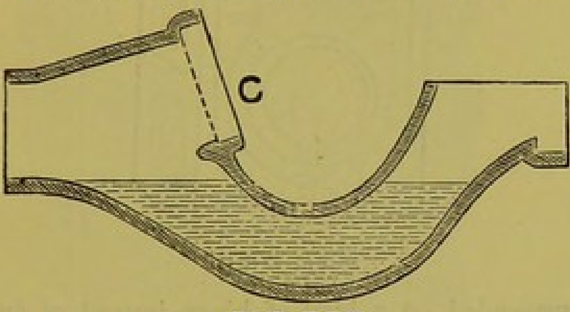


FIG 233.

the waist is considerably smaller than the inlet and outlet ends. Fig. 234 is another trap

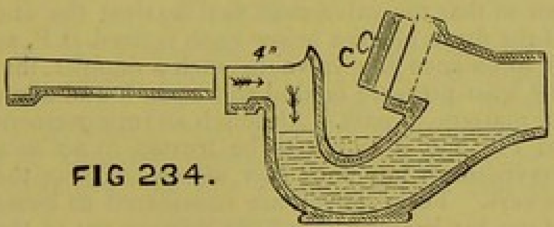


FIG 234.

made on the same lines as the last, excepting that it has a 3 in. vertical drop from the inlet drain to the surface of the water in the trap. It also has the advantage of a foot or base. I consider these traps could be improved by making the channel-pipes much deeper, so that the sewage flows through the channel instead of spreading over the floors of the man-holes, which is often

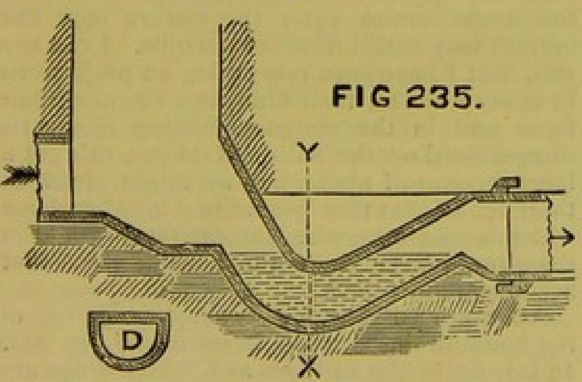


FIG 235.

found to be the case, excepting where they have been made deeper by building brick sides to them.

Air-tight stoppers are fixed at C C in the last two figures. On removing these stoppers rods can be passed through for removing any obstruction, or cleansing that portion of the drain leading to the sewer. Although convenient when necessary these stoppers are rarely wanted, as anything that passes through the trap will float away into the sewer. At all events, I have never found it necessary to make use of them excepting for cleansing purposes. The advantages of contracting the water way through a trap have been pointed out. There is one patent trap to which this point is carried to a further extent than any we have referred to. This trap is shown by Fig. 235, the small drawing D being a section across X Y. The inlet of the trap is made rather larger to allow for water to accumulate, and thus get a head so as to accelerate the speed through the trap. This trap has no base or cleansing-pipe on the outlet.

Fig 236 is another patent trap different to

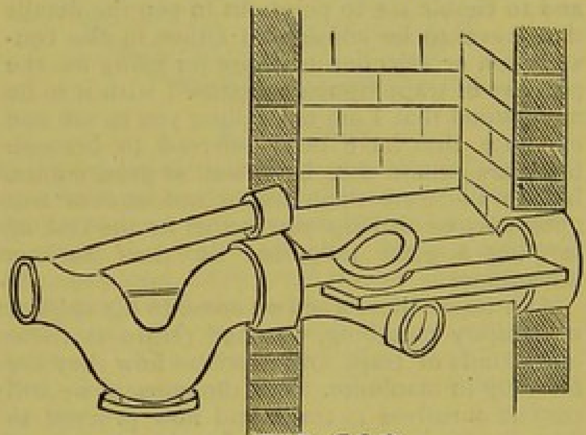


FIG 236.

any of those that have been described in that the channel-pipe has shelving sides, which form the floor of the manhole. Several engineers like this trap and channel, but objections have been taken to the position of the trap, which cannot be got at for removing an obstruction unless the workman lays down in the manhole tor passing his hand into it. The channel is also very shallow.

Fig. 237 shows a very good trap, which has

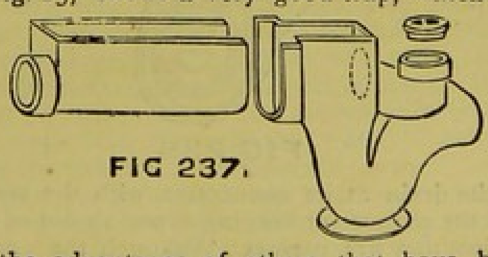


FIG 237.

all the advantages of others that have been described, and the further one of having a deep channel inlet-pipe.

Fig. 238 is another main drain trap, the special advantages claimed for it being the gun metal valve at E, which can be removed should the trap become choked and the manhole filled with sewage, for the accumulation to flow away into the sewer and enable the workmen to get to the trap for removing the cause of stoppage, and also the shape of the trap which is reduced in size in the waist, and made oval in section at that part.

All the traps that have been described have special features, and have been selected from a long list because of their various advantages,

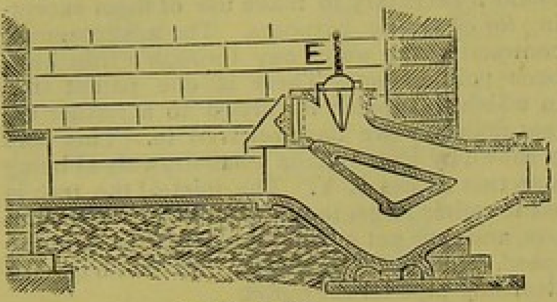


FIG 238.

and to enable me to point out to you the details that have to be considered either in the construction or selection of those for fixing for the purpose of trapping main drains. I wish it to be understood that I am not telling you to use one of those that have been referred to because there are others that have similar good points, but to illustrate them would not answer any good purpose or help you further in the task of forming a good judgment on their various advantages.

At a future time, when we come to the subject of sanitary plumbing, we shall return to these later kinds of traps and describe how they are fitted up in manholes. For the present we will confine ourselves to traps, and now proceed to describe those that are fixed for the purpose of keeping sewage from flowing from the sewers into the house drains. One of the commonest is known as the "valve trap," sometimes a "tide flap," and is of the shape shown by Fig. 239. These flaps are generally fixed on the end

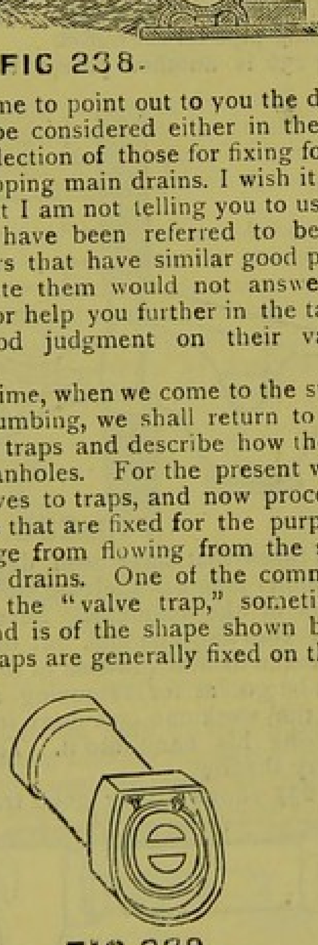


FIG 239

of the drain at its connection with the sewer. For the purpose of keeping sewer air out of the drains they are useless. Although the end of the pipe is ground to a smooth surface, for the flap to fit against, in practice they are rarely found, when in use, to be closed. Pieces of paper, solid sewage and other matters that pass through the drains get behind the valve and hold it partly open. Where the drains have a sluggish fall and do not get properly flushed, these flaps prevent the solids passing away, and may be said to do more harm than good. When these valves are held open, in the manner described, and the sewers become gorged with sewage, they will not prevent a back flow up the house drains, in which case they are perfectly useless. Where the house drains have a fairly good fall and all the solid sewage is washed away by good water flushes they may at times be used; but, from experience, drains are better without them. An improved kind is shown by Fig. 240. In this fitting the valve is

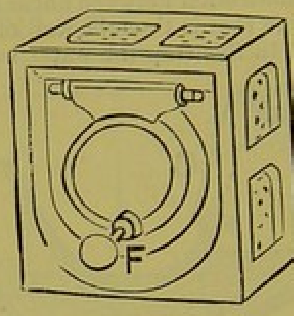


FIG 240.

suspended on a kind of hinge instead of on links as shown by Fig. 239. The flap is not hinged to rest on an inclined surface as in the first one, but is suspended nearly vertically; but so that the valve shall rest against the end of the drain block a heavy knob is fixed at F, so as to balance the valve in such a manner that the least pressure behind will open it and allow all matters to pass. Although an improvement on Fig. 239, it is not to be trusted to act as a preventor of any back flow of sewage from the sewers. These valves are considered as being of use for keeping rats from passing out of the sewers into the house drains, but people's opinions vary very much on this point. It has been stated that rats can get their paws behind the flaps and open them, so that an easy passage can be had. To do this the rats must have somewhere to stand upon, and as the flaps are generally fixed some height above the bottom of the sewer the rats would have some little difficulty in attaining their object. Where the house drains enter the sewers near the bottom they would have less trouble. I can say this, that I have seen rats sitting on projections in sewer walls on their hind legs cleaning their faces and in the distance looking like little images fixed on the walls. Rats as a rule get a large amount of abuse, but we might plead on their behalf that they get rid of a lot of garbage which would otherwise decompose and add to the already large amount of noxious gases that accumulate in sewers.

An improved valve for keeping sewage out of the house drains is shown in section by Fig. 241. In this fitting the ball lays at G when things are following their usual course. Should the sewers become filled above their ordinary condition by storm water, or in places affected by tides, the ball will float to H, and if the water in the sewers continues the rise the ball will float to I, and covering the outlet end of the house drain prevent sewage flowing back into it.

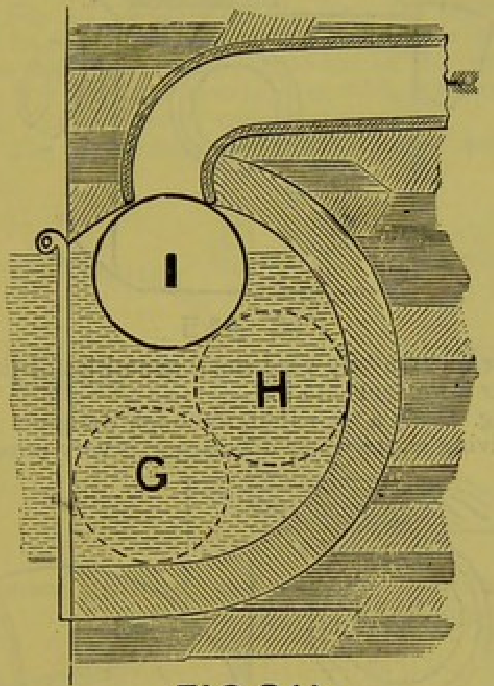


FIG 241.

Fig. 242 is another kind of valve invented for the special purpose of fixing in low lying districts and places where flooding of house basements takes place either by rising tides or during a rainfall, causing the sewers to become overcharged. In this fitting a copper ball is

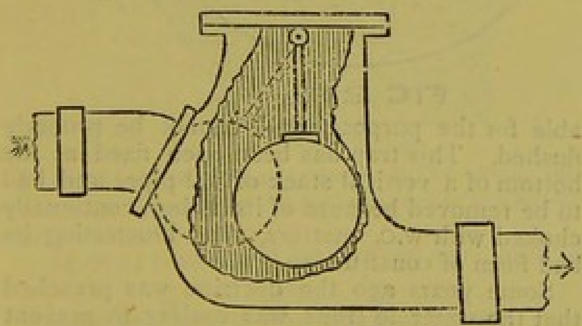


FIG 242.

attached to a spindle suspended from the top by a kind of rule joint. The joint being so made that the ball can only float in one direction. The ball is shown in the position it occupies when under ordinary conditions; should the sewage begin to flow backwards the ball floats and is guided by the spindle to the opening over the inlet-pipe, as shown by dotted lines, which it effectually closes. An advantage claimed for this tide valve, is, that paper and such matters do not get onto the ball but flow away underneath it. If the ball got clogged with anything it would not fit the end of the entering-pipe, and would thus become useless for its purpose. That appears to be an unlikely event in this fitting.

I once saw a combined trap and tide valve as shown by Fig. 243. In this trap, which is very much like Fig. 222, excepting that the centre chamber is very much larger, a floating ball with guide pieces is fixed so that it can slide up and down in the centre chamber. A valve is attached to the float by means of a connecting piece, the valve when down fitting over the entrance to the trap but beneath the water in it.

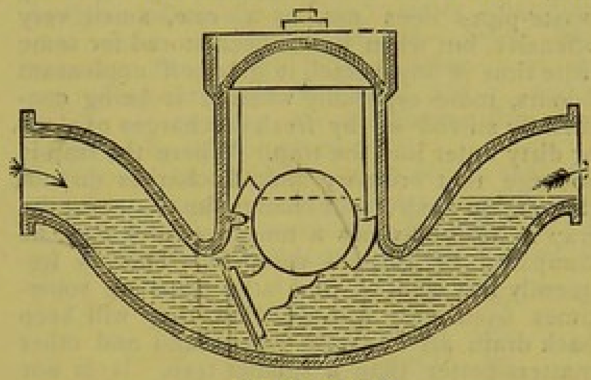


FIG 243.

Sewage entering the trap pushes the valve open but a back pressure causes the valve to fit tightly onto its seating, I have not had an opportunity for seeing this trap in use, but from its appearance and shape, have grave doubts as to its acting properly and cannot but think the working parts must get clogged with paper and other matters. The shape of the trap is no good, for reasons given when speaking of Fig. 222.

Gully and Interceptor Traps.

Gully-traps are those traps that are fixed in street gullies or gutters for receiving any water that may fall on the streets or pavements. The best traps for this purpose have been referred to in a previous lecture, and are constructed on the principles of that shown by Fig. 215. Some people prefer those shown by Figs. 220 and 221, and although, when properly constructed, they may answer their intended purpose fairly well, they are not nearly so good as the first one described, which is made of vitrified stoneware, and being in one piece, less liable for the water to leak out of them. It is not at all uncommon to find the water in brick-built traps leak through the walls of cellars under the side walks of houses in towns.

Sometimes gully-traps are fixed near houses for receiving rain-water from the roofs, yards, &c., and also the discharges from baths, sinks, wash-hand-basins, &c. When fixed for the latter purpose they are called by some engineers "Interceptor"-traps, and are intended to interrupt the communication between the waste-pipes and the sewage drains in such a way that bad air cannot pass from the drains through the waste-pipes into the house. We will leave the arguments for this system of carrying out work until we come to sanitary plumbing, and for the present confine ourselves to the description of the traps used for the purpose of intercepting waste-pipes from the sewage drains.

None of the traps that we have hitherto mentioned are suitable for the purpose, although Figs. 215, 220, and 221 are often found fixed for intercepting waste pipes. For this particular purpose they become very objectionable by reason of the large quantity of water they contain. The water that passes through ordinary waste-pipes does not, as a rule, smell very offensive, but when it has been stored for some little time in any vessel, it gives off unpleasant odours, more especially when it is being continually stirred up by fresh discharges of slops or dirty water into the trap. Where the trap is so large that ordinary sink discharges do not thoroughly flush it and change the contents, the trap in itself becomes a nuisance, and may be compared to a small cesspool. This is frequently lost sight of, and large traps are sometimes fixed with the idea that they will keep back drain air and also catch sand and other matters better than a smaller trap. It is not the size of the trap so much as the "dip" it has that keeps back sewer air, and excepting in special cases sand and other matters do not require to be caught, but should be washed away into the sewer. It is not at all necessary to either strain or filter the sewage as it leaves the house. In towns that are sewered, the water is used as the power for removing certain objectionable matters, and the proper arrangements should be made so that that power is not wasted or anything done to detract from its usefulness. Hence the reason for small-sized traps. In addition to the size of the traps their shape is of great importance. We will dwell upon a few that we often meet with in practice. Fig. 244 is a section of one that holds a larger quantity of water than is necessary, and has

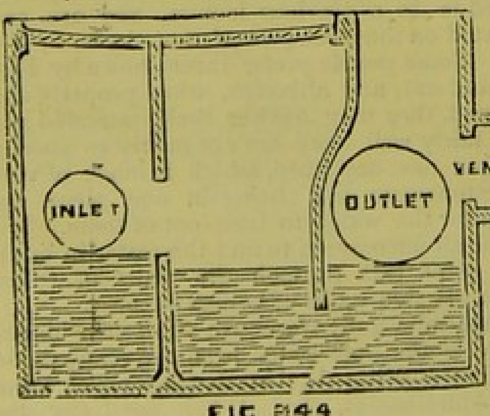


FIG 244

several corners that can neither be reached for cleansing or kept clean by any ordinary water discharges, so as to render it unsuitable for fixing anywhere near a house.

Fig. 245 is another trap, although spoken well of by some authorities cannot be said to be a trap that would be kept clean by ordinary water currents through it. No doubt, if fixed in some positions it would act to a certain extent as a grease interceptor, but would be an evil in itself

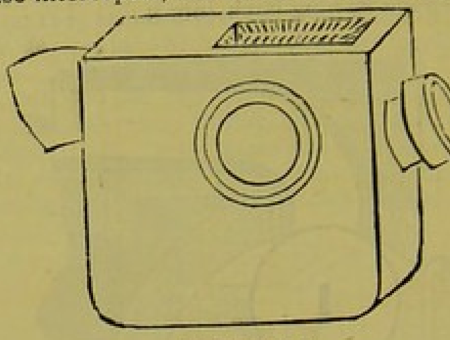


FIG 245

if fixed where only very small quantities of dirty water were sent into it.

Fig. 246 is a trap that, although designed for receiving waste-water discharges, is very unsuitable for the purpose, and cannot be properly flushed.

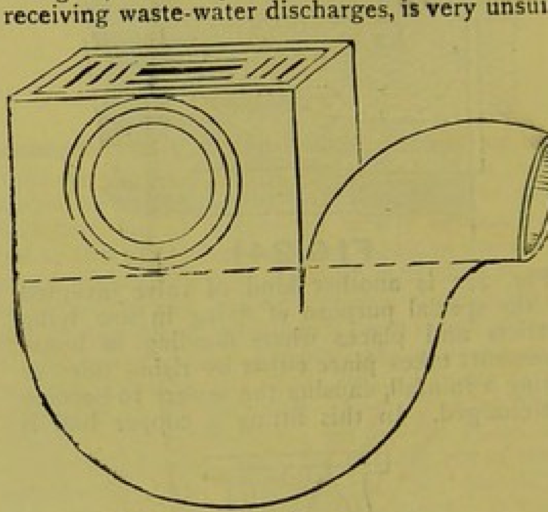


FIG 246

able for the purpose, and cannot be properly flushed. This trap has been seen fixed at the bottom of a vertical stack of soil-pipe, and had to be removed because of its being continually choked with W.C. matters, thus illustrating its bad form of construction.

Some years ago the doctrine was preached that the water in traps was useless to prevent

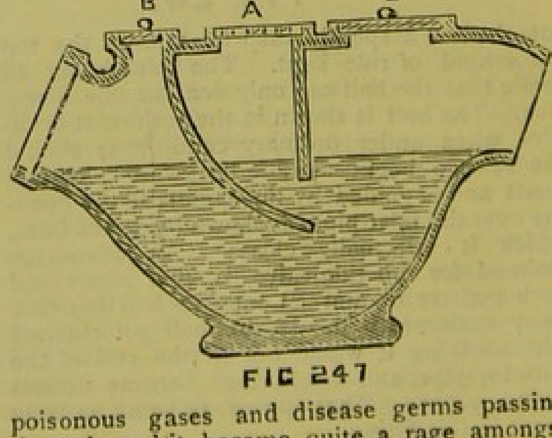


FIG 247

poisonous gases and disease germs passing through, and it became quite a rage amongst manufacturers and sanitary engineers to have traps made with two dips or seals, and also so as to form two traps.

Fig. 247 is a double dip trap, the argument in its favour being that if any bad air passed the first dip it would escape out of the grating at A. Stoppers were fixed at B, B, for access to the inlet and outlet ends of the traps.

The illustration Fig. 248 shows another

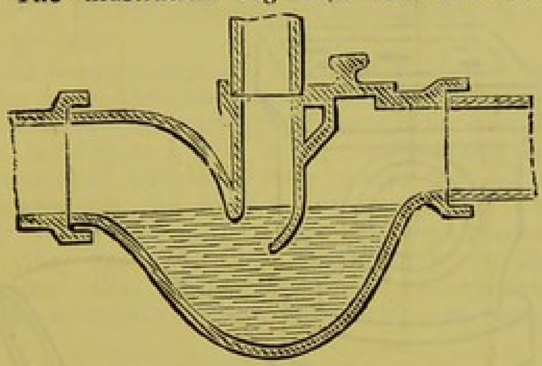


FIG 248

ouble dip trap, and Fig. 249 another one.

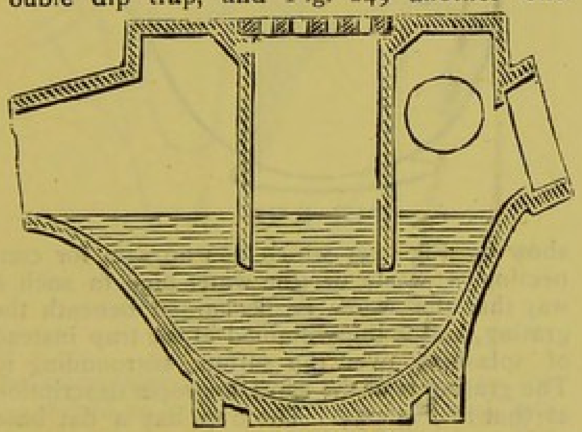


FIG 249

Several others that are made on the same lines as those shown could be given, but it is unnecessary to do so.

In each case it will be noticed that, although

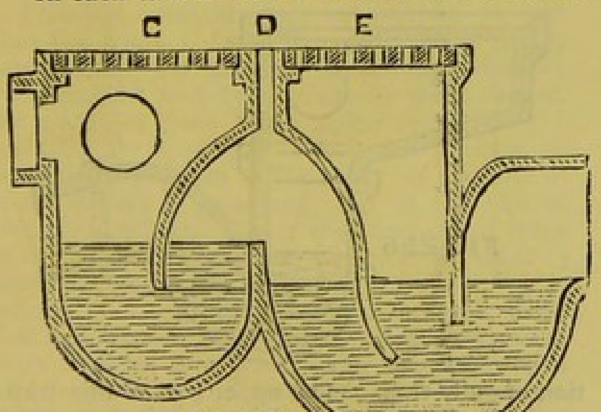


FIG 250

the traps have two dips, they are immersed in the same body of water, so that should noxious gases emanate from the water they wou'd escape from the surface at all points, and on the house side of the trap as much as on the sewer side. Supposing that disease germs had passed into the trap, and had multiplied there, the double dip would be of no more use that a trap with a single dip, for keeping them out of the house.

Fig. 250 is another trap constructed with the same object in view as those immediately preceding, but this trap has three dips, and the further advantage of two water chambers, the water in each chamber being kept separate from that in the other. In this trap air gratings are fixed at C and E, and at D is an opening for ventilating the space enclosed by the dip-pipes.

Fig 251, is a single trap so far as the grating for receiving surface-water, but the inlet for connecting the waste-pipe has another trap as shown, thus forming a double barrier for

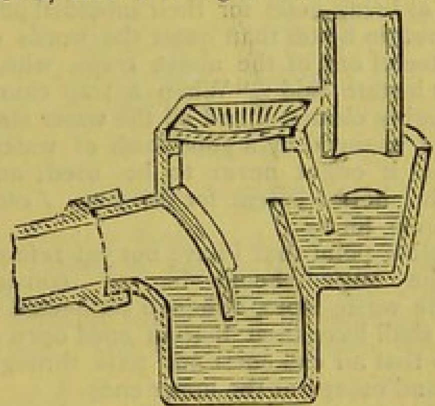


FIG 251

preventing drain air getting into the house through the waste-pipes. The illustration Fig. 252, is constructed on lines similar to Fig 251.

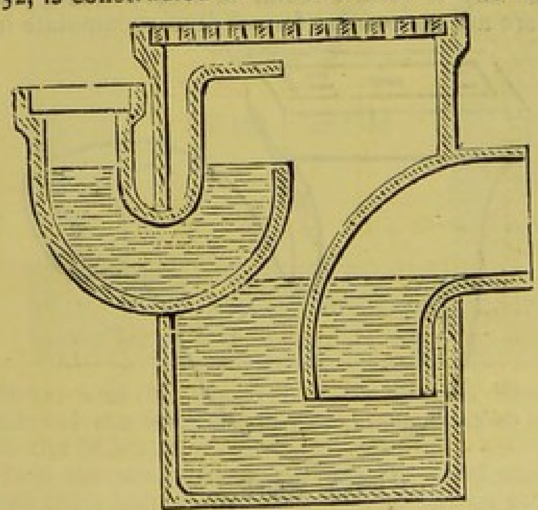


FIG 252

One more illustration of a double trap is shown by Fig. 253. This is really two separate traps with ventilating pipes as a provision for preventing them being " air-bound."

I have already explained to you the evils of large-sized traps, and also those having parts inaccessible for cleansing. All the traps that we have now referred to have some disadvantage, although each one is good when seen from the inventor's point of view. But if we are to be

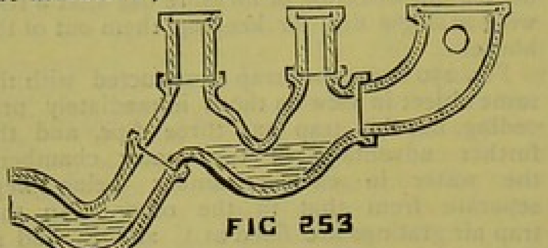


FIG 253

governed in our judgment by fixed laws, and those laws dictate that traps are to be as nearly as possible kept clean by the discharges passing through them, or failing that, can be easily cleaned by a scrubbing brush, we cannot accept them as being good for their intended purpose. I cannot do better than quote the words of the patentee of one of the above traps, who, in a public lecture said: "When a trap cannot be thoroughly cleansed, and all the water standing in it be changed by a good flush of water sent into it, it ought never to be used; and so, though I hold a patent for this trap, *I condemn it* as unfit for use."

Another point that I have not yet referred to is, the traps should be so constructed that the waste-pipes, although connected to the traps, shall have their bottom ends open to the air, so that air can enter and pass through the pipes and escape at the upper ends.

There are great numbers of good Interceptor traps in the market, and we will now deal with a few of them. Fig. 254, is one of the commonest description. The waterway through this trap is quite circular in cross-section, and there are no corners for solids to accumulate in.

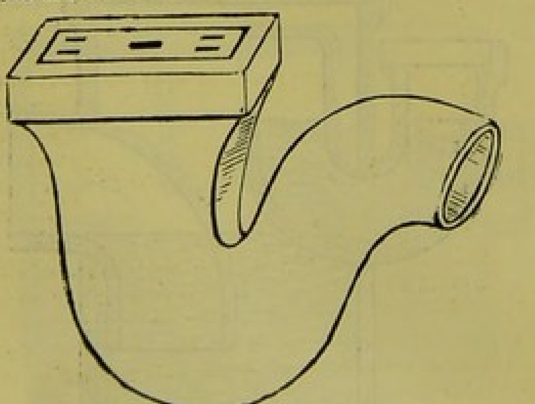


FIG 254

The dip is fairly good, and 2 in. in depth of water has to be evaporated out of the trap before the seal is broken. When a trap of this shape is fixed for receiving discharges of waste-water from sinks or similar fittings, the waste has to empty *over* the grating, with the result that the whole of the paving, or whatever surrounds the trap, gets splashed and soon becomes offensive. This evil is aggravated if an ordinary five hole stoneware grating is fixed over the trap as shown by the illustration. This kind of trap would be further improved if it had a flat foot or base, so that there would be less risk of its being fixed out of level, and which might have the undesirable effect of robbing the trap of part of its water-seal.

An improvement on the last kind of trap is

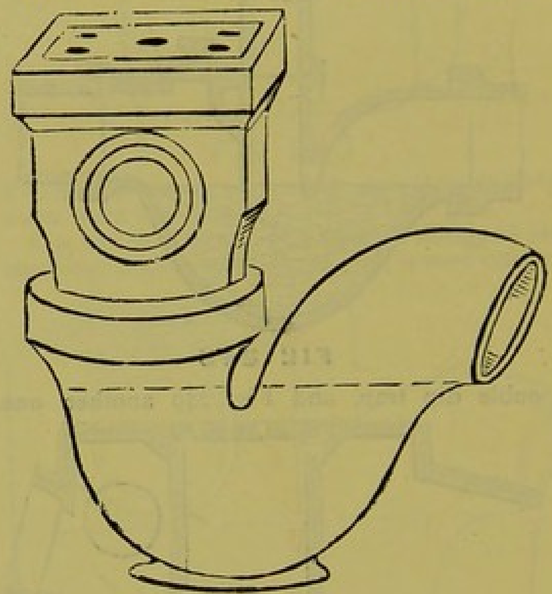


FIG 255

show by Fig. 255 which has an arm for connecting a waste or rain-water-pipe in such a way that the water is discharged beneath the grating, and is thus retained in the trap instead of splashing over the surface surrounding it. The grating is of the same improper description as that to Fig. 254. The trap has a flat base to it, and is made in two pieces. The upper piece can be turned in any direction to suit waste-pipes and thus avoid having to make unnecessary bends in them.

Fig. 256. is considered to be a good description of gully-trap.

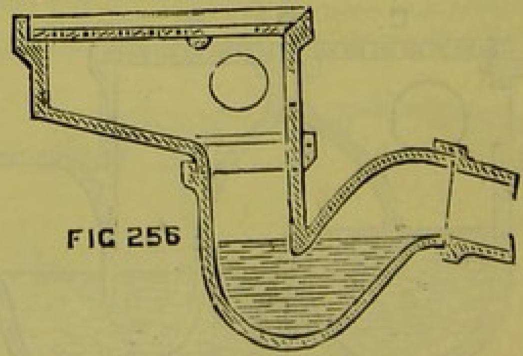


FIG 256

The upper part of this trap can be turned in any direction to suit the waste-pipes that discharge into it, and a provision is also made for the connection of a rain-water-pipe as shown by the illustration. It may be objected that the hopper head to the trap is too large, so that the splashings of waste-water would make the place smell offensive, and that the use of the under grating is doubtful. The plumber would also have some little difficulty in making the joint between the waste-pipe and the trap.

The interceptor trap shown at A, Fig. 216, is considered to be a very good one. This trap has the further advantage of having from 2½ in. to 3 in. dip.

An improvement on this trap is shown by Fig. 257. The inlet arms are constructed so that the incoming stream of water is not broken up, but acts as a kind of injector, breaking up the crust of congealed fatty matter that accumulates on the surface of the water in the trap, and also plays in the bottom of the trap, scouring away heavy muddy matters that would otherwise accumulate and eventually choke the drain or trap.

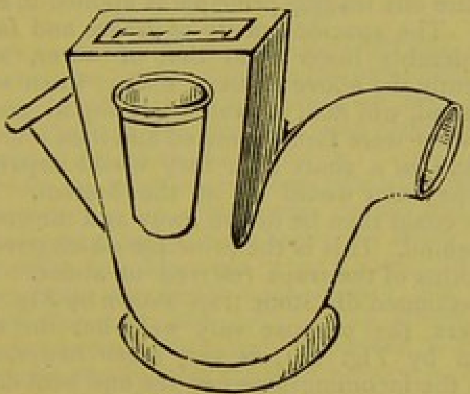


FIG 257

The water that brings these matters into the trap should be made to carry them through into the sewer, and will do so if care is taken when arranging the waste-pipes, and other fittings, that the column of water is sent through the pipes with a good velocity and in a compact stream.

I think it necessary here to mention to you that the traps I have illustrated were simply selected for the purpose of making clear the various good and bad points in their classes, the examples given being typical only. Why I mention this is, so that I shall not become an advertising medium to the profit or pleasure of some makers or patentees, and to the loss or chagrin of others. There are numbers of traps in the market as bad and as good as those I have introduced, but with the necessary knowledge it is not difficult for you to select those that are most fitted for the various classes of work required to be done, and the selection need not be confined to those that I have used for the purpose of my lectures. These remarks will also apply to my future lectures on traps or any other fitting, patented or not, that may be used by us when carrying out any work entrusted to us for execution.

Surface Water Traps.

Some of the traps used for receiving surface water were referred to in previous lectures. See Figs. 213, 215, 216, 220, 244, 245, 246, 251, 252, 254, 255, 256 and 257. Reasons were also given why some kinds of traps were better than others for that purpose.

In addition to the above traps there are several in common use which are made of cast-iron. One of those most frequently seen is called a "bell-trap," and is of the shape shown by Fig. 258. As this trap was referred to at length in "Plumbing Practice," it is unnecessary to say more than that it is very untrustworthy as a trap, has a small water-way through it and is frequently found with the grating and

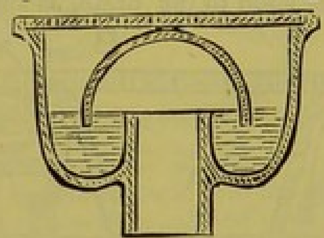


FIG 258

bell removed, or broken, in which cases it is perfectly useless for keeping smells from passing through. Fig. 259 is another cast-iron-trap which, although better than the preceding, is not a good one. The water-way through this trap

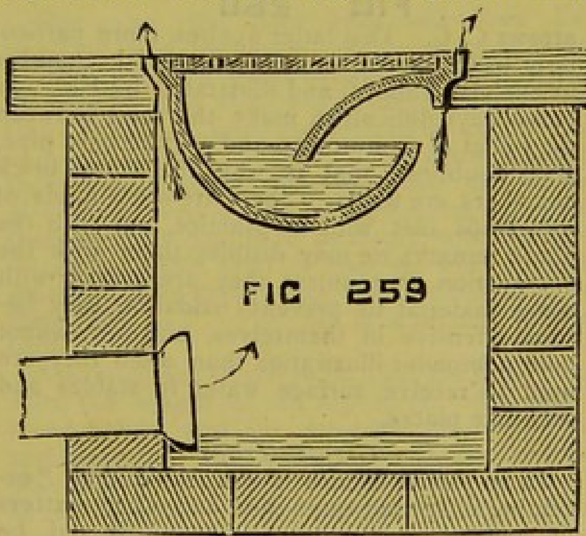


FIG 259

is larger and the removal of the grating does not break the water-seal in the same manner as with the bell-trap.

Both the above traps are usually fixed over small brick built chambers as shown by Fig. 259, the chambers being covered with stones, in which the traps are fixed. It is usual to simply fix these traps with the top edges sunk into rebates in the stones, and no cement for bedding them used. When so fixed it is urged, sometimes, that the traps can be easily removed for access to the chamber beneath for the removal of mud or sediment that generally accumulate in that part. The arrows in the figure denote the escape of drain-air when the traps are so fixed.

Fig. 260 is another kind of iron trap that is sometimes met with. For this trap it is claimed that the inner lining, A, the bottom edge of which dips in the water, can be taken out for access for passing cleansing rods into the drains or for cleaning out the body of the trap. This trap cannot be accepted as being, what is usually termed, self-cleansing, as it is impossible for any current of water that passes through to scour the sides and rub off the foul matters that are generally found adhering to them. There is also a risk of bad-air passing out as shown by the arrows B, B, or, when the outlet of the trap is not made good to the drain, as shown by the

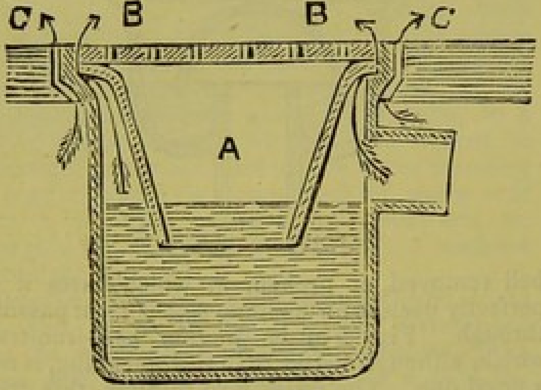


FIG 260

arrows C, C. This latter applies more particularly when the trap is fixed in a brick chamber as explained above, and illustrated by Fig. 259. It is always difficult to make the joint between the outlet of an iron trap and a stoneware pipe, and, doubtless, that is why the small brick chambers are used. There are other kinds of iron traps met with in practice, but with the above remarks we may dismiss them with the observation that unless they are coated with some material to prevent oxidation they become offensive in themselves, and we cannot take a broader illustration than when they are used to receive surface water in stables and such like places.

Grease Traps.

In an earlier lecture it was stated that "excepting in special cases sand and other matters do not require to be caught, but should be washed away into the sewer. It is not at all necessary to either strain or filter the sewage as it leaves the house." The special cases referred to are where certain matters cannot be washed away into the sewer. This is generally found to be the case with what passes down the scullery sink. The sand generally used in large mansions for cleaning copper cooking utensils, would scour away if it was not for the fatty matters which concrete the sand, earth from vegetables, and other substances together. It is the fat and grease from sinks that is generally the cause of drains choking up. The grease washed off the plates and dishes and mixed with the hot water used is sent down the waste-pipe in a liquid condition into the drain. In some cases the grease will congeal in the drains only a short distance from the sink, in other cases it will travel a considerable distance before it loses its liquidity, and where the drains are at a temperature above that at which grease solidifies it will pass away and do no harm. This latter only occurs in very large mansions and hotels where large quantities of hot water are used, or where steam is allowed to escape into the drains, thus keeping them at such a degree of heat that the grease is kept in a fluid condition.

It is usual with leading sanitary engineers to fix a specially constructed trap for catching the grease from sinks, and preventing its passing into the drains. There are several patent traps in the market which have been designed for this purpose, and although they vary in shape and size one leading principle is applied in each case. The specific gravity of grease and fat is considerably lower than that of water, consequently the above matters, either when solid or melted, will float on water. If liquid grease and water were forcibly mixed and then allowed to stand for a short time they would separate, and the water would be at the bottom. The water could then be drawn away and the grease left behind. This is the principle which governs the forms of the traps referred to above. The old-fashioned dip stone trap, shown by Fig. 220, answers the purpose very well, but the trap shown by Fig. 221, is very much better, and when the incoming-pipe has the end bent down so that it discharges beneath the surface at A, it is very rarely found that grease will pass into the drains. It is not by any means recommended that these traps shall be built up or made of brickwork. The writer has seen traps so constructed that had become defective and allowed the water to leak through the walls into the earth. It is much better to use those that are made in one piece out of burnt clay, and with vitrified surfaces. These traps are not porous, and with hot water and soda a man can scrub them as clean as when they were new.

Fig. 261, is selected as an example of one make of these traps and which, from some considerable experience with them, has always been found to answer its purpose very well. At D and E, are removable caps for access for cleansing the inlet and outlet-pipes should it be found necessary to do so. This very rarely occurs, but when the grease is not removed out of the trap at the proper times the drain beyond will get foul. At F, is an open grating over the connection of the sink waste-pipe with the trap to prevent air-binding and also for ventilation. Grease traps are frequently found fixed inside the house, and in most cases beneath the scullery floor. This ought never to be allowed, excepting in cases where there is no alternative, but this will be referred to again at a future time. Grease traps have been made of sheet, or cast metal, and with an outer jacket of the same material, the necessary service and waste-pipes being attached so that a current of cold

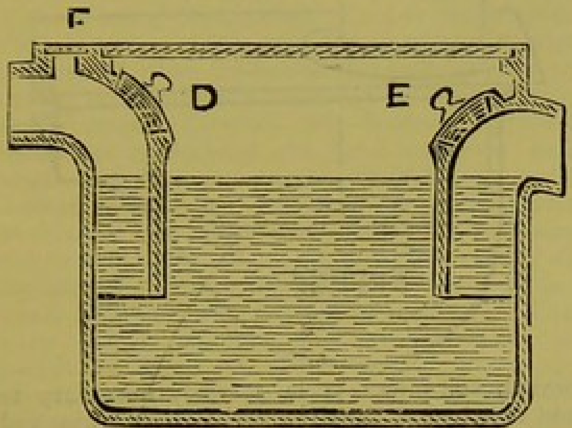


FIG 261

water is continually passing through the space between the grease trap and the outer jacket, so as to reduce the temperature of the greasy water that passes through and solidify the grease in the inner chamber.

From my previous remarks you will draw the inference that in some cases grease traps are unnecessary, and their absence in other cases will result in a blockage of the drains. In these latter cases they become a necessity, but in all cases they are also evils. The stench that issues when a grease trap is opened is one of the most abominable that can be imagined, and it is a great pity that with the engineering knowledge of the present day something else, and of a less objectionable nature, cannot be invented or designed. All the disinfectants the writer knows of have been tried, with a view of making these places less offensive if only for the short time necessary for their being emptied and cleansed, but with very poor results. They are offensive not only to the neighbourhood, but to the men who have to clean them out.

There are several engineers who are giving up the use of grease interceptors and are now specifying ordinary gully traps, and are also fixing automatic acting flushing cisterns, so that these traps are periodically flushed. The writer's experience of these arrangements only extends back about two or three years, so that he cannot give any decided opinion as to the success of their working. It is about as difficult to force floating grease through a trap as it is to drive the contents out of any ordinary washout closet, and it is more than probable that with small gully traps, the grease from scullery sinks will pass through the traps into the drain, where it will congeal, and no amount of flushing will afterwards remove it. I do not wish you to think the grease floats into the drain and sets in lumps. It is not so, excepting in cases where the cook has emptied the contents of the dripping pan down the sink, and which I have known to be done. The grease accumulates in the drains by a series of thin layers which little by little gather to such an extent as to eventually partially choke it. A portion of the solidified grease will then become detached, float a certain distance until it gets jammed and thus complete the blockage. Fig. 262 is a sketch section of a drain taken out some time ago showing how the

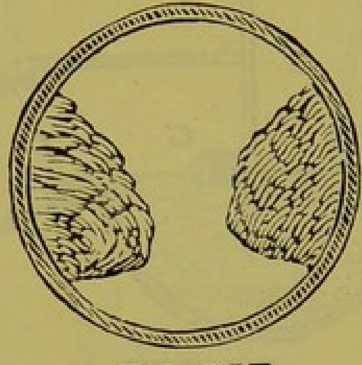


FIG 262

grease had become attached to the sides above the level of the surface of ordinary water discharges. In this case it was only a question of time when a complete stoppage would have taken place. Drains have also been taken out which were completely blocked with grease. With this slight divergence from our subject we will now return to traps.

Water-Closet Traps.

The rules that have been laid down for selecting good drain traps apply with equal force to those used for water-closets The commonest kind used by plumbers is the D trap. This trap has been so often condemned by engineers, and so much has been said and written against them that it seems almost a waste of time to give them even a passing reference. But, as there are still people to be found who use and recommend this kind of trap we will try and prove to those people that they are mistaken in their faith in it. Fig. 263 is a section of the trap.

Assuming the depth to be 9 in., the band 6 in. wide, the length of the top 12 in., when measured inside, and the dip-pipe 4 in. diameter and projecting into the trap a distance of 6 in. The superficial area of the cheeks will be found to be about twice 78 inches, or 156 inches. The area of the top—12 in. by 6 in.—72 inches. The area of the band 21 in. by 6 in.—126 inches. The dip-pipe is exposed on both sides to the splashings by what passes from the W.C., so the area of that part of the trap will be 2 by 6 ins. by 12 inches, a total of 150 square inches. Add the above amounts together and we get a total internal surface of this trap of 504 square inches, or 3½ square feet. This large amount of internal surface is one great disadvantage, as it gets covered with what passes from the W.C., but does not get properly washed afterwards. The shape of the trap is also bad, as no amount of water sent through will thoroughly wash the sides or pass over the parts outside and behind the dip-pipe. And then again, water discharges by themselves will not keep the inside of the trap clean, whereas in a well-shaped trap the paper and other semi-solid matters will rub against the sides, and by their friction wear off any small amount of fur that may accumulate

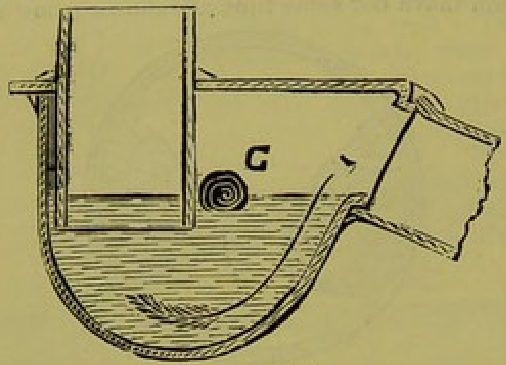


FIG 263

between the times of usage of the W.C. The size of the trap is against it. Approximately it holds about 7 pints, or nearly one gallon of water, which is more than can be entirely changed by any ordinary water discharges from a W.C. If a D trap is made with glass cheeks so that the passage of water through it can be watched it will be found that the incoming water will rush round the bottom of the trap, as shown by the arrow, any solid matters will roll over and over at G, and after the force of water is spent be left in the trap where it will decompose and give off, amongst other gases, carbonic acid gas. In an unventilated trap this gas will have such a corrosive action on the lead as to eat it into holes. The dip-pipe is exposed on both sides to the action of the above gas, with the result that it is generally found to be corroded before the other parts of the trap are similarly affected. When holes are eaten through the dip-pipe the trap is useless for keeping smells from escaping, but this cannot be discovered without first taking up the W.C. apparatus, so that a close inspection can be made. D traps are generally made with a dip of about 1 in., but if care is not taken with the fixing, or the outlet should be dragged down by an imperfectly fixed soil-pipe, this dip is reduced considerably and they have been found with only about ¼ in. water-seal. Some years ago, when the writer was first starting as a journeyman, he was doing some, what was then considered to be first-class work, and traps 14 in. long by 10 in. deep by 7 in. wide were ordered to be fixed. If any reader cares to take the trouble he can set out a trap to the above dimensions and work out for himself the capacity and also the amount of internal surface that a trap of that size contained, when he will find that the so-called improvement was really an aggravation of the evil.

Fig. 264 is a sketch of another shaped lead trap that several years ago was considered to be a first-class one. The writer has made and fixed them, and prided himself on the skill with which he made the joint on the outgo to the

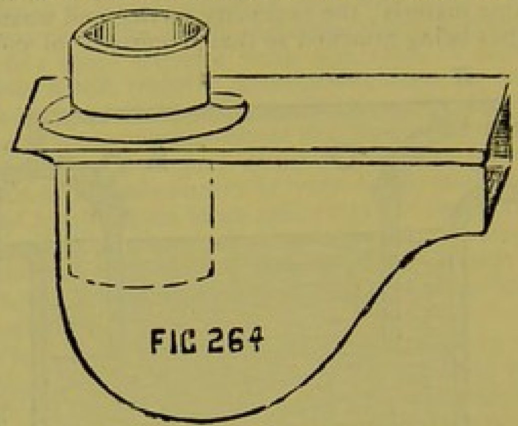


FIG 264

branch soil-pipe. It is scarcely necessary to add that he has seen the error of his ways and ceased to use or recommend them.

Several plumbers, at various times, have tried to improve the D-trap. One of them bossed up the body of the trap leaving round corners in the bottom and at the ends. A patent was taken out by another for casting them the same shape. In this latter case the dip-pipe and top were cast separately and afterwards "flam'd" or burnt onto the body, thus doing away with the soldering except onto the outgo. Two other patents were taken out for casting the traps all in one piece. These traps were a great improvement on the old-fashioned D-traps, and were better cleansed by what passed through them, but some of the old evils were retained. Amongst the improvements in hand-made-traps was the "V-dip," sometimes called the "mansion-trap," shown by Fig. 265. The outer edge of this trap

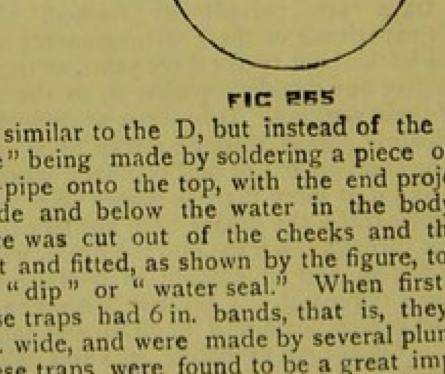


FIG 265

was similar to the D, but instead of the "dip-pipe" being made by soldering a piece of 4 in. soil-pipe onto the top, with the end projecting inside and below the water in the body, a V piece was cut out of the cheeks and the top bent and fitted, as shown by the figure, to form the "dip" or "water seal." When first made these traps had 6 in. bands, that is, they were 6 in. wide, and were made by several plumbers. These traps were found to be a great improvement in several ways; they were cleaner in their use, and a smaller flush of water would keep solid matters from accumulating in the body. If any part of the trap or the dip became perforated by corrosion it was soon found out by water leaking through the holes, so that smells could not be escaping for any length of time without being discovered. This is not so with the D-trap. One of our leading master plumbers further improved this trap by bossing up the body and then soldering on the top, with the V shaped division. He further improved this trap by making the band narrower and smaller, so that it was 4 in. wide in the body instead of 6 in., as formerly made. The result of this was the internal surface of the trap was reduced to about 2 ft. 11 in., and the capacity of the part retaining water to about four pints instead of about seven pints as in the D. The same master plumber afterwards took out a patent for, and cast, these traps, with slight alterations, in pig-lead, so that they had no soldered parts excepting the joint to the soil-pipe. This trap was afterwards modified, and what may be termed a revolution in traps was made by the inventor of the last one described. Instead of the body of the trap being made larger than the inlet and outlet, which used to be considered the right thing to do, a trap was made with the body considerably smaller than either the inlet or outlet.

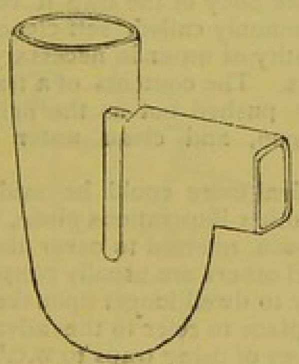


FIG 265

Fig. 266 illustrates the anti-D-trap to which reference is made, and which holds two and a half pints of water. It was generally thought that this trap would never answer for fixing under W.C.'s, but several years test in actual work has proved the inventor was right in the bold step he took, and they are now preferred by all leading sanitary engineers to any other kind. For obvious reasons I cannot say more about this trap, but the reader is referred to "Sanitary Plumbing" and "Dulce Domum,"* which contain full descriptions of this trap and also several tables showing the results of experimental tests with all kinds of traps, and under varying conditions. It is difficult to find out who first introduced traps under water-closets and what was the shape of the earliest ones that were made. Those that have been taken out of very old buildings vary in description and shape. The writer has seen some thousands, but yet is not in a position to say with confidence if the D or the round pipe-trap is the

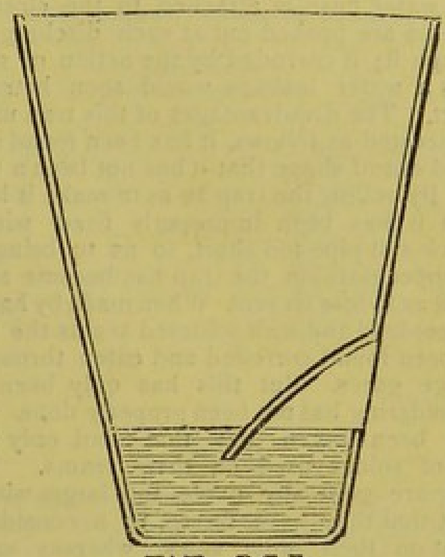


FIG 267

oldest. At the "Parkes' Museum of Hygiene," is an old cast-iron-trap and closet-basin in one piece. Fig 267, is a section of this closet, which is here shown for the sake of illustrating the trap. The basin part is of the same shape, but a little larger than the common long hopper which is so much used at the present time. The principle of the trap being similar to that shown by Fig. 259.

One of the earliest patents taken out for a water-closet was by Alexander Cummings, in 1775. The illustration, attached to his specification, shows a round pipe ꝏ shaped trap. This trap is very popular at the present day, and is deservedly so from certain points of view. If not made too large it is the most cleanly in its use of any other kind of trap. In its modified form in the shape of a half ꝏ as shown by Fig. 268, it is used in all parts of the country. In

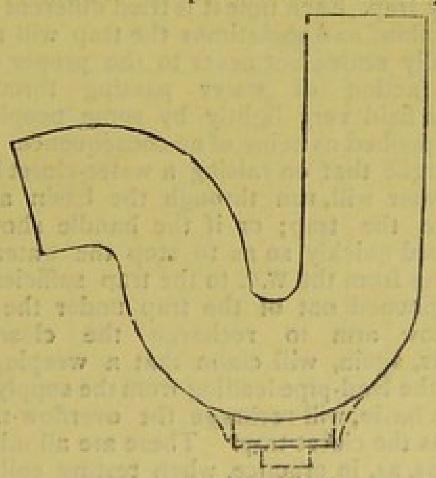


FIG 268

the North of England, Scotland, and several other places it is the only trap used, and is generally made by hand. But this trap has its drawbacks. To first describe its good points; it

* Batsford, Holborn, Publishers.

has no corners or places that are not washed at each usage of the W.C. If not too large, and a good water flush is attached to the closet, the contents are pushed out at each discharge sent through it; if corroded by the action of sewage gases a water leakage would soon betray the defect. The disadvantages of this trap may be enumerated as follows, it has been found so distorted out of shape that it has not been a trap at all. By pulling the trap so as to make it longer, when it has been improperly fixed with the branch soil-pipe too short, so as to bring it to its proper position, the trap has become so distorted as to lose its seal. When made by hand out of sheet-lead and with soldered seams the solder has been found corroded and eaten through by sewage gases. But this has only been when the soldering has not been properly done. Traps have been taken out that had only about ¼ lb. of solder used on their seams. These traps are generally made too large, with the result that they have furred to a considerable extent on their inner sides, whereas smaller traps have been kept clean by the friction of passing matters. But if these traps are made so that they shall be cleanly in their use the greatest evil of all then obtains by the discharges sent down from a W.C. passing right through the trap and not leaving sufficient in the body to form a water-seal. This action is often attributed to syphonage, that is, the soil-pipe attached to the outgo of the trap acts as the long leg of a syphon and "syphons" the water out of the trap. But, this is not so as any reader can prove for himself by standing any ordinary lead P-trap without any soil-pipe at all on a bucket or stand, place a valve-closet on the trap, partly fill the basin with water and raise the handle in the ordinary way, when he will find that frequently the water left in the trap will not be sufficient to form a proper seal. It makes very little difference whether he first charges the trap with water or tries the experiment with an empty trap. Each time it is tried different results will follow, and sometimes the trap will remain partially sealed but never to the proper extent. This action of water passing through a trap is held very lightly by some people, and pooh-poohed as being of no consequence. They will argue that on raising a water-closet handle the water will run through the basin and recharge the trap; or if the handle should be dropped quickly so as to stop the water from passing from the W.C. to the trap sufficient will be syphoned out of the trap under the basin overflow arm to recharge the closet-trap. Others, again, will claim that a weeping-pipe, from the lead-pipe leading from the supply valve to the basin, will recharge the overflow-trap as well as the closet-trap. These are all mistaken notions, as, in practice, when testing soil-pipes, by means of a smoke machine, smoke is frequently found to pass through a W.C. trap when of the description under discussion. During this last twelvemonth the writer has had to substitute the traps shown by Fig. 266 in place of the round pipe-traps, shown by Fig. 268, in about 10 or 12 cases. In some cases ventilating the traps was tried, but found to be of no use for preventing the action described. The above illustration refers to cast lead traps, machine made traps, and hand-made traps, the results being about the same with each description. Various round-pipe traps have been made with the object of arresting the impetus of the passing water. Fig. 269 is a sketch of one that was

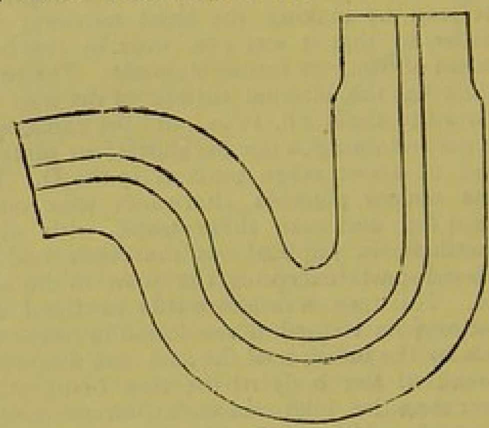


FIG 269

found to be very successful in doing so, but by enlarging the body of the trap it ceases to be, what is commonly called, self-cleansing, and a larger quantity of water is necessary to change the contents. The contents of a trap should be as literally pushed out as the pellet out of a boy's pop-gun, and clean water left in the trap.

A great deal more could be said on closet-traps and other illustrations given, but as those that have been referred to cover the principles on which all others are usually constructed, it is unnecessary to dwell longer upon them. Neither is this the place to refer to the advantages and disadvantages of using traps to W.C.'s. A passing reference may be made to a patent taken out some time ago for doing away with water-traps to W.C.'s, and substituting flap-valves on the ends of the branch soil-pipes. The main stack of soil-pipe having an enlargement at the point of junction for the flap-valve to work in without forming an obstruction to anything passing from a higher level. The writer has not seen this principle in work, but cannot think otherwise than it is always liable to be out of order. The remarks made on the flap-valve, shown by Fig. 239, apply also in this case. Before entirely leaving this part of our subject it will be well to draw the readers' attention to the evils of having brass caps and screws soldered into water-closet-traps. The writer has found these caps and screws soldered into the sides of traps where it was impossible to get to them, as they were between the floor joists, for removing any obstruction or for cleansing the traps. In other cases he has seen the screw caps so fixed that the W.C. apparatus had to be removed before the cap could be taken off. He has also found the caps unscrewed and left so that the trap was perfectly useless for keeping drain air from escaping.

In one large building the writer was inspecting he found the work done in a wretchedly bad manner and bossed lead caps placed loosely over the cleaning holes in the traps, so that drain air was escaping night and day all the year round, until the stench became so unbearable that it became necessary to make an examination as to the cause.

Traps for Sinks, Baths and Washhand Basins.

In selecting a trap for fixing under sinks, baths or washhand basins the same thought has to be bestowed as on those for W.C.'s. The matter that passes through a sink, for instance, will frequently clog the trap. Amongst the rest of these matters is grease, and, what is nearly as bad, the curds from soap, especially in places where the water used is very hard.

The D-trap is an old favourite with some people for the purpose, but so much has been said against it that it is unnecessary to repeat the objections.

Another trap much liked by some plumbers is shown by Fig. 270. This trap may be

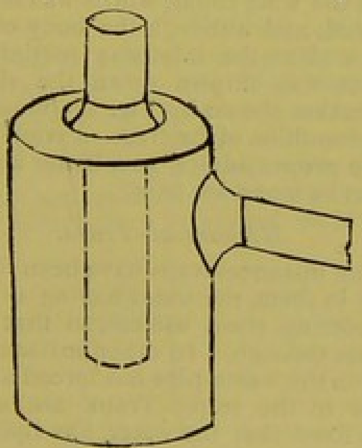


FIG 270

described as a modification of the D-trap. Although not the same shape it has the disadvantage that any water passing through does not clean the internal surface and the corners get clogged with foul matter as much as in the D-trap.

Fig. 271 is another form of this trap which is considered by some plumbers an improvement on the other one. One of the chief arguments in favour of these traps is they are proof against syphonage, and to a certain extent of evaporation of the water out of them. With these objects in view they are sometimes made so large as to hold as much as 2 gals. of water. The inevitable result is the contents of the trap become putrid, and when anything is sent through them, and this putrid matter washed out, an abominable stink is found near the discharging end of the waste-pipe. On cutting open one of these traps they are invariably found to be in a very dirty condition and the inside clogged with a black slimy matter, which in some cases gets

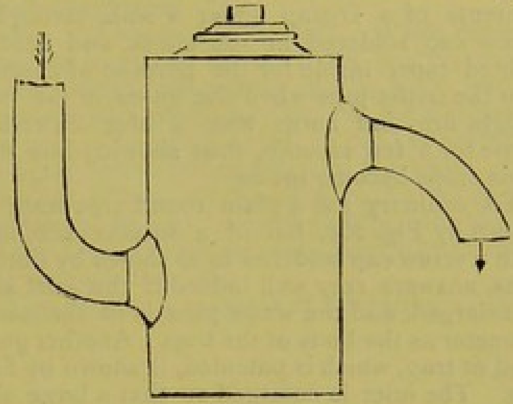


FIG 271

into the waste-pipe and chokes it up. These traps have frequently been taken out, as the stoppages were so frequent, and laid in a dry place. When, after a few weeks interval, they have been again examined they have been found to be almost fit for using again, as the slimy matter had dried up so that it could, by shaking the trap, be made to fall out. In the illustrated catalogue of a manufacturer of plumbers materials, these traps are described as "soap-traps," from their known property of retaining a certain amount of the floating matters that are sent into them. This is not quite the case. Soap curds may be retained for a time, but after they have accumulated to a certain extent, they get washed in large pieces into the waste-pipe, and form a solid plug, so to speak, and block up the pipe.

Another hand-made trap, sometimes used for sinks and similar fittings, is shown by Fig. 272. A glance will show that it must eventually get as foul inside as a D-trap, and become equally objectionable. Besides soap and grease, sand and grit frequently get into traps, and if not broken up and washed away, by discharges through the trap, these matters will so concrete

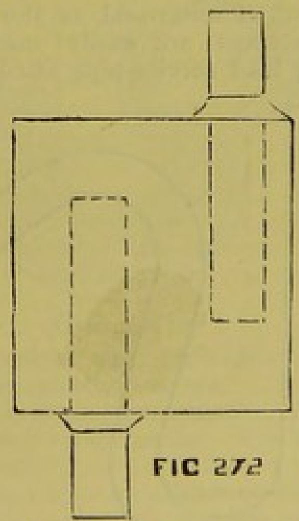


FIG 272

together that mechanical means have to be resorted to for removing them.

In one instance the writer was removing the contents of a D-trap under a sink, through a screw cap soldered in the cheek, and held a lighted taper inside for the purpose of peering into the outlet-pipe when the gases in the trap caught fire and burnt with a blue flickering flame for a few seconds, thus showing how foul these traps become inside.

For ordinary use a plain round pipe-trap, as shown by Fig. 268, but of a smaller size, and with a screw cap soldered in as shown by dotted lines, answers very well indeed if the inlet end is enlarged, and the waste-pipe is of the same diameter as the body of the trap. Another good kind of trap, which is patented, is shown by Fig. 273. The inlet is enlarged so that a large size grating can be soldered over it, and thus allow water to pass through quickly and fill the bore or water-way of the trap. This trap has also the advantage of a deep water-seal. When fixed under wash-hand basins this is an important item for consideration. These fittings are sometimes not often used, with the result the water will evaporate out of the traps when they become useless. It has been deemed advisable

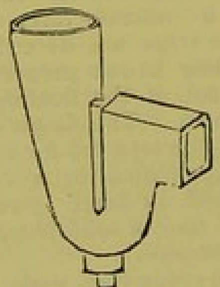


FIG 273

in some instances to fix special made traps with an extra depth of water-seal, as shown by Fig. 274. These traps are easily made out of extra strong lead service-pipe filled with sand.

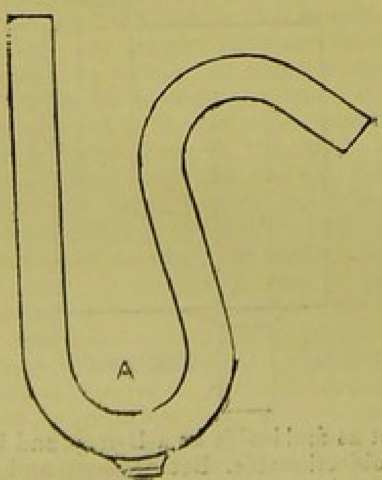


FIG 274

By bending the pipe, as shown in the figure, the throat at A does not cripple to any serious extent, and not nearly so much as when made to the shape of machine-made traps. If a slight buckle should occur it can be worked out through the hole made in the heel for soldering on the brass screw cap, which is necessary for removing anything, such as a finger ring, or other small article that may get into the trap, or for passing a cane or small wire brush in for cleansing the trap.

One is sometimes in a difficulty to know what to advise in extraordinary cases. Quite recently,

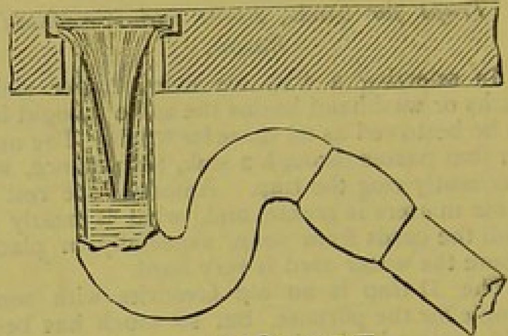


FIG 275

when making a sanitary survey in a nobleman's mansion, the writer saw a round pipe-trap under a sink in the wine cellar, which was acting very well indeed, and although the body of the trap was quite clean the inlet was partially choked with what was thrown down the sink. The sketch section shown by Fig. 275 illustrates the internal condition of the trap. Periodical cleaning is the proper advice, as a better kind of trap could not be found for fixing.

Mechanical Traps.

In some instances traps have been found with no water in them, the water having evaporated, thus rendering them useless, so that drain air could pass through. In other instances a back pressure in the waste-pipe has forced air through the water in the trap. Traps are sometimes found so fixed that the water has siphoned out

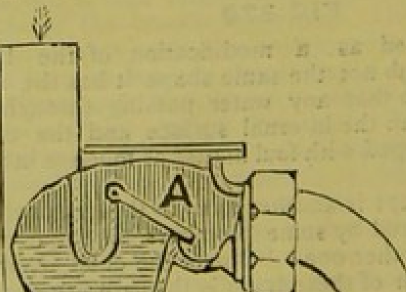


FIG 276

of them. With the object of preventing some of the above actions a great deal of ingenuity has been displayed by inventors, and several traps that would offer resistance to such actions have been patented. Some of these traps have hinged valves in the body, as shown by Fig.

276. This trap has a water chamber, arranged to form a water-seal, and also a flap-valve at A which has to be pushed open by the discharges for them to pass. A back pressure in the waste pipe would press the valve more firmly on to its seating. Fig. 277 is another kind of combined water and flap valve-trap. Both of these traps, and others, which are similar in construction, are liked by some plumbers and no doubt answer their purpose very well indeed, so long

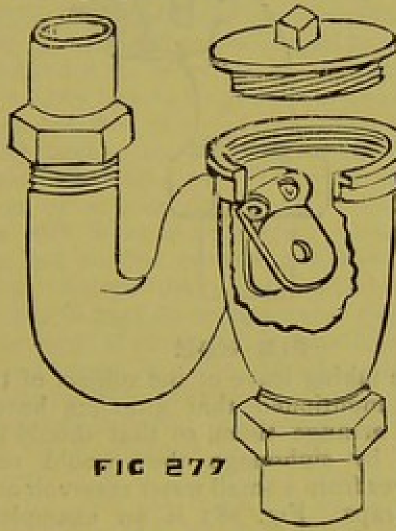


FIG 277

as clean water passes through them. Another kind of mechanical trap has the flap-valve hinged in the body of the water-trap, so that the valve is immersed. In an earlier lecture, (on flap-valve Fig. 239), reasons were given why valves are always liable to be rendered useless, so it is unnecessary to repeat what was there stated.

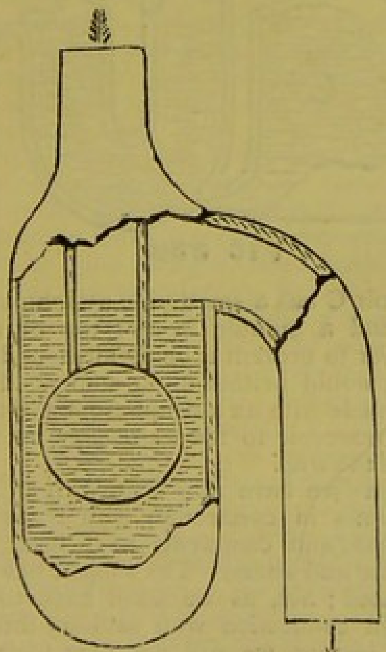


FIG 278

There are other descriptions of, so-called mechanical, traps which have balls inside, either floating on the water in the trap or sunk to the bottom. Another kind has the ball on the outlet side of the trap. We will select one of each as an illustration.

Fig. 278 has a floating ball. Water entering the trap as shown by the arrow pushes the ball aside, which afterwards floats back into its position and seals the end of the dip-pipe in the trap. The ball is of no use to prevent a siphonic action taking place on the water in the trap but a back air pressure in the waste-pipe causes the ball to fit more tightly over the end of the dip-pipe and prevents the air from escaping through the trap.

Fig. 279 is an example of the heavy ball-trap.

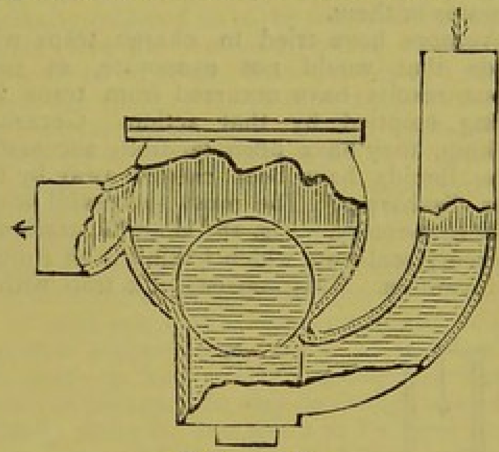


FIG 279

In this case the ball lays over the opening in the bottom of the trap, and is entirely covered with the water. Discharges through the trap push the ball aside, after which it resumes its

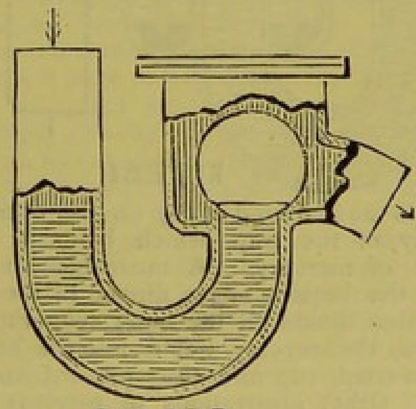


FIG 280

original position and prevents air being blown through by a back pressure.

Fig. 280 is a representation of a ball-trap with the ball on the outlet. The illustration explains itself.

Ball-traps have an advantage over flap valve-traps, in that the balls revolve and thus rub off any matters that may be adhering to them. Another advantage is that the balls are made of vulcanised indiarubber, or of hard metal and rest on indiarubber seatings, so that should any small thing get between the valve and seating it would not hold the valve open in the same manner as it would in the case of the flap valve. It has been urged that as indiarubber is a perishable material, balls made with it would not last many years. The further objection has been raised that this kind of trap does not get scoured inside by the discharges through it. Fig. 279 and 280 have the further disadvantage of having caps screwed on to the outlet side of the traps, so that should they be removed for cleansing the trap or renewing the balls, and not properly replaced, bad air could escape through them in the same manner as has been described when speaking of brass screw caps being soldered into traps on the top or above the water in them.

Inventors have tried to charge traps with liquids that would not evaporate, as such serious results have occurred from traps becoming emptied by that action. Generally speaking, they have been far from successful, as the liquids have been carried away by the water discharges. The most successful liquid has been mercury. Fig. 281 is an illustration of a mercury seal-trap, which I think is an American invention. This consists of a trap with a

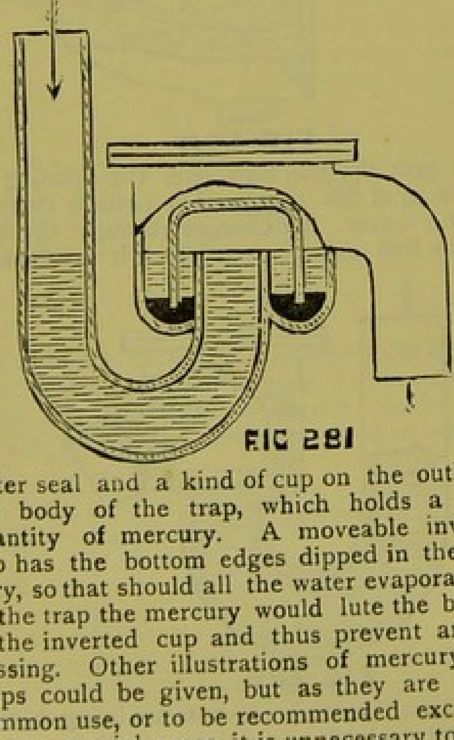


FIG 281

water seal and a kind of cup on the outlet of the body of the trap, which holds a small quantity of mercury. A moveable inverted cup has the bottom edges dipped in the mercury, so that should all the water evaporate out of the trap the mercury would lute the bottom of the inverted cup and thus prevent any air passing. Other illustrations of mercury seal-traps could be given, but as they are not in common use, or to be recommended excepting in very special cases, it is unnecessary to dwell upon them.

Various systems have been tried to prevent water being siphoned out of traps, and at the same time avoid the use of ventilating pipes. The simplest method has been to fix an air inlet valve, as shown by Fig. 282. The hinged valve at B opening to allow air to pass inwards, but closing when a back pressure has been exerted. This valve can be made either as shown, or the valve can be horizontal. Although these valves have been fixed inside a house, it cannot be considered good practice as they, in time, get so choked with dust that they do not close tightly. Neither is it a good plan to have a waste-pipe closed at one end. It is much better to fix a proper ventilating-pipe; but this will be entered upon when we come to sanitary plumbing.

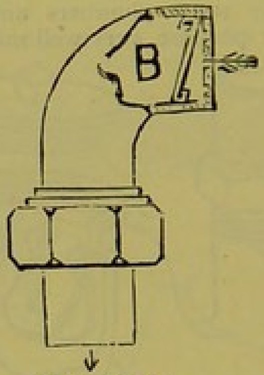


FIG 282

Before taking leave of the subject of traps, it may be mentioned that attempts have been made to arrange them, so that should they be emptied by siphonage they would recharge themselves from a small water reservoir attached to the traps. Fig. 283 is an example. The

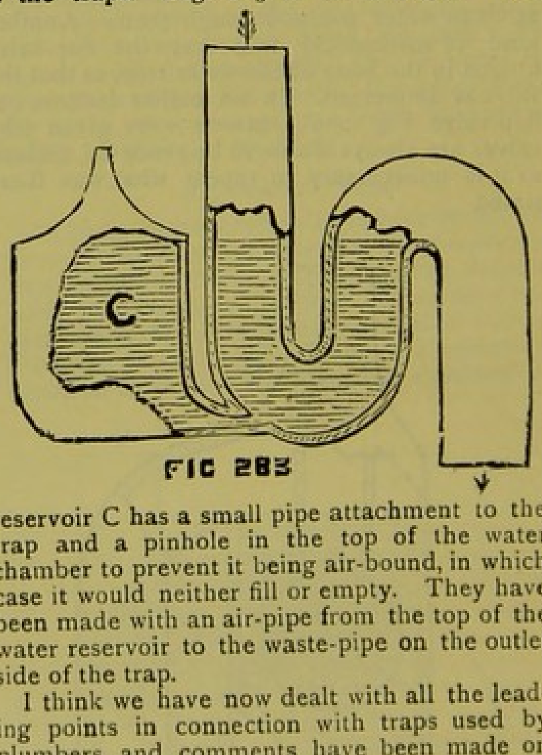


FIG 283

reservoir C has a small pipe attachment to the trap and a pinhole in the top of the water chamber to prevent it being air-bound, in which case it would neither fill or empty. They have been made with an air-pipe from the top of the water reservoir to the waste-pipe on the outlet side of the trap.

I think we have now dealt with all the leading points in connection with traps used by plumbers, and comments have been made on their use and abuse. The subject has not been exhausted; but, as we shall have to refer to traps in connection with sanitary fittings in a future lecture, we will not now further dwell upon it but pass on to the next in the syllabus issued by the City and Guilds of London Institute for the Advancement of Technical Education.

SOIL PIPES.

WE will first deal with soil-pipes under the headings of size, materials, and position and afterwards with other points in connection with them. With regard to size, we must first consider the number of W.C. fittings that are connected with the soil-pipe, and the average quantity of water, &c., discharged from a fairly well flushed W.C., which is about two gallons. This quantity has to be got rid of quickly, and, as far as possible, in a compact volume, instead of being broken up by the resistance of the air inside the soil-pipe. This introduces the question of ventilation or air relief - pipes ; but we will leave that subject alone for the present and confine ourselves to the hydraulic question. Before the water reaches the soil-pipe it has to pass through a water-closet. The exit openings of valve W.C.'S vary from 3 in. to 3½ in. in diameter, and the contents of the basins pass through the openings, in some cases, in less than two seconds, presuming the basins to be half filled, which is the usual quantity. A slight resistance is sometimes met with when passing through the traps, but on entering the soil-pipe the speed at which the water travels increases in proportion to the vertical distance it has to fall, provided there is no air resistance, or the air driven down by the fallen water is allowed to escape through pipes fixed for that purpose. Should the water-closet be used for the reception of water from slop pails and the basin filled to the brim, it will be found that it will take about three to four seconds to empty it into the soil-pipe. We may accept this as a fairly good basis to work upon, as all closets, including hopper basins, are at times used for the reception of slops from pails, and when so used nearly approach the valve closets in their action. At all events we will assume it to be so. From this reasoning we learn that about three gallons of water has to pass through the soil-pipe in about as many seconds. Assuming the soil-pipe to be quite straight, fixed vertical and 2 ft. long, we find on referring to Table 2, in "Box's Practical Hydraulics,"* that a short pipe 2 in. in diameter with 2 ft. head of water will actually discharge 73·6 gallons per minute, or 1·23 gallons, nearly per second. Table 21 shows the maximum discharge through a 2 in. pipe, 3 ft. long, to be 88 gallons per minute, or 1·46 gallons per second. This latter example is based on the supposition that the top of the pipe has a trumpet mouth similar to a standing waste pipe in a cistern, and may be said to nearly approach the same conditions as a water-closet basin with a short piece of 2 in soil-pipe. Both the tables give a larger quantity of water as passing through the pipe than would actually occur in practice, but they will help the student to form some idea as to what duty a 2 in. pipe will do. If we want to get rid of three gallons of water in three seconds of time, and a 2 in. pipe will convey that quantity of water away in the given time, we may at first sight be led to think that the above size of pipe is suitable for use as a soil-pipe. But in practice we should find, in addition to the check formed by the trap, the air between the water in the basin and that in trap, also the length of sloping-pipe, which is generally soldered on to the outgo of the trap, we should have the ventilation-pipes, which would allow air to enter and thus destroy to a certain extent the value of the head of water formed by the reservoir, in this case the W.C. basin. Other objections to so small a pipe are as follows :—

Supposing that a stack of soil-pipe extended the height of a large building and had branches from W.C.'S on each floor, the 2 in. pipe would answer equally as well as the short one, above used for illustration, provided that two, or more, W.C.'S were not used at the same instant of time and that proper vents were fixed to allow the air, pent up between the falling columns of water, to escape. It may be thought to be an unlikely thing for two W.C.'S to be used at the same instant of time, but in hotels and large buildings it is of common occurrence, and gives rise to those intermittent smells which are so difficult to trace to their source.

From another point of view we cannot consider a soil-pipe in the same manner as we would an ordinary water-pipe. There are certain semi-solid matters mixed with the water and which have to be considered. Further still, if the soil-pipes are made very small, the W.C. traps and also the exit holes in the bottom of the W.C. basins should be reduced to the same size as the soil-pipe and thus prevent anything passing through and, by lodging in the pipes, form a stoppage. The important question of ventilation-pipes, not for the purpose of allowing a current of air to pass through the soil-pipe, but to break siphonic action and also to relieve air compression in the pipes, will be dealt with further on. In theory a 2 in. soil-pipe would, if properly ventilated, act very well ; but he would be a bold man indeed who staked his reputation on its being applicable to ordinary practice.

We will now consider the practicability of using a 2½ in. pipe as a soil-pipe, and first compare it with the 2 in. Circles are to each other as the squares of their diameters. The square of 2 being 4 and the square of 2½ being 6·25, we find that the proportion of a 2 in. pipe to one 2½ in diameter is as 4 is to 6·25. A 2½ pipe is more than half as large again, in cross area, than a 2 in. pipe, hence it will convey more than half as much again water away in a given time. Hence it may be argued that a 2½ in. pipe is

* Published by Spon.

large enough for using under W.C.'s, and there is little doubt it would answer very well for that purpose. Absence of practical tests with this size pipe makes one hesitate to recommend it for use. The only objections the writer can think of is the fact that some users of W.C.'s seem to think they are intended as rubbish shoots. If this size pipe should come into general use makers of sanitary fittings would have to reduce the size of the outlets from the W.C.'s, and great care would have to be taken in arranging the bends and branches. Extraordinary care would also have to be taken when specifying the sizes of the ventilation-pipes and also the positions of the connections with the soil-pipes. It may also occur to some students that a pipe of the above diameter would always be choking in places where proper toilet paper was not used in the W.C.'s, or in certain factories where other material than paper is used by the workpeople.

We will now consider the practicability of using a 3 in. soil-pipe. By following the same line of reasoning that we did with 2 in. and 2½ in. pipes we find that a 3 in. pipe is considerably larger than either of the other two. The square of 2 is 4; the square of 2½ is 6·25, as before stated, and the square of 3 is 9; so that a 3 in. pipe is more than twice the size of a 2 in., and nearly one-third larger than the 2½ in. pipe. On referring to the tables we used before we find that a pipe 3 in. in diameter and 3 ft. long will discharge 220 gals. per minute. On comparing the discharges from the various sized pipes we find that, for the lengths used for illustration, a 3 in. pipe will discharge two and-a-half times the quantity of water that a 2 in. pipe will, and one and a-half times as much as a 2½ in. pipe.

The quantity of water discharged is thus seen to increase in greater proportion than the relative sizes of the pipes. This is accounted for by the fact that as the diameters of pipes increase the friction of water passing through them decreases.

The table above referred to gives the discharge from a 3½ in. pipe, 3 ft. long, as being 303 gals. per minute, and a 4 in. pipe, of the same length, as 400 gals. With these figures before us it is less difficult to form a judgment as to the best sizes to be used for soil-pipes.

To fall back on practical experience, it is not at all uncommon to find 4 in. and 5 in. soil-pipes so incrusted with fur as to leave the water way through them reduced to 2 in., 2½ in., and 3 in., and continue to answer their purpose until a portion of the incrustation has become detached; this portion getting jammed in the pipe forms a blockage and leads to the necessity of renewing the pipe.

I should like here to slightly diverge from our subject for a moment to preach the doctrine that soil pipes and urinal waste-pipes would never fur up inside if water heated to a degree above "blood heat" was used for flushing those fittings. It is cold which causes the salts in urine, &c., to crystalise on the surfaces on which they are deposited. Assuming "blood heat" to be about 98 degs. Fahr., and that heat keeps the urinal salts in a state of solution, water heated to that degree used for flushing W.C.'s and urinals would prevent the furring-up of pipes. I daresay in these days of science and improvement someone will invent the necessary apparatus for carrying out the above object, but until that is done we must keep to mechanical means for gaining the same ends.

As it would be troublesome and difficult to periodically remove the incrustation that forms in soil, &c., pipes, it is much better, if we cannot prevent them otherwise, to take such precautions that they shall not accumulate to an objectionable extent; in other words, that they shall be rubbed off by the friction of passing matters To do this, in the case of soil-pipes, they must be kept so small that what passes down the pipes will rub against the sides.

To return to our subject. Practical experience has shown that a 3 in. soil-pipe answers the purpose very well indeed, and that with W.C.'s fairly well flushed a pipe of this size does not get foul inside. In 1880 a pipe of that size was fixed, and had three W.C.'s (in daily use since by some 50 or 60 people) attached. The writer has had the privilege of frequently seeing this pipe, and never knew of anything occurring to its prejudice. Some short time ago he saw a portion of this pipe cut out for inspection, when it was found to be nearly as clean inside as when it was first fixed. Theory tends to prove, and practice has proved, that soil-pipes much less in size than those generally fixed, will answer their intended purpose, and at the same time be without the objections that have been raised to the larger pipes. But at this point other issues are raised. The first one, which is entirely practical, is the arranging and fixing of the pipes. No soil-pipes pass direct from the W.C.'s to the drains without either bends or branches. To begin with bends: they

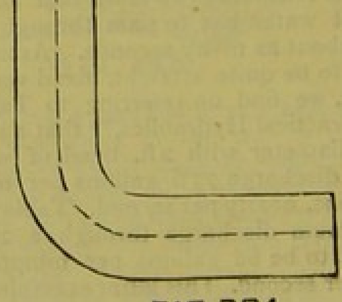


FIG 284

should never be made to a too small radius. Writers on hydraulics tell us that a great loss of head of water is caused by sharp bends and turns in pipes. That is, more water will pass through a straight pipe of a given length than through another pipe of the same size and length that had several bends in it. And more water will pass through a pipe with bends made to a large radius than through a similar pipe that had sharp bends. Assuming Fig. 284 to be a pipe bent to a radius of one diameter, that is, the quarter circle described by a pair of compasses set to the same length as the diameter of the pipe will represent the centre line drawn on the side of the bend. A bend made this shape will seriously retard the velocity of the water passing through it, and, in the case of soil-pipes, be more liable to become blocked with passing matters than if it had been made as shown by Fig. 285. Theorists

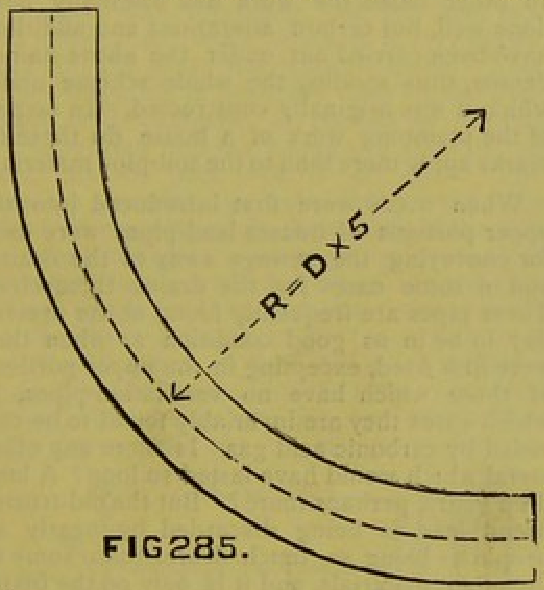


FIG 285.

tell us that the sharpest bend that can be made to offer the least resistance to the flow of water should be to a radius of not less than five times the diameter. Following this line of reasoning, we are led to the conclusion that, with bends of not less than the above radius, small size soil-pipes cannot be objected to on account of the bends in them.

The same line of reasoning applies, and with equal force, to branch joints. Let Fig. 286

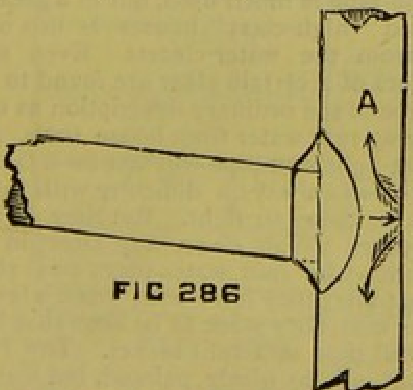


FIG 286

represent an ordinary branch soldered joint, the branch having a slight inclination as usually carried out in practice. As shown, the branch joint is really worse than the bend illustrated by Fig. 284, and would offer a greater resistance to the flow of water. In addition to the sharp turn the water would have to take, the current would strike against a surface at nearly right angles, with the result that a portion of the water would be thrown upwards, as shown by the arrow A, and in the case of a good velocity down the branch pipe, be kept there until the force was spent, when this headed up water would fall down the pipe. The branch would be much better if the end of the entering pipe was bent, as shown by dotted lines in Fig. 287, in which case the branch would more nearly approach a bend in its construction. This applies to all soil-pipes, irrespective of size, as, in addition to the other reasons that have been

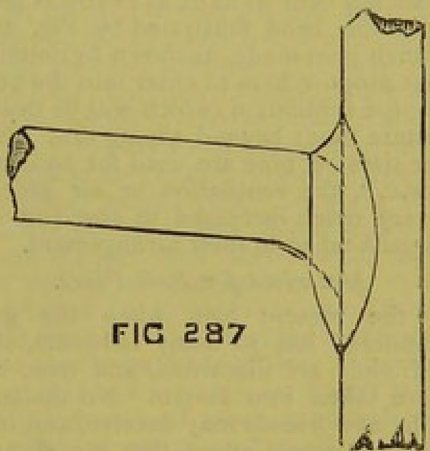


FIG 287

given, there would be less liability of anything coming down from a higher level splashing up the branch pipe. Should soil-pipes less than 3 in. in diameter be used it would then become necessary to go further still, and the branch itself be continued so as to form a portion of

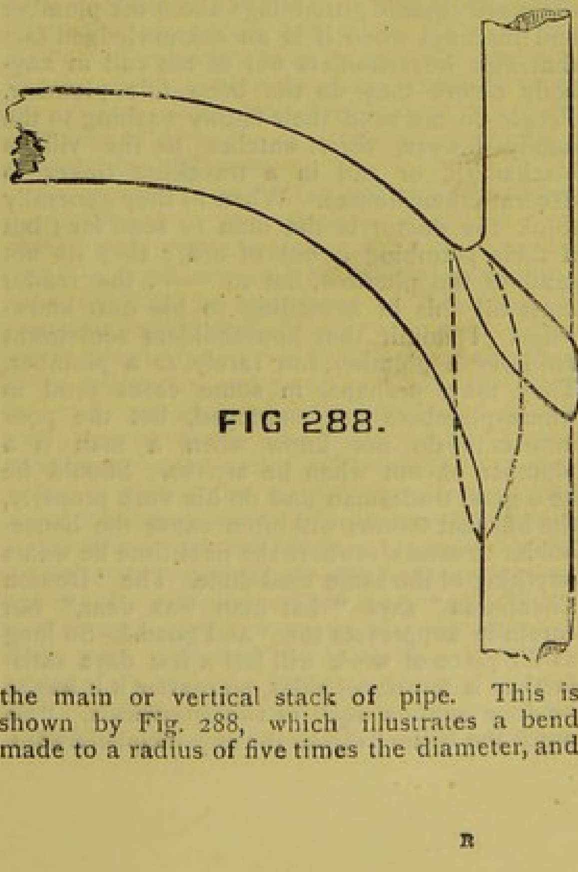


FIG 288.

the main or vertical stack of pipe. This is shown by Fig. 288, which illustrates a bend made to a radius of five times the diameter, and the pipe from the higher level branched into the top of the bend. When work is fixed this way it does not look so smart as when the joints are made, as shown by Fig. 287. In addition to this, it is found in practice that pipe has to be cut to waste to suit the lengths between the branches, and the joints in the vertical stack of pipe come at unequal intervals. In the case of a very high building and a stack of pipe is carried up the whole height, this would look conspicuous, and suggest the idea of short remnants of pipe being used instead of proper lengths as sent out by manufacturers. Although not quite so good, the main stack can be continued and the branches bent so as to, as nearly as possible, approach the bend illustrated by Fig. 288 and the branch joint made, as shown by dotted lines. I do not propose here to enter into the question of soil-pipe ventilation (which will be dealt with at a future time) beyond saying that when the smaller sizes of pipe are used for soil carriage from W.C.'S, the ventilation or air pipes have to be very much increased in size, and special precautions taken in their arrangement.

Materials for Soil Pipes.

In the present age, when the goddess "Cheapness" has so many followers, old and trusty friends are discarded, and new, untried ones are taken into favour. No matter how often the new friends may deceive, and in some cases cause actual injury, they are always forgiven, not in a charitable sense, with the hope they will not err again, but with a perversity which causes people to shut their eyes to the facts of the case. Their eyes may be shut, but their ears are ever open to the quiet whisperings of "cheapness." No wonder that there are chronic grumblings about the plumber and his ways when it is an acknowledged fact that nine householders out of ten call in anybody before they do the bona fide plumber. People do not send their family washing to the family lawyer, their watches to the village blacksmith, or call in a travelling tinker to decorate their houses. When ill they generally think the doctor is the man to send for; but if their plumbing is out of order they do not send to the plumber, but to ——, the reader must fill this in according to his own knowledge. I admit that householders sometimes send *for* a plumber, but rarely *to* a plumber. They may, perhaps, in some cases send to where plumbers are employed, but the poor innocents do not know when a man is a plumber or not when he arrives. Should he be a good tradesman and do his work properly, the bill that follows will often cause the householder to send elsewhere the next time he wants anything of the same kind done. The "Demon Cheapness" says "that man was dear," but carefully suppresses the "and good." So long as the piece of work will last a few days satisfaction is felt on all sides, no matter if it has to be done again a week or two afterwards. "So much the better" thinks the unprincipled tradesman. If householders would simply cast the yearly cost of repairs to their plumbing and work out the amount of invested capital it represents, they would soon find for themselves that their money would be laid out to better advantage by having their work done properly, and by having certain portions renewed by good men instead of being constantly taxed for repairs by indifferent workmen. I have inspected the sanitary arrangements of hundreds of houses in town and country. In some cases the class of work can only be called "wretched." In other cases the work has originally been done well, but certain alterations and additions have been carried out under the above-named demon, thus spoiling the whole scheme under which it was originally constructed. In no part of the plumbing work of a house do these remarks apply more than to the soil-pipe materials.

When W.C.'S were first introduced into the upper portions of houses lead-pipes were used for conveying the sewage away to the drains, and in some cases for the drains themselves. These pipes are frequently found at the present day to be in as good condition as when they were first fixed, excepting in the upper portions of those which have no ventilation-pipes, in which cases they are invariably found to be corroded by carbonic acid gas. Is there any other metal which would have lasted so long? A hundred years, perhaps more? But the old-trusted friend lead is being discarded by nearly all people as being so much dearer than some of the other materials, and it is only on the better kinds of work that it is now used. I have known in several cases good lead soil-pipe taken down and light cast iron substituted for no other reason than a nail might be driven into it. The only place where there is any probability of a nail being driven into a soil-pipe is that portion connected to the trap under the W.C. floor. But this portion is always made of lead, even when an iron soil-pipe is fixed from the branch to the drain. It is not only in Jerry built houses that iron soil-pipe is much used, but in a great many so-called "high-class" houses is this material fixed from the water-closets. Even sanitary engineers of a certain class are found to specify iron-pipe of the ordinary description as used for conveying rain water from house roofs. Assuming that light iron-pipe will last for a fairly long time, there is always a difficulty with the joints in making them air-tight. But they do not last many years. Walk down any street in a town and notice the rain water-pipes and you will find that after they have been fixed a few years there is scarcely a stack to be seen that has not a cracked pipe or a split socket. The fronts of the pipes may be nicely painted, but frequently the back sides are eaten entirely away by oxidation. Open the bottom ends of some of these pipes, and in some cases a half-pailful of iron rust can be found, thus showing that corrosion has taken place both on the inside and outside of the pipes. In spite of these experiences numbers of people still use light iron as soil-pipes.

With regard to the joints. They are usually made, when made at all, with red lead cement. This is not a good material to use for jointing iron pipes, as the iron and lead form a galvanic couple which, when moisture is present, causes the iron to corrode much more quickly. By the same reasoning lead paints are not good for covering iron pipes. The back sides of the pipes are not painted, and the iron will corrode at the edges of the painting more than at any other part. But supposing that red lead is a good material to use for joints, it is very rarely found that the joints are properly made. This part of the work is generally done by the carpenters or bricklayers. A portion of cement may be pressed into the fronts and sides of the joints, but the back side is left open. The joints are generally so tight fitting that it is difficult to properly caulk them, even if the iron was strong enough to withstand the strain upon them when being caulked. When the soil-pipe is fixed inside, and no hot water passes down it, a *properly* made cement joint may last for a considerable length of time, but when the pipes are fixed outside and exposed to heat rays from the sun, alternate expansions and contractions of the pipes will cause the cement to work out

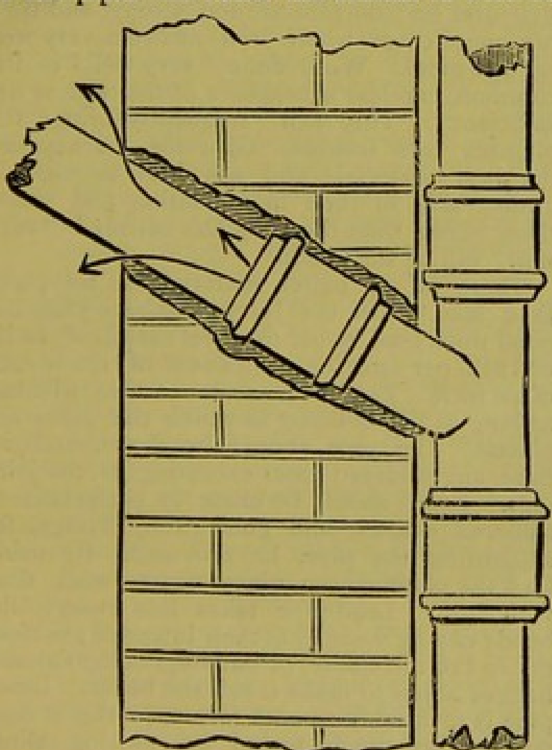


FIG 289.

of the sockets. In a great many cases joints come in positions where it is difficult to make them, and such cases frequently come to light when making sanitary inspections. At a South of England health resort four houses were found to be defective from the above cause. Fig. 289 is a fragmental section, showing an iron soil-pipe with Y-branch, and the joint with the lead soil-pipe made good inside the wall where it was difficult to properly make the joints. In the above four houses there were nine joints found to be defective. In each case the smoke used for testing escaped as shown by the arrows. The greater number of the above W.C.'s were situated near bedrooms, into which the smoke passed, through the hollow partitions. In each house there had been illness, and the examinations were made at the request of the medical gentlemen in attendance on the patients. This occurred in one town, and numbers of cases in London and other towns could be given, but enough has been said to prove to you the risk that is run when light iron soil-pipes are fixed to houses. It may surprise some to hear that zinc D-traps and soil-pipes have been found in houses. Some few years ago when fixing deep well pumps to some houses a few miles from London, curiosity led to the houses being looked over. In going into the food larder of one it was found that a W.C. was fixed on the floor above and, as there was no ceiling to the larder, the W.C. trap could be seen to be made of zinc. The soil-pipe was fitted in an angle of the larder and that was also seen to be made of zinc. The zinc was bright as if it had not been fixed very long. On attempting to rub off what appeared to be a small piece of mortar a hole appeared. On further scrutiny several small patches of a similar description were seen, and near the elbow, between the vertical pipe and the trap outgo, holes were found as large as horse beans. The houses had never been occupied and the only explanation that can be given is, that some of the workmen had used the W.C. as an urinal. The corrosive action had taken place on the inside and could not have arisen from mortar or lime as none was near the places where the holes were found. The above simple facts are quite sufficient to prove the unsuitability of zinc as a material for soil-pipes.

An experience with zinc soil-pipes has been given, and now the question arises, is iron coated with zinc, commonly called "galvanised iron," a good material to use? Personally I have not had an experience of the action of sewer air on this kind of pipe, but can cite a case where a soil-pipe of this description was tested three successive years and each year the joints had to be remade. Looking at the question logically, we must come to the conclusion that as zinc will not resist the action of the acids in sewage gases it cannot be trusted as a preservative agent for iron-pipes used for conveying sewage.

Assuming galvanised iron to be a good material for soil-pipes we still have to contend against the difficulties with the joints. These it is unnecessary to repeat. We will now deal with iron protected from rusting by other means. In the last lecture it was shown that ordinary lead paints are of little or no value for preventing the rusting of iron. The "oxide of iron paint" is recommended by some authorities as a preservative against rusting, but the paint must be made from the sesquioxide and not from the protoxide, the latter being liable to rust in itself. A coating of (freshly slacked) lime-wash answers fairly well for internal coatings of water-pipes, and some water companies apply this wash to the insides of their mains. Portland cement wash has been spoken of as being a good coating material. Coal-tar is frequently used for pipes that are going to be laid underground, but is not nearly so good as Dr. Angus Smith's solution, which consists of a mixture of coal-tar, pitch, a small quantity of linseed oil, and sometimes a little resin. This is heated to about 300 deg. Fahr., and the pipes, after being cleaned from sand and rust, are dipped into the composition. After a considerable amount of experience with soil and drain-pipes protected by this process, I can only say that it is the best that I know of when properly done. A great deal of pipe is found to be improperly coated, with the result that rust will soon show itself through the coating, but when well done this rarely occurs.

The Bower-Barff process of protecting iron from rusting, by causing the surface to become covered with a coating of the black magnetic oxide, has been spoken of as being a very good one, but I cannot speak from experience as to its efficiency for covering the surfaces of iron used for soil or drain-pipes. Neither have I ever heard of iron-pipes so protected being used for drains. Most of the engineers that I know prefer the "Smith's process" to all others for preserving iron-pipes.

Some engineers will specify cast-iron soil-pipes and are not careful to state the substance the iron is to be or the strength of the pipes. If they prefer iron soil-pipes they should use those of a strength equal to what water companies use for their water mains. This will be imperative in the near future. There is very little doubt about this, as no known tests for soil-pipes and drains are equal to the "water test." All pipes used for the conveyance of sewage should be subjected to that test. Some American engineers insist upon this test, both for vertical and horizontal drains, and there is no other that can be so thoroughly trusted. When iron pipes are used the joints should be yarned and run with metallic lead, not lead cement, and properly caulked. Neither should soil-pipes be of a composite character. If iron is used for the main stack the branches and other connections should be made of the same material. In very few cases are the stacks of soil-pipes repeated; every job is different to any other, and requires different fittings and connections. This being so you would find in practice that each job would want especially made branches, bends, and connections, thus entailing the cost of special patterns and cores for casting them from, besides the waste of time when waiting for the castings being made. If architects could be persuaded to sink their individual ideas and design their houses so that one set of iron castings would answer for all W.C. soil-pipes, the above objections would fall. The "if" is the rock which obstructs the way of this uniformity of design being carried out. Neither are iron fittings found to be, generally speaking, smooth inside. This applies more especially to junctions and branches. An inside examination of these pieces generally shows roughnesses and irregularities on the inner surfaces of the iron, which cannot be removed by either filing or chipping. Even when Dr. Angus Smith's solution is used for coating the pipes, and a good thick glazed surface is left on the insides of them, the above evils are not removed. Engineers who specify iron soil-pipes ignore, or are ignorant of, most of the above facts, and leave it to the plumber to get over the difficulties in the best manner he can. The result is a patchwork job, lead-pipe and iron-pipe being interspersed, and the lead used as a makeshift. The iron-pipe is used principally because of its cheapness, but there is every reason to suppose that if the iron-pipe was of the proper description, all the fittings were properly cast, and the way through them properly bored out so as to get smooth internal surfaces, the cost would exceed that of lead. Some readers are doubtless thinking that these strictures on iron-pipe are too strong, and they can quote cases where iron answers very well for soil-pipes. Work done "very well" in the common, careless acceptance of the term is not sufficient. "Very well" frequently brings the plumber into trouble. Give the journeyman the best materials and ask him to use his utmost skill in their manipulation and something better than the only half-satisfied "very well" will be the result.

There is no better material for soil-pipes than lead. Not the Jerry plumbers 5 lb., but good thick lead, equal to sheet metal of 10 lb. or 12 lb. per foot; or a thickness of ·170 to ·204 of an inch. Lead of a substance that will last as long as the building in which the pipes are placed. The pipe should be drawn and not have any soldered parts excepting at the joinings. Bends should be made in preference to soldered elbows, and good strong fixings, for supporting the pipe, be provided. By using lead the plumber can make neater work than with iron. Lead-pipe takes less room; the bends can be made to fit their intended position; instead of the house, or building, being cut and hacked about to make it suit the bends. Lead-pipe is invariably smooth inside, so that it does not get so much fouled by passing slimy matters. A lead-pipe will allow more water to pass through in a given time than an iron-pipe of the same size and length. From this we glean that a leaden soil-pipe can be used of a smaller size than an iron one which has to do the same amount of work. Lead-pipes are generally used for pneumatic dispatch tubes because of its smoothness inside. First class engineers know the advantages that lead has over iron for soil-pipes, and I know of cases where nothing but lead is ever specified; the substance being as described above. Another advantage of lead is, any ordinary plumber can work it.

I have both seen, and fixed, copper soil-pipes and find that description of pipe makes first-class work, although it is not so easily worked as lead. I have worked by the side of plumbers who came from Newcastle who told me the trades of plumber and coppersmith were combined in that town and they could work either metal. They were both first-class plumbers.

I never heard of glass lined or porcelain enamelled iron-pipe being used for soil-pipes. If there were no difficulties with the bends, branches and connections this kind of pipe would doubtless answer the purpose first class. The difficulties with the joints could be overcome by using "gland" joints.

Positions of Soil Pipes.

We will deal with this part of our subject in the first instance, under the headings of "internally" and "externally." It may be said that the advantages and disadvantages are about equal. When the pipes are fixed inside they are not exposed to the sun's influence which causes them to expand and contract and at times to crack and break. But when so fixed they are liable to be injured by having a nail driven into them. When fixed near, hot water-pipes will rub against the soil-pipe and chafe a hole into it. If the soil-pipe should be injured, by any means, bad air could escape and thus pollute the atmosphere breathed by the inmates. The walls of the house do not have to be cut for the branches to pass through when the main stack is fixed inside. The warmth of the house will sometimes rarefy the air inside the pipes and help to create an upward current and thus to accelerate the ventilation. In very cold countries, such as some parts of North America, the soil-pipes are fixed inside the house, so that what passes through shall not become frozen and thus block up the pipe. But in America the soil-pipes are generally used to receive discharges from the waste-pipes from sinks and similar fittings. This is not our English practice. Some of the above arguments apply to soil-pipes when fixed externally. With regard to water freezing in the pipes, I never knew this to occur in our climate. I have heard of one case, but that primarily arose from the supply-valve to the W.C. leaking. The dribble of water down the soil-pipe froze as it fell until the pipe was entirely choked. Most of our leading engineers look upon the soil-pipe as a drain and treat it similarly, that is, never fix it inside the house if they can possibly help it.

If the soil-pipe is fixed outside and anything should occur to injure it, the escaping bad air could do little or no harm to the inmates, unless the broken part be near a window or other place where what escaped from the pipe could pass into the house. Or, if the hole in the pipe was large enough for water, or sewage, to escape, no harm would be done to ceilings, walls or furniture in the same manner as would occur if fixed inside. Prominent sanitary plumbers make it a standing rule to fix the soil-pipes outside the house whenever possible. I also think that they should be so fixed and always do so in cases where I can.

Now that sanitary science is becoming more understood, designers of houses are giving more thought to the positions of water closets, and generally arrange them near an external wall, so that both light and ventilation can be provided and the soil-pipe can be fixed outside. Modern houses, generally speaking, are better arranged than those of earlier construction and in which the W.C.'s were so fixed that the soil-pipes had of necessity to be fixed inside. When re-arranging the sanitary work of an old house it is sometimes found that the soil-pipe can be fixed out of doors, but in great numbers of cases this cannot be done unless a certain amount of alteration or re-construction of the building is carried out. This will be referred to again at a future time when we will take, as problems, some examples of such sanitary works that have come under the writer's notice. To complete our present subject we will just say that soil-pipes are frequently found to be fixed in bedroom, dining-room, drawing-room, and staircase walls, through so-called "fire proof" plate closets, in food larders and similar places. It is not at all uncommon to find these pipes carried through cisterns which held water for domestic use. No great amount of scientific knowledge is necessary for anyone to form a judgment as to the undesirability of any of the above places for fixing soil pipes.

We will now take a stack of soil pipe, not dealing with any branches, from the connection with the drain to the highest extremity. To begin, as the plumber does, at the bottom, and at the place where I find, when making sanitary surveys, more defects than at any other parts. The joints between the soil-pipes and drains are so often found to be improperly made that one of our leading master plumbers makes it a standing rule that in all cases the joint shall be above the floor or paving, and in view, no matter if the soil pipe is fixed inside or outside the house. In numbers of cases the joints are found not to have been made at all. This has arisen, probably from the evil of having a division of responsibility. The pipe-layer lays the drains and the plumber fixes his pipes, the joints between the two men's work are "nobody's business," and so get overlooked or forgotten. The plumber should be held answerable for the whole of the sanitary works in a house, including the drains, and there should not be any divided responsibility. The last drain-pipe or bend should be fixed so that the socket is level with, or an inch or two above, the floor line. The drain should be of the same size as the soil-pipe. Fig. 290 is a section of a joint found some little time ago. The end of a 4 in. soil-pipe was entered into a 9 in drain-pipe and pieces of newspaper were pushed in as shown at A and cement then daubed on the front of the joint by means of the fingers, but

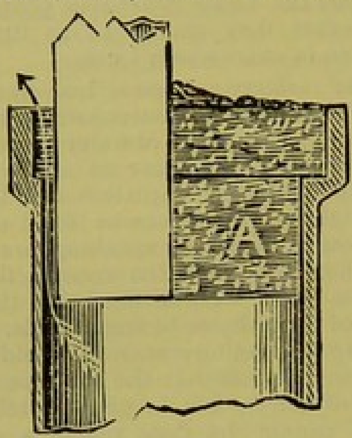


FIG. 290.

there was no cement whatever on the back side of the joint. The air from the drains was found to be escaping as shown by the arrow. In addition to the soil-pipe and drain being of the same size, great care should be taken to fix the two pipes "fair;" that is, the bore of the pipes in a line with each other. To ensure this being so the end of the lead-pipe can be flanged, as shown by Fig 291, the diameter of the flange being equal to the internal diameter of the

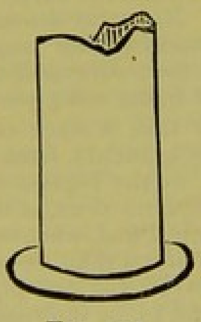


FIG. 291.

socket of the drain-pipe. Anotner way, commonly practised, is to have a loose lead collar

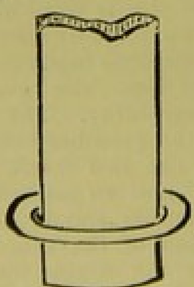


FIG. 292.

fitted as shown by Fig. 292. The end of the soil-pipe is slightly coned so as to fit into the barrel of the drain-pipe, a bed of oil cement then laid round the soil-pipe, in the bottom of the drain socket, and the loose lead collar, which had been slipped up the soil-pipe, pressed hard down into the drain socket, the joint then being made by filling the socket with cement. The best plan to adopt is to solder the above lead flange to the soil-pipe and then make the joint, as shown by the section, Fig. 293. This makes a much stronger joint than any of the others that have been described. I may here mention that when Portland or Roman cement has been used for making these joints, the lead has been so oxidised and corroded, by the action of the cement, as to almost lose its metallic properties,

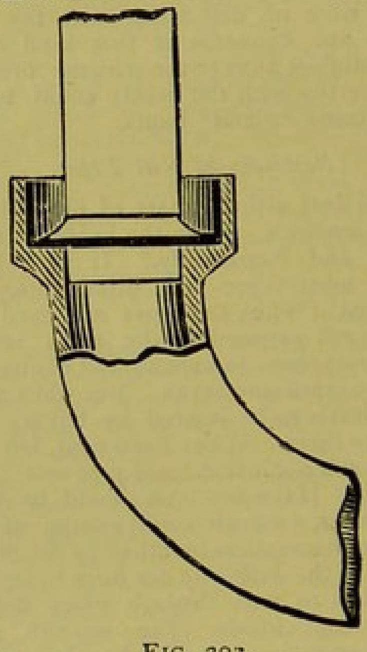


FIG. 293.

and has been reduced to a harsh and brittle condition. This has been when the surroundings were wet or damp. When in dry positions this action has not taken place to so great an extent, and this is a further reason why the joints, above referred to, should be above the floor line. In some cases where soil-pipes, of necessity, must be fixed inside the house, it is a broad question whether the soil-pipe should be continued through the wall to the drain outside, or if the drain should be brought into the house to the soil-pipe. Personal experiences on this matter have shown how difficult it is to lay down hard and fast lines for one's guidance. For years the writer has made it a fixed rule never to have a drain inside the house if by any means it could be avoided, and has always continued the soil-pipes through the walls and connected to the drain outside at least one foot clear of the house. A recent experience has proved that there is a liability of defects occurring from this. On making a sanitary survey of a nobleman's country mansion, which had been built only eighteen years, it was found by means of a smoke test that out of seven stacks of 8lbs. lead soil-pipe, with the bottom ends connected with the drains outside the house, five were defective, and smoke was found to escape inside the house near the bottom ends of the pipes. The lead pipes were good and the workmanship was also good. These pipes passed through the walls below the "damp course," and were consequently in a *damp* situation. The lime mortar had partly corroded the lead, and a settlement of the ground outside the house had caused slight fractures in the pipes. The holes through the walls for the pipes to pass through had been made good, but in such a bungling way that the smoke which escaped from the cracked lead pipes, passed through the holes into the house. If the drain pipes had been continued through the walls the settlement of the ground, or of the house itself, would have caused the pipes to break, they are sometimes found so broken, and the same evils would have resulted. I have found cases where the ground inside the house had settled, the drain had gone with the ground, and the socket left fixed on the end of the soil pipe. Fig. 294 is a sketch of such a case found in a bank in the West End of London. The presumption in this case is, there must have been

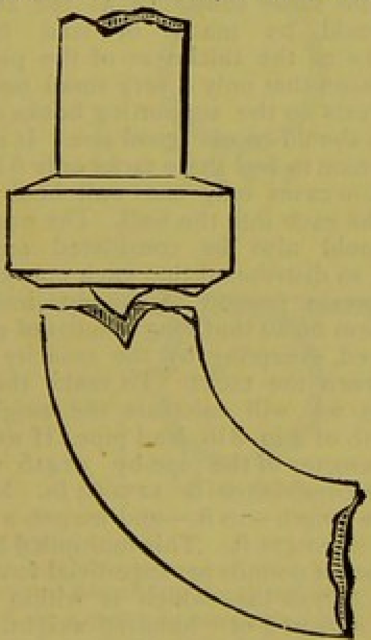


FIG. 294.

some defect in the drain pipe, or some sudden shock applied to cause the fracture, which afterwards was pulled open in the manner described. I do not know the tensile strain necessary to pull the materials, of which drain pipes are constructed, asunder, but should think it would be greater than that for a lead pipe. If this is so, one would have thought that the lead pipe would have broken instead of the other.

The writer has come to the conclusion that the best method for preventing the above evils occurring is to have heavy cast-iron drains, properly protected against rusting, fixed to the house walls and connected to the soil-pipe by means of a joint and bend, as shown by Fig. 295. In the sketch B is the lead soil-pipe; C is a copper pipe, about 10in. or 12in. long, with a flange on the bottom. This copper flanged pipe is passed over the end of the lead soil-pipe, which is then flanged over that on the copper pipe, a soldered joint being made at D and an ordinary lead joint at E. The iron bend should have a "Duck's-foot" to it, as shown at F, this foot to rest on a brick pier built up from the same foundations as the house walls, or to rest on a stone corbel built into the walls. The

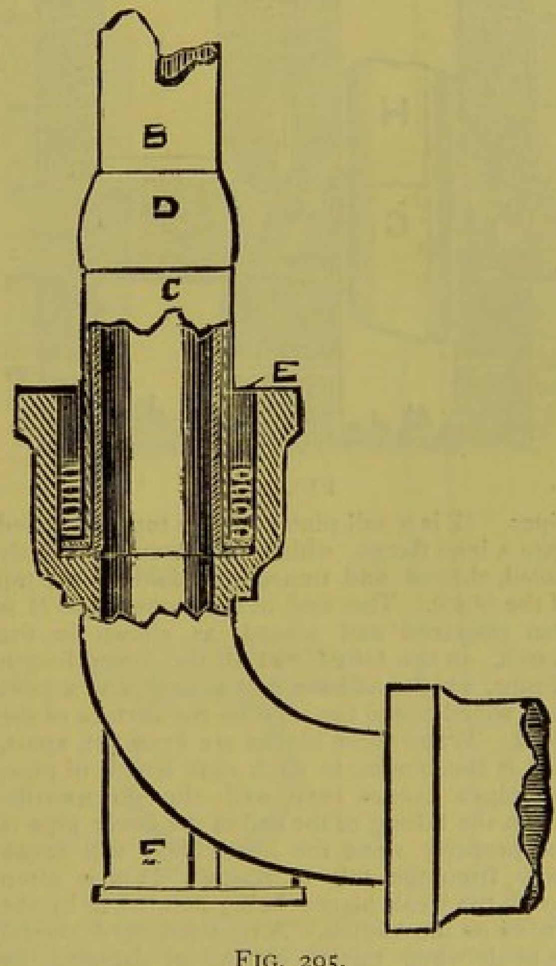


FIG. 295.

drain so fixed would help to support the stack of lead soil-pipe, and would be independent of the ground inside the house, so that if it settled it would not injure the drain. There would still remain the risk of the settlement of the outside ground breaking the drains, but that will be dealt with under the heading of "Drains" at a future time, when also will be considered the advantages and disadvantages of fixing traps at the bottom ends of soil-pipes.

When fixing soil-pipes inside a house there is little to say about them beyond the methods used for supporting the pipes. When in chases and there is plenty of room for the various pipes, the best and strongest fixing is a block made either of wood or stone with perforation through the block for the pipes to pass through. Lead flanges being soldered on the pipe to support it and prevent its slipping downwards. Fig. 296 is a sketch of a block and joints to two

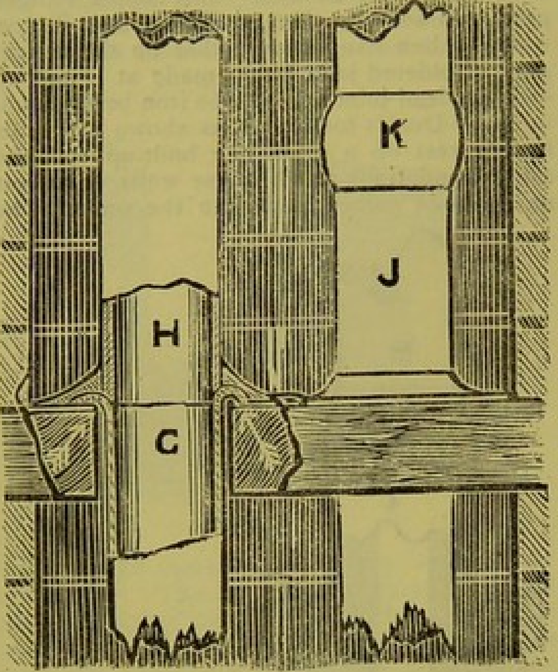


FIG. 296.

pipes. G is a soil-pipe with the top end tafted onto a lead flange, which has been previously soiled, shaved and tinned, and laid on the top of the block. The end of the upper pipe H is also prepared and placed, as shown in the sketch, on the tafted end of the lower length of pipe, which had been first shaved, and a joint then wiped round the pipe on the surface of the block. When these blocks are fixed 5 ft. apart, that is two blocks to each 10 ft. length of pipe, the pipes cannot very well slip downwards. When the tafting of the end of the lower pipe is not properly done the lower pipe will break away from the taft or flange. This is often found, the weak places being pointed to by the arrows in the sketch. A rounded bead should be made when tafting instead of dressing the flange down flat, as commonly done, which leaves a sharp arriss on the inner edge of the flange and which will frequently break off the pipe. Some men will not flange the end of the lower pipe, but simply open it to a good width, so that a good quantity of solder can flow into the opened end and round the entering end of the pipes. In these cases the blocks are dished down about an inch all round the pipes, the lead collar being dressed into the dishing, so that a good support is given to the pipes, and the joint is made of additional strength, by the solder that flows into the dishing and outside the opened end of the bottom length of the pipe. Some plumbers consider the fixing to the pipe J to be superior to the other. By this method the above weak point in the tafting is avoided. A lead flange is simply soldered to the pipe in its position, the joints on the pipe being kept separate, as shown in the figure at K.

Another way for fixing soil-pipes inside the house is by means of what is commonly called "tacks." These are pieces of sheet lead, about 9 in. or 10 in. square, soldered onto the pipes at intervals of 3 ft., 4 ft. or 5 ft, according to the instructions given to, or the whim of, the plumber. It is important that all soil-pipes should be well fixed. If this is not done they will break away from their fastenings and thus become fractured, or, they will drag down the outgo of the W.C. traps and thus partially destroy their water seal. To fix soil-pipes properly the following points must be borne in mind.

The walls should firmly hold the hooks or nails when driven in. In some cases it is necessary to plug the walls, with wood or lead plugs, at the points where the hooks are to be driven in. In other cases wood or stone blocks have to be built into the walls for pipe fixings. When stone blocks are used they have to be plugged for the nails. The next point is the "tacks." They are usually cut out of sheet lead of the same substance as the soil-pipe. They should be made of lead from 1½ times to twice the thickness of the pipe lead, for the reason that only a very small portion of the tack rests on the supporting hooks or nails. The tacks should be of good size. It is not at all uncommon to find these tacks only 6 in. long, and in some cases only one wall hook driven through the each into the wall. The number of tacks should also be considered and they should be so distributed that each one will support a certain portion of the pipe instead of putting them on so that long lengths of pipe are unsupported, excepting by the tenacity of the lead, between the tacks. To make this more impressive we will calculate the weight of a 10 ft. length of 4 in. 8 lb. lead pipe. If we multiply the diameter of the pipe by 3·1416 we find that the circumference is 12·5664 in. Multiply this by the length—10 ft.—and we get a superficial area of 10·472 ft. This multiplied by eight (the number of pounds per superficial foot) gives a total of 83·776 lbs., which is within a few decimal points of ¾ of hundred weight.

Fig. 297 is a view of a 10 ft. length of pipe which was found to have been fixed by means of two 6 in. tacks and each tack had one wall hook driven into it. The soil-pipe being made out of 8 lb. lead, the whole weight, as worked out above, had to be supported on two wall hooks. The fixings were insufficient and the pipe had gradually slid downwards, the hooks at A, A, cutting the lead tacks as shown by the dark spaces beneath the hooks. Soil-pipes should always have at least three tacks, four would be better, on each 10 ft. length and the tacks should not be less than 9 in. or 10 in. long so that two or three wall hooks could be driven into each tack with 3 in. spaces between the hooks. If the pipe is being fixed inside the house the tacks should, if possible, be on alternate sides, but if fixed outside the house the work looks smarter if the tacks are put on in pairs—that is, two tacks placed on opposite sides of the pipe at the same level as shown by Fig. 204 in an earlier lecture, but omitting the mouldings. The tacks should be firmly soldered to the pipe and precautions

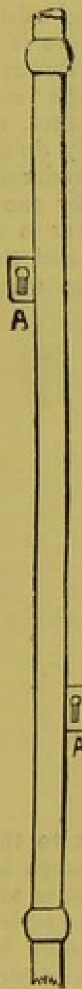


FIG 297

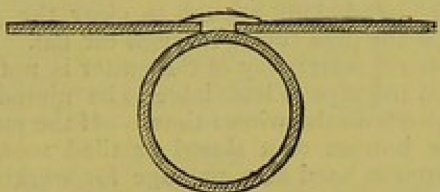


FIG 298.

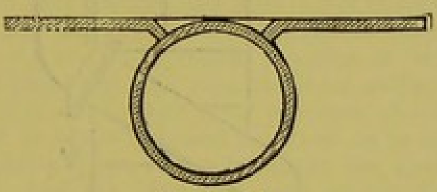


FIG 299

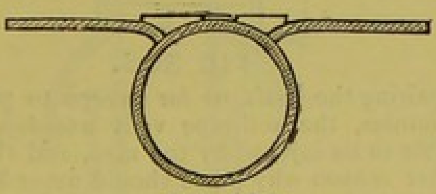


FIG 300.

taken to prevent them breaking away from the soldering, or a piece being torn out of the pipe. Fig. 298 is a cross-section of a soil-pipe showing a pair of tacks soldered on at the same time. In this case, which is common practice, the part of the pipe to which the soldering is attached is only about one inch wide, so that actually the two tacks are only equal in strength to one tack. If the tacks are soldered on separately, as shown in section by Fig. 299, the pipe is then much better supported by them and we have twice the surface of pipe to which the tacks are soldered. Another weak point in tacks, when improperly prepared, is their liability to break away at the edge of the soldering. This arises from a sharp-pointed shavehook having been used for shaving the lead and the tack reduced in substance at the edge of the soldering. This would not matter so much if the soldering was left ful at the edges of the seam to fill up the weakened part in the tack. If an attempt is made to do this a ragged edge is left on the soldering. The ragged edge being then trimmed, by means of a drawing-knife, the lead is partly cut and still further weakened. The remedy for this, is to make the necessary preparations for soldering on the tacks and then, instead of "wiping" the seam, to "draw" it with solder and a plumber's iron in the same manner as plumbers "draw"

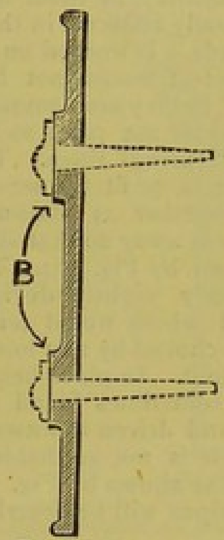


FIG 301

FIG 303

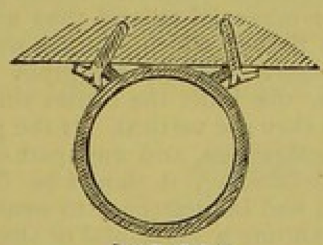


FIG 302


FIG 304

seams on leaden soil-pipes when they are made by hand. The soldering will then be left full at the edges as shown by section Fig. 300.

In some cases soil-pipes are fixed by means of "cast lead" tacks made from the architect's special design. Some large plumbing firms have their own designs. The advantage of cast lead tacks is, they can be made thicker where the nail, or hook, passes through as shown at B in Fig. 301, which shows a section of a cast lead tack. The dotted lines show the special made nails with large heads and broad flat stems which are much better than those with plain round shanks and which cut the lead more than the others.

Soil-pipes when fixed inside the house sometimes have "face tacks" which consist of narrow pieces of lead soldered on the face to the pipe. Fig. 302 is a section showing the tack. The great advantage of this kind of tack is the solder, which is a harder and tougher material than lead, being on the front of the tack, holes can be bored through it and countersunk and screws used for fixing as shown in the figure. These tacks are also an advantage for fixing all kinds of lead-pipes, especially when they are very close together, as they can be arranged to take up very little room. The screws can also be taken out for unfixing the pipe should it be necessary to do so for repairs or any other purpose.

When fixing soil-pipes inside a house we find it necessary to make "bends" in them to fit the walls, which are usually reduced in thickness as they pass upwards. I worked on one large job where the architect would not have bends over the "set-offs," as they are commonly called, but had chases cut for the pipes so that it was only necessary to "spring" them. That is, instead of making bends, to fit the set-offs, the bends being close together as shown by Fig. 303, the walls were cut away so that slight bends were made as shown by Fig. 304. This figure shows the pipe only slightly deviated from a straight line and which would render the pipe less liable to be choked by any foreign matter that might get into it. In pipes bent as shown by Fig. 303, it is sometimes found that the heel at C is bruised and driven downwards by falling matters. This is not so liable to occur with the pipe fixed as shown by Fig. 304. The process of bending pipes will be described at a future time.

In addition to bends for "set-offs," it is sometimes necessary to make them for the soil-pipe to pass timber or other joists, and thus avoid cutting away the timber which, if done, would weaken the structure. When soil-pipes are fixed in chases in the walls the chases should only be cut when they are vertical. If the pipe has to change its direction, and any part of it fixed horizontal, or sloping, it should be fixed on the face of the wall in preference to weakening the walls by cutting a horizontal or sloping chase in them to receive the pipe. This remark applies also to walls that have chimney flues in them. Although often found to have been done, the practice should be condemned.

In some cases soil-pipes are fixed inside for some part of their height and then turned through the outer walls of the house, and continued to the parapet or roof. To prevent the rain water, which sometimes streams down the outside pipe, soaking into the walls and making a damp place inside the house, it is advisable to solder a lead flange on to the pipe, the bottom edge of the flange to project as a kind of apron, as shown by the sketch Fig. 305. The water will then drip clear of the walls, as shown by the arrow.

If the pipe is continued inside the house for its whole distance, the next point that we have to deal with is where it passes through the roof. If the roof consists of a lead flat there is very little troub[le] to make a good job. There are two ways of doing this. One is simply to cut a hole through the roof, pass the pipe through and make a soldered flange joint onto the lead flat and pipe. It is generally necessary to make a "set-off" bend in the pipe, just beneath the roof, so that it will be a few inches clear of the wall and give room for the plumber to get his hand round for wiping the joint on the roof. If this is not done there is some difficulty in making the joint, and when done it always looks a bungle. If there is a lead gutter where the lead pipe passes through the roof, it is always advisable to make the "set-off" bends long enough to clear the gutter, so that the pipe comes through the flat. By doing this the water-way of the gutter is not reduced, and the pipe is less liable to be injured by snow shovels in the winter time. If the gutter is at the bottom of a slated or tiled roof, and the gutter is used as a passage for workmen when

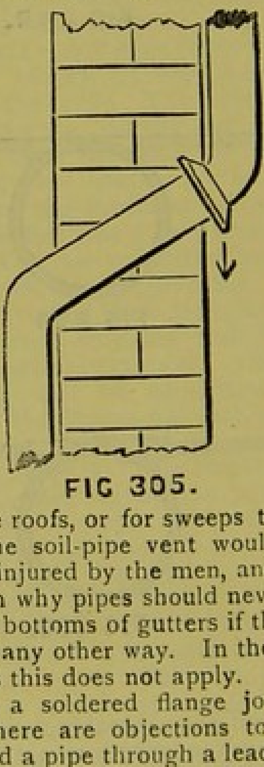


FIG 305.

repairing the roofs, or for sweeps to get to the chimnies, the soil-pipe vent would always be liable to be injured by the men, and this is another reason why pipes should never be carried through the bottoms of gutters if they could be arranged in any other way. In the case of very wide gutters this does not apply.

Although a soldered flange joint makes a good job, there are objections to this way of making good a pipe through a leaded roof. The greatest objection arises from the rigidity of the work; the metals being so fixed that they cannot move by expansion, the result frequently being a fracture of the lead near the joint to the pipe. A better method is for the plumber to work up a hole in the lead on the flat to a height of 6 in., leaving room for the pipe to pass through and a space of at least ¼ in. all round, between the pipe and bossed up lead, to allow for expansion or contraction. It is not so difficult, as it may appear at first sight, to boss up the lead on the flat, if the plumber goes about it in the right way. The usual method is to raise the lead by bossing the under side until it forms a kind of hemisphere or dome, and then drag the lead from the flat part, or base, and so form it into the desired shape. A hole is then cut in the top of the raised part, the hole being gently worked larger until the piece of lead is as shown by Fig. 306. If the bossing is carefully done the lead is not much reduced in thickness at any part. It is quite as easy to make the piece of pipe in the lead bay, by working the outer

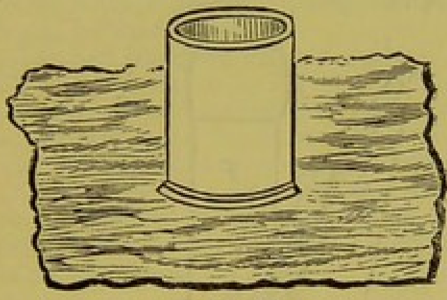


FIG 306.

edges of the lead down, leaving the centre standing up, but in a case where the lead bay is a large one, this takes a very long time to do, and the lead has to be cut to a larger size to allow for the shrinking in of the edges or outer part. By this method the lead is not reduced in substance at any part. In places where plumbers do not have much practice in lead bossing, a short piece of pipe could be soldered on to the lead flat for the same purpose. A lead cap should be bossed up and soldered on to the soil ventilation pipe, so as to cover the space between it and the stand up lead on the flat.

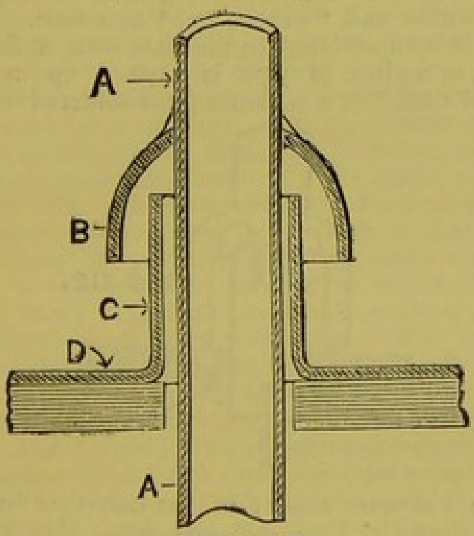


FIG 307

Fig. 307 is a sction showing the whole arrangement. A A is the S. P. vent ; B the bossed cap soldered on to A ; C the stand up part on the lead flat; and D the lead flat.

If the S. P. vent is carried through a steep pitched leaded roof the pipe should still be kept in a straight line. The lead can be bossed up, or a piece of pipe soldered on, for the vent-pipe to pass through, as above described, and as illustrated by Figures 306 and 307; the only difference being that the outer pipe is made at an acute angle, looked at on the highest side, instead of at right angles to the piece of lead. The common way of carrying a pipe through a sloping roof is shown by Fig. 308, which is not nearly so good a method as the one above described. The bends are unnecessary and it may be considered a waste of time to make them. Each bend in a pipe acts as a check on the velocity of whatever passes through it, either water or air. The vent-pipe should be carried

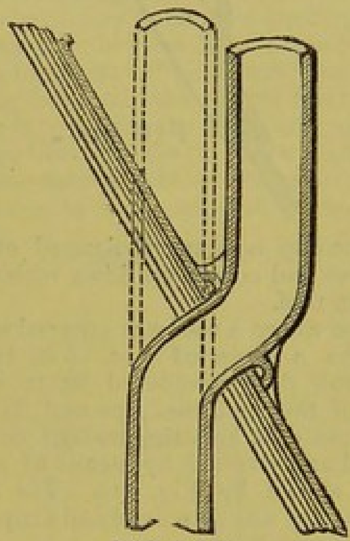


FIG 308.

through the roof as shown by the dotted lines in the figure.

If the roof is nearly upright, the pipe would have to be as shown by Fig. 308, but in any other case the bends are unnecessary.

A great many modern built houses have asphalt roofs. To make good a ventilation-pipe

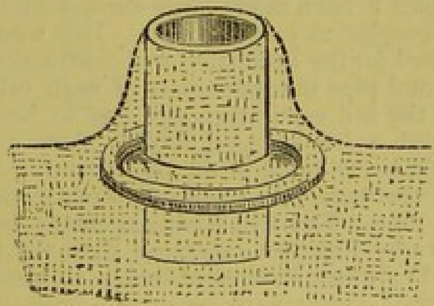


FIG 309

through a roof of this kind it is best to solder a flange with welted edge on to a short piece of lead pipe, fix it in its position and make good the asphalt to it. Fig. 309 is a sketch showing this pipe fixed on a roof and the asphalt made good to it, the finished surface of the asphalt being as shown by dotted lines. A better key is given for the asphalt if the welted edge is serrated, or made rough, and a space left for the asphalt to go under the flange. For making good through a "cemented" roof the above method is a very good one.

After the plumber has fixed his ventilating-pipe he should then solder on a bossed lead cap similar to that shown by Fig. 307, but the bottom

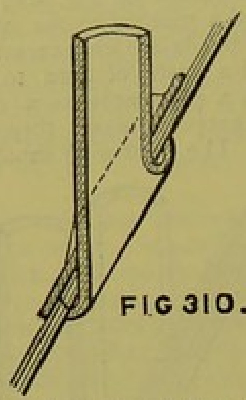


FIG 310.

edge of the cap is better if flanged out two or three inches and continued down within an inch or so of the roof.

In a case where a roof was covered with large slate slabs a piece of 5 in. 8 lb. lead pipe had a narrow flange soldered on to it, to suit the rake of the roof, the pipe and flange were placed in position, and the bottom end of the pipe tafted and rivetted by means of a beaded edge, as shown by Fig. 510. The four-inch ventilation-pipe was then fixed and a cap soldered on, as shown at B Fig. 307.

The same method would do for a roof constructed of cast iron plates if it were not for the voltaic action which would take place. At a large public building in London with a roof of this kind a specially made brass connection was used. Fig. 311 is drawn from memory and represents a view of the arrangements. I think this would have been better if the upper half only of the brass connection had been used, and the part F been made large enough for the ventilation-pipe to pass through. This would have allowed for the expansion and contraction of the roof and pipe independently of each other.

If the soil ventilation-pipe has to be carried through a zinc covered roof a short zinc-pipe should be soldered to the roof covering and the lead ventilating-pipe then passed through the zinc pipe. The whole arrangement being as shown by Fig. 307, excepting that the parts C and D are zinc instead of lead. I have made a "wiped" flange joint between a lead pipe and a zinc flat, but the practice should be condemned. The principal objection being (*a*) the pot of solder is entirely spoilt for using again until the zinc taken up by the alloy when soldering, has been extracted; (*b*) a voltaic action sets up in damp weather between the various metals, which leads to the destruction of one of them and (*c*) the lead pipe and zinc roof are so tied together that the metals cannot freely expand or contract. I have also soldered a lead flange onto the lead pipe by means of a "wiped" joint and then soldered the edge of the lead flange to the zinc roof covering by means of fine solder and a copper bit. The first method described is by far the best, and it is always advisable to take such precautions that no two different kinds of metals are in actual contact, especially in damp situations.

For making good a pipe through an ordinary slated roof, it is usual, on first class works, to

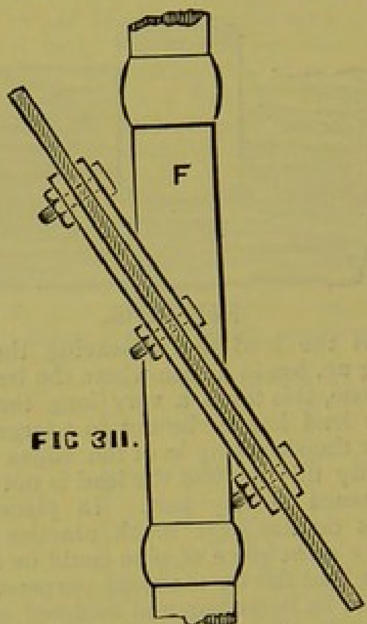


FIG 311.

remove a slate and substitute a piece of lead of the same size. The lead being fixed with regard to position and "weathering" as a slate. The pipe is then soldered to the slate with a flange joint, or a piece of pipe is worked up in the "lead slate," or a separate piece soldered on to

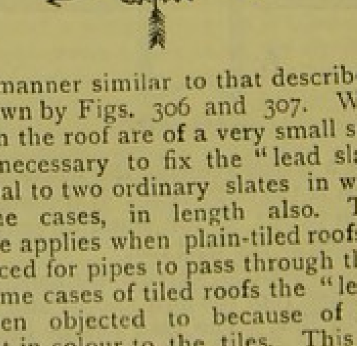


FIG 312.

it, in a manner similar to that described before and shown by Figs. 306 and 307. Where the slates on the roof are of a very small size it becomes necessary to fix the "lead slate" of a size equal to two ordinary slates in width and, in some cases, in length also. The same principle applies when plain-tiled roofs have to be pierced for pipes to pass through them.

In some cases of tiled roofs the "lead slate" has been objected to because of its being different in colour to the tiles. This is easily gotten over by fixing the lead a course lower, so that the next course of tiles will cover the lead, the tiles being notched so as to fit close up to the ventilation-pipe. In all cases the "lead slate," or "lead tile," should have its bottom edge on the surface of the tiling so that the water may run outwards.

The common practice of passing a pipe through a slated or tiled roof and making good the slates or tiles to the pipe by means of cement, or putty, is far from being satisfactory and should be condemned.

Another, and bungling way of making good through a roof is shown by Fig 312. This is a highly dangerous arrangement, as when testing drains and soil-pipes by means of a smoke machine the writer has frequently found smoke inside the roofs and in upper rooms from the slip joint. The course of the escaping smoke is shown by the arrows, and drain smells would pass in the same way.

Soil Pipes Fixed Externally.

There is no part of a plumber's work which shows a man's skill more than a soil-pipe when fixed externally. Being in view, the least bruise or irregularity in the pipe can be seen by the onlooker. Lead-pipes generally get slightly bent and bruised by being moved about, so the plumber's first care is to straighten the pipes. This should be done by means of the hands, the plumber pressing on the outside of the bend, which should be laid upwards, and his assistant lifting up the end of the pipe as it lies on the bench. The common practice of trying to straighten a pipe by beating it with a "dresser" is far from being a good one; the pipe is reduced in certain parts, and the marks of the dresser can never be entirely removed. Bruises in a pipe are generally knocked out from the inside by means of a dummy, and, no matter how carefully this may be done, the plumber rarely succeeds in entirely removing the marks made by his tools. To get bruises out of pipes, without disfiguring them, it is best to have a "mandril," about 2 ft. or 3 ft. long, made out of hard or tough wood, one end of the mandril being about ½ in., and the other end about ⅛ in. smaller than the bore of the pipe. The small end of the mandril should be made round, and the thick end cut off and left flat. The thin end should be pushed into the end of the pipe, and the mandril driven through with a short piece of deal quartering, either using the quartering as a "ram," or placing it close to the mandril and

FIG 313

driving it with a large and heavy "box mallet." A dummy with a long rod is sometimes used for this purpose, but as the head of the dummy gets flattened and spoilt for its proper use, and the inside of the lead-pipe gets very much scratched by the head of the dummy, the piece of quartering is considerably better for the purpose. Just as the mandril is passing the bruise in the pipe the outside should be gently tapped with a lead "flapper," the flapper being made out of a small remnant of sheet-lead, with one end folded to form a handle. Fig. 313 is a sketch of the usual way of doing this. The advantage of a flapper over a dresser being that no tool marks are made on the pipe by its use. Another point, when fixing outside soil-pipes, is to fix the pipes straight, and also perpendicular, excepting where they have to be fixed otherwise. With this purpose in view it is always best to use a chalk line, with a "plum-bob" on the end. Suspend the bob from the top of the building (if the pipe is to be fixed to that part), and, after chalking the line, "strike" a chalk mark on the walls. This line should be "struck so as to represent the side of the pipe in preference to

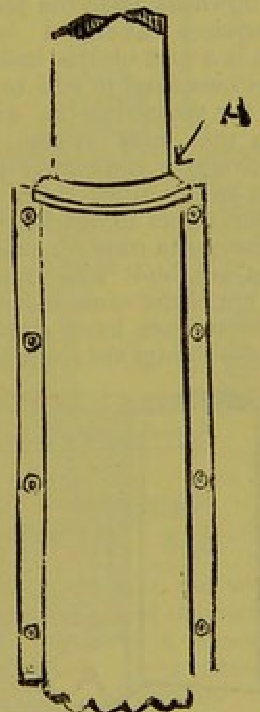


FIG 314

the middle of the back, in which latter case it could not be seen when the pipe was fixed in its place. It is also a good plan to set out on the walls where the pipe fixings or "tacks" would come so that they could be arranged to look well on completion. The positions of the joints should also be considered, and an effort made to get them at equal distances apart. By spending an hour or so on these apparently trivial details a man can often make his work appear much smarter than it would have done if he had neglected to arrange it before he commenced fixing any portion.

A great many buildings have the lower part or plinth projecting beyond the main walls. This necessitates a pair of bends, sometimes called a "swanneck," as shown by Fig. 303, in the soil-pipe to pass over the plinth. In some cases, especially where there is a great amount of traffic, a chase is cut through the plinth, and the soil-pipe is carried straight down, thus saving the two bends, and also the risk of the pipe being bruised by passers by, or knocked against by brooms or other objects. When not recessed it is always advisable to protect the bottom end of a soil-pipe from injury by fixing a shield or guard in front of it, as shown by Fig. 314. The shield should be about 4 ft. high, and could be made of galvanised, cast or wrought-iron, and fixed to the walls by means of common iron pipe nails. The shield looks neater, and dust cannot so easily fall down behind it if a capping is made and fixed on the top edge, as shown at A in the figure. The bottom end should have pieces cut out to allow for any rain-water that may get inside to run outwards and away from the house walls.

As we pass upwards from the plinth the next point that requires attention is a "string course." This is a part of the building which, although sometimes fixed to add to its appearance, is useful for protecting the walls beneath from any rain that may stream down those above. This stringing sometimes projects only an inch or two, and in other cases perhaps 1 ft. The plumber has either to bend the pipe to fit round the course, or to pass it straight through. Where houses are built with stone walls the string courses are of the same material. Brick built houses sometimes have stone dressings, and the string mouldings are made of stone. In

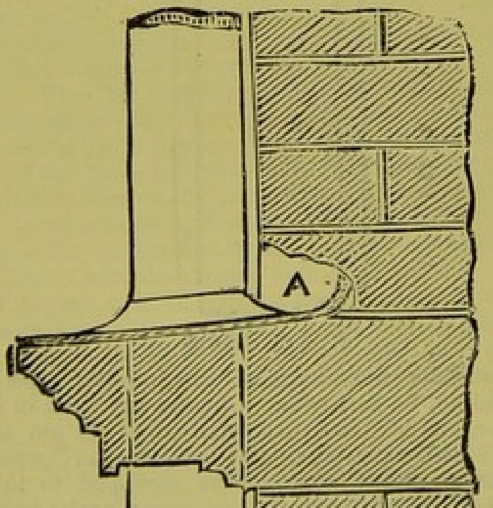


FIG 315

other cases, brick built houses have brick mouldings, such as string courses and cornices. Where stone is used for the horizontal mouldings of a house the upper surface of the projecting portion of the moulding is weathered so that the rain-water may run outwards and drip clear of the walls beneath. Where bricks are used the upper surface is weathered by a coating of cement, or covered with sheet-lead. In this latter case, when the soil-pipe is continued in a straight line through the string or cornice, a "wiped" soldered joint should be made between the lead covering and the soil-pipe, as shown in sectional elevation by Fig. 315. The lead that stands up against the wall should be dressed back into a recess, cut into the wall as shown at A, so that the plumber can get his fingers behind the pipe to wipe the joint, and thus ensure no water getting behind and soaking into the wall. The common practice of wiping the joint on the front of the pipe and up the sides is far from being a good one, and when finished does not look at all workmanlike. Fig. 316 is a front elevation, showing how this

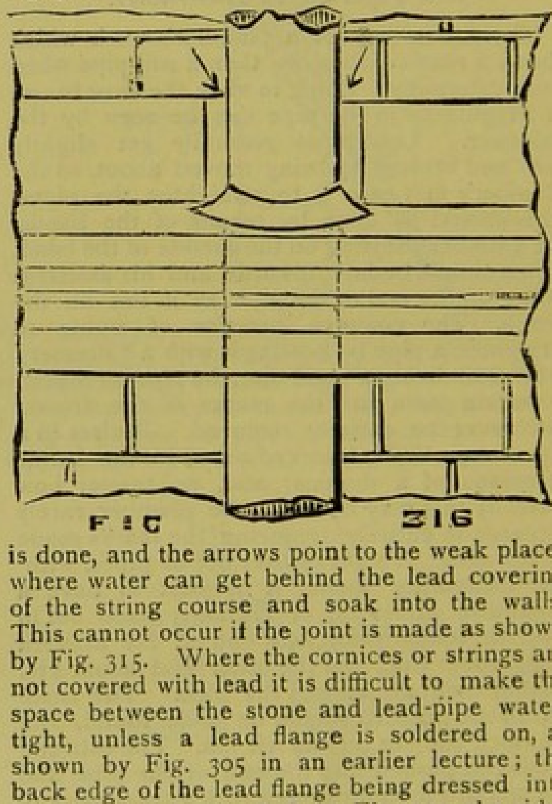


FIG 316

is done, and the arrows point to the weak places where water can get behind the lead covering of the string course and soak into the walls. This cannot occur if the joint is made as shown by Fig. 315. Where the cornices or strings are not covered with lead it is difficult to make the space between the stone and lead-pipe watertight, unless a lead flange is soldered on, as shown by Fig. 305 in an earlier lecture; the back edge of the lead flange being dressed into the wall, as shown at A in Fig. 315, the sides and front of the flange laying on the stone some three or four inches. Cement fillets are sometimes made round the pipe, but the practice is not a good one.

Instead of passing the soil-pipe through projecting cornices, one often finds bends made as shown by Fig. 317, which is a side view. This is not by any means a good plan to adopt. The beauty of the mouldings is spoilt by having the lines broken by the projecting pipe. To a good plumber the making of the bends is not difficult, although they take a considerable time. A pipe bent as shown by the figure will take from about 10 to 15 hours, according to the skill of the workman. Although they may look nice from a plumber's point of view, they cannot be considered as an ornament to a building. The space at B is sometimes found convenient for

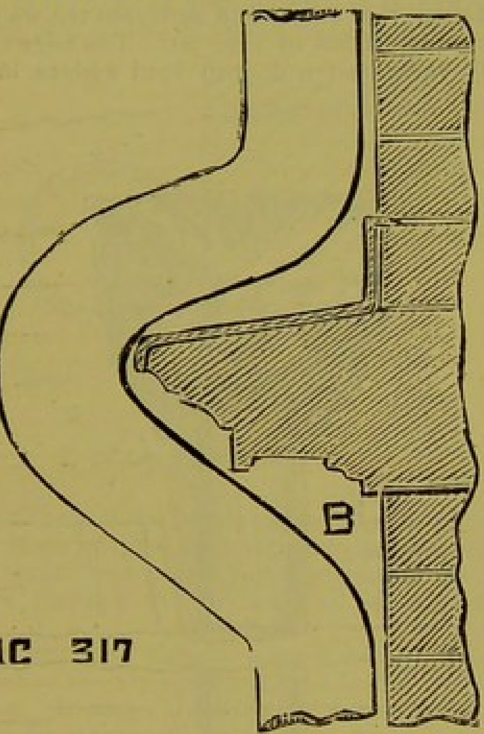


FIG 317

birds to construct their nests in. The bends are also objectionable for the reasons given when writing on Figs. 284, 285, 303.

In some cases soil-pipes have been fixed in chases, cut into the walls outside the house. In other cases, the pipes have been built in the walls so that they were entirely hidden from view. Neither of these principles are to be recommended, either for soil or rain-water-pipes. Any plumber, with a fairly good experience, can cite cases where he has had to cut away walls for finding the causes of dampness showing through, and discovered the defects to have arisen from pipes recessed or buried in the walls. The difficulty in these cases is to find the actual place where the defect is situated. A leakage may be taking place near the top end of the pipe, but the dampness arising from the defect may not make its presence known until the water had passed downwards a considerable distance. Instead of recessing pipes it would be much more preferable to fix them ½ in. or 1 in. clear of the house walls.

Soil-pipes may not be considered "things of beauty," but there is no reason, beyond expense, why they should not be made an architectural feature on a building. Numbers of people object to the pipe being seen, as the sight of it suggests a water-closet. This is squeamishness which ought to give way before necessity. But the pipe need not have the appearance of a common soil-pipe. If architects can design rain-water-pipes, why should they not give the same thought to soil-pipes? There are some high-class architects who do this, but the practice is not so common as it should be. But plumbers can often make the pipe look smart by fixing astragals and ornamental ears to them. Even a piece of ½ in. or ¾ in. lead-pipe sawn down the centre, and the half-pipe bent round the soil-pipe, and soldered on with fine solder, will add to its appearance. A small plain moulding, as shown by Fig. 205, soldered on the soil-pipe, as shown by Fig. 204, looks very well. Ornamental ears, cut out of thick sheet-lead, look better, and are much stronger than the "tacks," as illustrated by Fig. 204. The joints to the soil-pipes, when astragals are fixed, should be made by means of a blow-pipe or spirit lamp, using fine solder. This kind of joint is illustrated by Fig. 318, a piece being broken out to show a part of it in section.

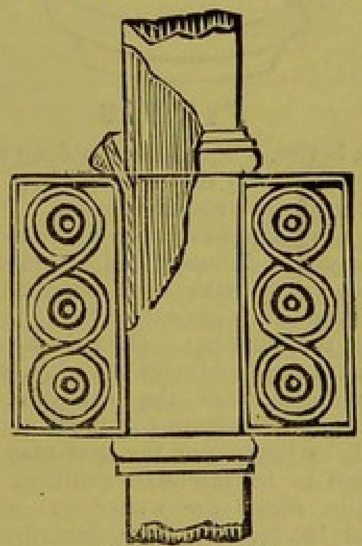


FIG 318

When properly made, and the solder made to flow down to the bottom of the socketted end on the lower pipe, this joint is very strong, and is not so objectionable in appearance as the large bulbous joint, shown by Fig. 2 in an earlier lecture.

Sometimes an architect will specify that the soil-pipes shall match those used for conveying rain water. If these pipes are round in section, and of the common description, the sockets and ears can be copied by working a piece of 5 lb. or 6 lb. lead on the socket of one of the pipes, as shown by Fig. 319. The ears can be made by means of a wooden pattern being pressed, face downwards, in sand, and the print filled up with molten lead, the socket and ears being then soldered on to the pipe. It is much better to have a wooden pattern made slightly smaller than the iron-pipe for working the lead sockets on, as, when an iron-pipe is used, the extra thicknesses of the lead will cause the sockets to look larger and bolder than those on the iron-pipe. A block cast out of "hards" is better still for working the lead sockets on. A few jobs have come under the writer's notice where an ordinary round leaden soil-pipe has been encased inside a cast-iron sheathing, made to imitate rain-water pipes, which were square or oblong, in cross section. In other cases, where the rain-water-pipes were made of lead, of a similar section to those mentioned above, the round soil-pipes have been covered with a lead sheathing to match those used for rain-water. Soil-pipes have been covered with sheet-lead, bossed to an ornamental pattern so as to make

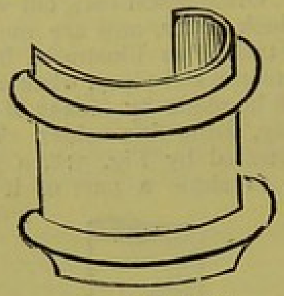


FIG 319

them look better. Square and oblong soil-pipes have been used, but they do not keep so clean inside as those of a round section.

Where soil-pipes have been made to look like rain-water-pipes, dummy heads, to match those on the rain-water, have been fixed on the top ends. These heads generally being made out of lead by the plumber. Or iron heads, with the backs cut out to fit over the pipe, have been used. In these cases the soil-pipe, or soil-ventilation-pipe, has been continued through the house wall, or parapet as the case may be, and up the roof to its intended position. At one large job, in which the writer was interested, instead of heads, as above described, being fixed, projecting stone blocks were built into the walls of the house and figure-heads carved as shown by Fig. 320. Similar heads were carved on the string courses, special stone blocks being built in the walls so as to project beyond the mouldings. In other cases stone bosses with foliage carved on them have been introduced.

In the illustration, Fig. 320, the top stone with carved head forms a weathering in itself, but where the pipe passes through the lower head a lead flange is soldered onto the pipe so as to throw off any water and thus prevent it running down the pipe and soaking into the walls.

In some instances soil-pipes have to be fixed in nearly horizontal directions. When so fixed, inside the house, deal boards, or planks, should be placed beneath to support them. When the soil-pipe ventilation is continued inside a roof a good fixing is a board placed edgeways and the pipe fastened to it by means of "face tacks" and screws. These tacks should not be more than 2 ft. to 2½ ft. apart. If this distance is exceeded the pipe will sag down between the tacks.

Sloping pipes fixed on the external face of the house walls should have the tacks soldered on so as to match those on the vertical pipes. But if these are very far apart a kind of secret tack should be soldered on the back side of the pipe between the others and built into the walls, as shown in section by Fig. 321. The edge of the tack being fastened with lead wedges in the

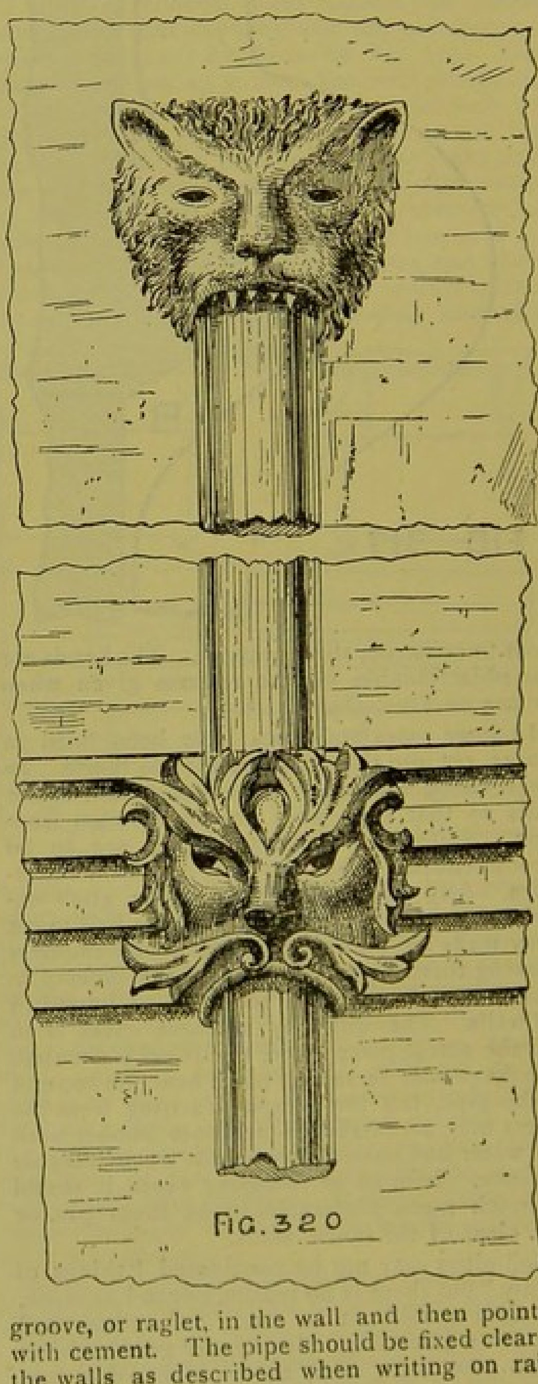


FIG. 320

groove, or raglet, in the wall and then pointed with cement. The pipe should be fixed clear of the walls as described when writing on rain-water-pipes.

Sloping pipes never look nice on the face of a building and should never be so fixed if it is possible to avoid it. In some cases they can be hid by means of a stone moulding with a hollow on the top for the pipe to lay in and a provision made for getting rid of the water, during a rainfall, that would get into the hollow. A dummy lead box could be fixed, the mouldings being horizontal, of such a depth as to hide the sloping part of the pipe. A reference to Fig.

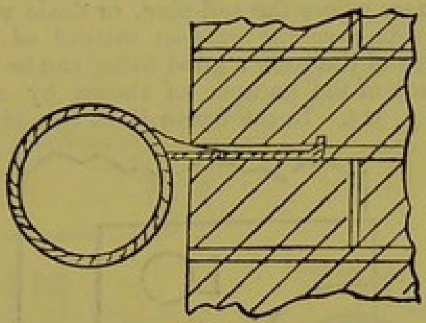


Fig. 321.

209 will help to make this more clearly understood if we imagine that the pipe leading into the trough was bent and continued inside, thence through the bottom and down to the drain.

The soil-pipe should always be continued full-size to the highest roof of the house, for ventilation. In some instances the size of the pipe should be increased for reasons we will deal with later on. The top end of the soil-vent-pipe should never be fixed near any dormers or openings into roofs, nor against chimnies. If any water-cisterns are near, the vent-pipe should be continued some distance away from them. It may be accepted as an ordinary rule that if the top end of the vent-pipe is a few feet above the ridge of the roof, any smells from the vent would not pass into the house. The only exception to this is when any house ventilation-shafts are fixed on the ridge. Ventilating engineers know that passing air currents have a greater influence on ventilators placed on the ridge of a roof than when fixed in any other position. There are exceptions to this, but they are not common. If one of these ventilators is fixed as described the soil-pipe-vent should be kept some distance away. House ventilation has not yet been reduced to an exact science, neither can engineers guarantee that an exhaust ventilator will always act in the way intended, or that air will not be drawn through it into the house. For these reasons it is not safe to fix a soil or drain-vent anywhere near a house ventilator.

The soil-vent-pipe should be well fixed on the roof, and in cases where the soil-pipe is fixed outside and the vent has to cross a gutter, the pipe should have a casing as shown at B Fig. 322, between the parapet and the slope of the roof. A piece of lead, about a foot square, should be fixed for the pipe to pass through as shown at A. The top edge of the lead being turned into a groove in the wall, a soldered flange-joint made to the pipe at C and the bottom edge of the piece of lead to hang over the turned up part of the gutter similar to the lead flashing.

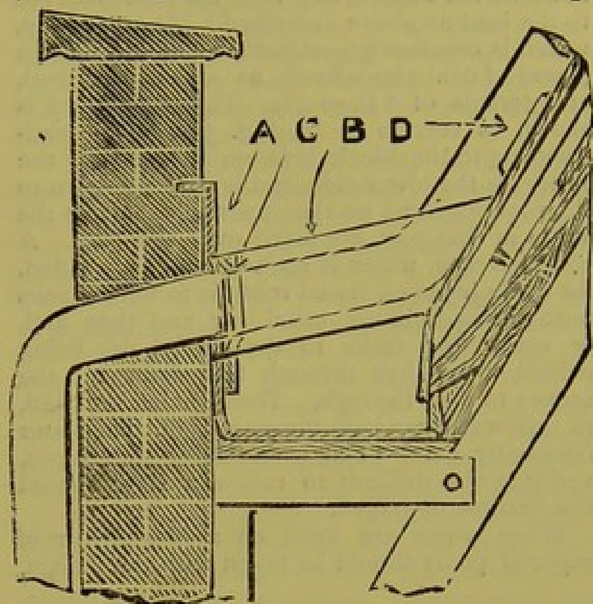


FIG 322

The lead flange is an important point, as it not only prevents any water falling on the outside of the pipe, and the casing, running into the wall and making it damp, but forms a kind of base for the pipe to thrust against, should the fixings above get broken, and thus prevent the pipe sliding down the roof. The pipe that lays on the sloping roof should also be well fixed. The best method is to have a wooden plank fixed on the roof, about 1 in. clear of the slates, or tiles, the plank to be covered with strong lead, and the sides of the pipe to be soldered to

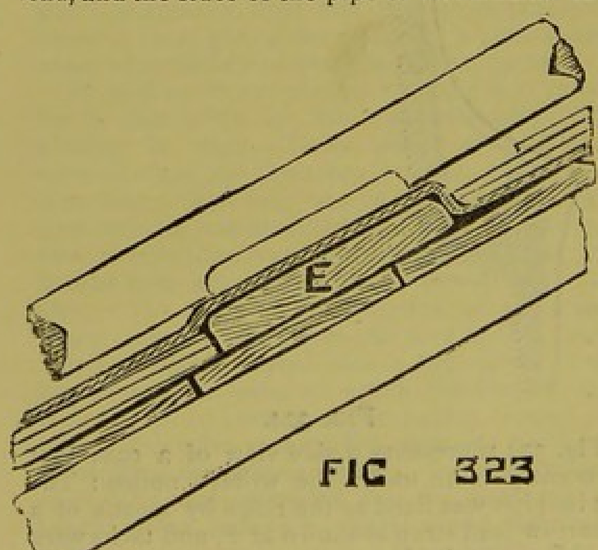


FIG 323

the lead about 3 ft. apart. The soldering being about 9 in. or 12 in. long, as shown at D, Fig. 322. In some instances this plank has been fixed onto the roof boarding, the plank covered with lead, the lead formed into secret gutters at the sides of the plank as shown by Fig. 136 in an earlier lecture, and then the pipe soldered to the lead as above described. Another way, which is commonly practised, is to have short pieces of deal plank fixed, as above described, at intervals of 3 ft. or 4 ft. The wood block is shown in section at E, Fig. 323. The lead-covering to the block lays on the top of the slates on the lower side, and is dressed down to the roof boarding on the upper side, so that the slates at that part are fitted over the lead. A common way, which is not to be recommended, for fixing pipes on slated roofs, is to solder tacks onto the pipes in the usual way and then nail, or screw the tacks to the roof, holes being drilled or punched through the slates for the screws to pass through. These holes are bad, as rain-water can pass through them. The slates frequently get broken when fixing the pipes, and it is also difficult to renew a slate should one become damaged.

When pipes are fixed on a Mansard roof especial pains should be taken with the fixings.

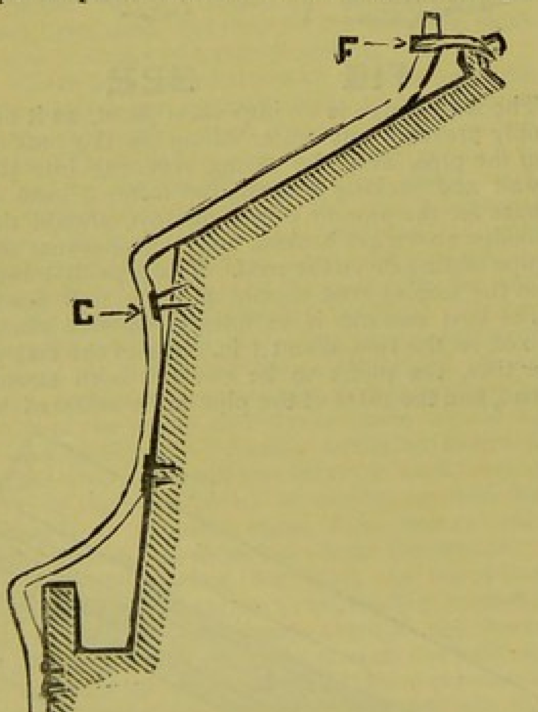


FIG. 324.

Fig. 324 represents a side view of a case that recently came under the writer's notice: The 4 in. pipe was fixed at the ridge by means of a narrow lead strap as shown at F, and tacks were soldered to the pipe and screwed through the curb flashing as shown at G. These fixings were not strong enough to support the pipe, with the result shown by the sketch. Iron clips have been used for fixing pipes to roofs, but they are not at all good, and soon rust away by the voltaic action which takes place between the lead and iron. For the same reason, copper screws are better than iron for fastening pipe tacks to blocks on roofs when that method of fixing is adopted.

In cases where the soil-pipe, or drain vent is continued above the parapet instead of up to the ridge of the roof, a good fixing can be made to the top of the parapet as shown by sketch plan Fig. 325. In the figure H is the pipe; I,

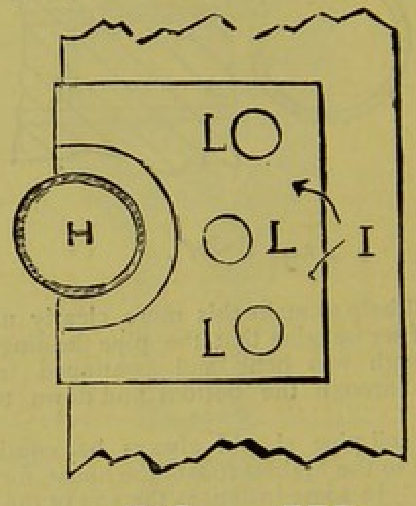


FIG 325

a piece of strong sheet lead, soldered to the pipe as shown at K. L, L, are lead dowels for fastening the lead tack to the stone coping.

Lead dowels or "dots," are always better than nails or screws for fixing sheet lead to stone work. Fig. 326 is a vertical section

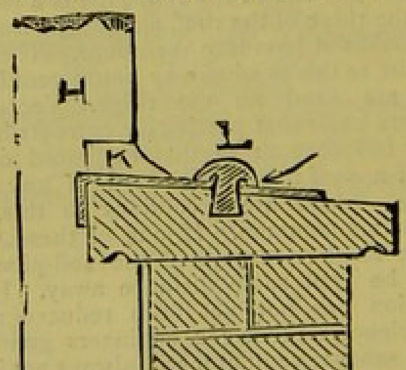


FIG 326

of Fig. 325, showing one dowel. To make this properly a hole is cut into the stone, the bottom of the hole being larger than the top, and a hole cut in the lead—the edges of this hole being worked upwards about ⅛ in. A "dot mould," made of iron with a rounded hollow on the underside, a hole through the top for pouring in the lead, and a handle for holding, as shown in partial section by Fig. 327, is held over the dowel hole, when the lead is poured through the small hole until it is filled to overflowing. The lead should not not be poured too hot, or it will shrink so much on cooling as to render it necessary to make a

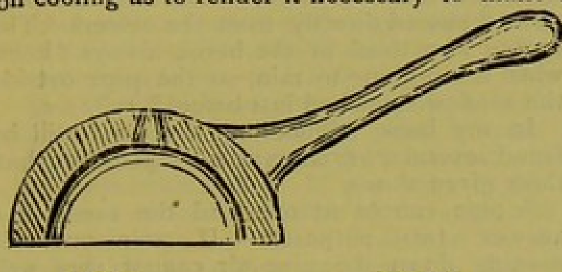


FIG 327

kind of rivet-head to the dowel. If this is done in a careless manner the dowel will sometimes work loose. The best plan is to have a caulking tool with a face about ⅛ in. thick, and drive in the edges of the dowel-head all round as shown by the arrow Fig. 326.

If, in a case, as shown by Fig. 326, the pipe stood about 2 ft. or 3 ft. above the coping the lead pipe would support itself; but if it was necessary to fix it higher than that it would be necessary to provide some kind of support to prevent it buckling and tumbling sideways. The simplest method is to solder a narrow flange onto the pipe as shown by Fig. 328, fix an iron band under this flange, and have two or three ⅜ in. galvanised wrought-iron stay-rods

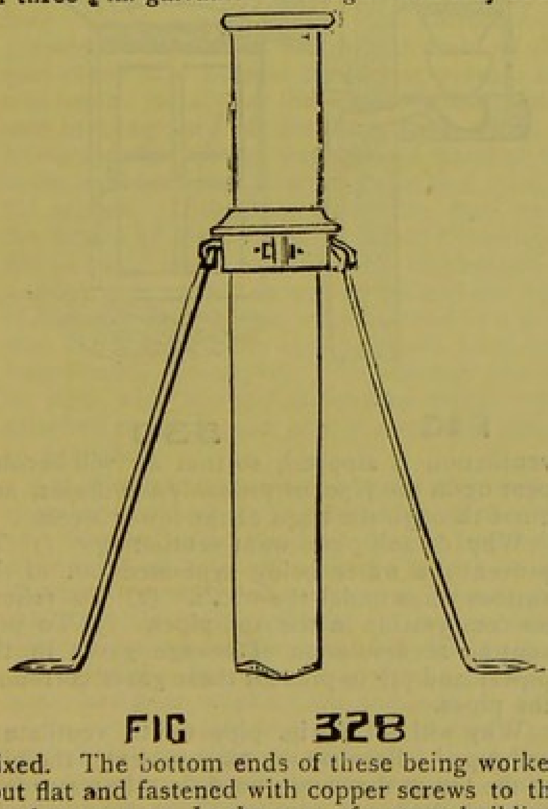


FIG 328

fixed. The bottom ends of these being worked out flat and fastened with copper screws to the roof or parapet. In the case of a stone building, the ends of these stay-rods can be fixed in the usual way by inserting them into dowel holes and filling up the spaces with lead or sulphur.

In some cases where it has been necessary to fix these ventilation-pipes to a greater height, say 10 ft. or 15 ft., it is advisable to substitute copper for lead pipe, as, being lighter and stiffer, the copper will resist being bent by a high wind better than the lead. Galvanised iron has sometimes been used for this purpose, but I prefer copper pipe.

The above remarks will apply to all pipes that are fixed on roofs where they have no other kind of support. Where it is necessary to fix a soil vent-pipe through the projecting eaves of a roof, it is a good plan to fix a lead slate on the sloping roof, with a pipe either bossed up or a separate piece soldered on, as described when writing on Figs. 306, 307 and 308; the vent-pipe to pass through this and have a bossed lead cap soldered on to keep out rain-water. This is a better method than bending the pipe to fit round the eaves, the shape of the bend being similar to the one shown by Fig. 317. It is not necessary to make the upper bends if the pipe is to be fixed near the eaves, in which case a plain swan-neck bend is all that is necessary. After passing the vent-pipe through the eaves of the roof, the pipe is sometimes continued up the slope. To make a neat job, and also to save making more bends than necessary, one bend can be made on the pipe to suit the slope of roof, and the lead slate soldered on the underside before fixing, the pipe and lead slate being afterwards fixed in their position.

We have now dealt with most of the leading points in connection with soil-pipes and their fixing, and will now pass on to

Soil Pipe and Trap Ventilation.

This is a very important part of our subject, and I purpose to deal with it from a practical point of view, giving the results of a great many years experience and thought on the matter.

To lead up to our subject I should like to refer to the days of my apprenticeship, beginning in 1859. There were no technical schools then, or literature on the subject of plumbing. If a boy was to ask the men any questions he was snubbed and told he was too fast, so that if he wanted to learn anything he had to keep his eyes and ears open and mouth shut. The subject of ventilation of soil-pipes was a common topic with the men at that time. Their technical school was a tap room, their blackboard the table, on which the illustrations were drawn by means of the fingers dipped in beer. Primitive as were the methods used for illustrating the subject matter, the discussions used to be very animated and the language at times rather heated.* This would naturally interest a youngster with an inquiring mind. "Take your rain-water into the top of the soil-pipe," was the doctrine preached by the advanced men. "What do you want ventila-

* This was over thirty years ago. The men of to-day are of a different stamp and better educated.

tion at all for, I can't understand," would be the reply. "A ½ in. pipe was all you wanted," would be advanced by someone who had considered (?) the matter. The men were not alone in their ideas of what was right. Architects and others, under whom the plumbers worked, knew no better. I may add that there are still people in the world who are working and advising according to the knowledge of 30 years ago and who are staunch opponents of all "new-fangled" ideas. Why not make the rain-water-pipes act as ventilators to the soil-pipes? Because the top ends of soil-pipes should never be near any windows or places where the escaping bad air could gain access to the house. The top end of a rain-water-pipe is always below the eaves of the house, excepting in certain cases, such as a tower or a turret or similar building attached to a house. Hundreds of illustrations could be given, but we will only take one or two as examples of rain-water-pipes connected to soil-pipes. Our first will represent something like between one and two thousand houses built in London squares by what was considered the leading firm of builders 40 or 50 years ago. Fig. 329 is a sketch side

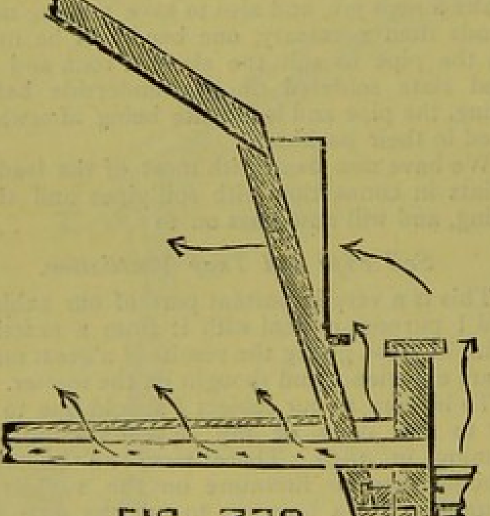


FIG 329

elevation of a dormer window of a bedroom inside a Mansard roof. N is the soil and rain-water-pipe with an open head out of which air, as shown by the arrows, can pass through the dormer window, and also through the floor of the bedroom, from the rain-water gutter which runs to the valley gutter between the front and back roofs.

Another example of one which is very common in suburban villa residences is shown by Fig. 330. In this case, O is a rain-water-pipe from the upper roof, the top end of which is near a window. P is an open rain-water-head which receives the water from the upper roof, also from the roof over the W.C., and very often a bath and slop sink waste-pipe besides. In a case in North London three children had diphtheria in the room to which the uppermost arrow points. In this particular case there was no trap in the main drain, so that the escaping air had passed directly from the sewers. The people who lived in the house always "knew when it was going to rain, as the pipe outside the window smelt bad just before."

In my book "Plumbing Practice," will be found several other cases worse, if possible, than those given above.

A pipe cannot at one and the same time answer two purposes. If rain-water is running down the pipe air cannot very well pass upwards. Hence, when rain is falling, the

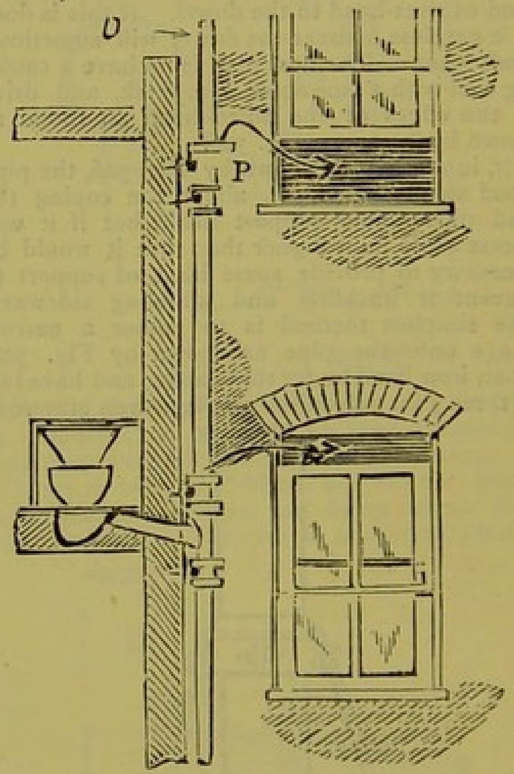


FIG 330

ventilation is stopped, so that air will become pent up in the pipe, or probably the drains, and burst through the traps at the lower levels.

Why do soil-pipes want ventilating? (1) To prevent the water being syphoned out of the various traps under the W.C.'s. (2) To relieve air compression in the soil-pipes. (3) To prevent an accumulation of sewage gases in the pipes; and (4) to prevent these gases corroding the pipes.

Why will not a ½ in. pipe do to ventilate a soil-pipe? Because the air must enter the pipe at the top at the same speed that the water falls through the lower portion. This brings us to the question of "syphonage," which should first be considered. To make this clear, we will assume that the atmospheric pressure on the earth is equal to about 15 lbs. on each square inch of surface This pressure is the same on all surfaces at the sea level of the earth and presses on liquids equally with solids. If you had a tube filled with water the pressure on the whole of the surface of the water would be equal to the area of the surface in inches × 15 lbs. If the tube was bent to the shape of the letter U and filled with water, it would stand at the same level in both legs of the tube because the atmospheric pressure is the same on the water surfaces in both legs. If you were to lift the pressure of the atmosphere off the surface of the water in one leg of the bent tube the water would rise in that leg and lower in the other, because the pressure of the atmosphere on the exposed water surface would force it downwards. If, instead of the U tube being filled with water in the position shown, it had been turned the other side upwards, thus ∩, and one leg immersed in a vessel full of water, the water in the outside leg would run out by reason of its weight, and the water in the vessel would be pressed downwards by the atmosphere, and thus forced into the bent tube. This would continue until an equilibrium was established by the water in the bottom of the vessel being reduced to the level of that in the outer leg. This action is called syphonage, and the bent tube a syphon. Now if you were to make a hole in the top of the syphon it would cease to act in the manner described. Air entering the hole would again reduce the atmospheric pressure to an equilibrium in both ends of that part of the tube outside the water vessel, and also on the surfaces of the water in the vessel and in that part of the bent tube which is immersed, so that the water would stand at the same level both inside and outside that part of the syphon. If the hole was made very small the action of the syphon would still continue, but so much water would not be discharged in a given time as with a syphon without the hole. If a large hole had been made instead of a small one the action of the syphon would have been immediately destroyed. We will now proceed to deal with a water-closet-trap which, when attached to a soil-pipe, acts in a manner similar to a syphon.

Let Fig. 331 represent a W.C. trap, with a short piece of soil-pipe soldered on to the outgo. The water in the bag of the trap being quite level on both sides of the throat or dip. If a small quantity of water was thrown into the trap, the same quantity of water would simply run out of the trap and dribble down the soil-pipe. But supposing that a pailful of water had been emptied into the trap, so as to fill its bore or water way, this water would have passed through the trap and filled the bore of the soil-pipe, falling, by its weight, with a velocity in proportion to the distance fallen through, and pushing the air in the soil-pipe before it. By displacing the air in the soil-pipe the atmospheric pressure is taken off the surface of the water in the trap at A but not at B. If the trap is 4 in. in diameter, and we measure the water surface at B we get 4 in. by 4 in.

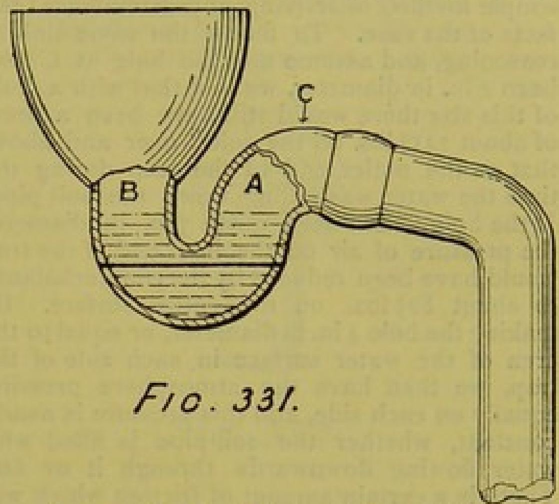


FIG. 331.

by ·7854 equals 12·566 in. This multiplied by 15 lbs., as representing the atmospheric pressure on each square inch of surface, gives us a force of nearly 188½ lbs. pressing on the water at B, and literally pushing it out of the trap when the pressure is removed from A. But the whole of the water is not pushed out. So soon as the water surface is lowered to the level shown by the thick line the air passes through the trap and breaks the siphon, as it is sometimes called, by filling the vacuum caused by the falling water in the soil pipe, displacing the air in it. When this occurs the atmospheric pressure is again reduced to an equilibrium on the water in the trap. But it is too late. There is not sufficient water left in the trap to seal it, and thus prevent air from the soil-pipe passing through. To prevent the water being pushed out of the trap it is necessary that the atmospheric pressure shall always be in a state of equilibrium on both sides of the dip or throat. If we were to make a hole ½ in. in diameter at C this equilibrium would be established when the water in the trap was in a state of rest. But if the soil-pipe was filled with water in the manner above described, or by the usage of a valve water-closet the equilibrium of air pressure would be disturbed, and a siphonic action would again take place, but not to quite the same extent as without the hole. If we measure the area of the hole, take that as an approximate basis to work on, compute the amount of air pressure that would be exerted through the hole to counteract that on the water surface in the trap at B, and deduct it from the total pressure on the water in the inlet side, we can then form some idea as to the inequality of the air pressure. To work this out we have ·5 in. by ·5 in. by ·7854 by 15 equals 2·945 lbs. Deduct this from the 188½ lbs. pressure on the inlet of the trap, and we have left about 185½ lbs. of pressure forcing the water out of it. This must not be taken as being exactly correct because there are other details which should be considered, but to work them all out would only tend to confuse. This argument is given as a simple method of arriving approximately at the facts of the case. To follow the same line of reasoning, and assume that the hole at C had been 2 in. in diameter, we find that with a hole of this size there would still have been a pres- of about 141½ lbs. on the inlet, over and above that on the outlet end of the trap during the time the water was falling down the soil pipe. If the hole C had been made 3 in. in diameter the pressure of air on the inlet end of the trap would have been reduced by the counterbalance to about 82½ lbs. on the entire surface. By making the hole 4 in. in diameter, or equal to the area of the water surface in each side of the trap, we then have the atmosphere pressing equally on each side, and this pressure is nearly constant, whether the soil-pipe is filled with water flowing downwards through it or not. There is a certain amount of friction which will retard the velocity of the air passing through the hole C in the trap, but this we need not take any notice of, as, in practice, the air that pushes the water out of the trap has to pass through the opening in the bottom of the W.C. basin, which is considerably less than 4 in. in diameter.

But we cannot leave an opening on the outgo side of the trap, as the air from the soil-pipe would escape at that place, and the trap would no longer be of any use. It is necessary, therefore, to fix a pipe from this opening to some position where what escaped from it would do no harm. The position of the ends of these pipes has been dealt with in an earlier lecture, so we have only to deal with the sizes of the pipes. Air, to a certain extent, is similar to water when passing through pipes or tubes in that it rubs against the sides, and the consequent friction retards the velocity. If a ½ in. pipe of a certain length had been soldered over the hole C in the trap, Fig. 331, so much air would not have passed in the same time as through the holes. If the ½ in. pipe was of a considerable length, and had bends in it, this friction would so retard the velocity of the air as to render the pipe quite useless when water was falling down the soil-pipe, although, when no water was falling, the ½ in. pipe would be quite large enough to restore an equilibrium of atmospheric pressure on the outlet side of the trap with that on the inlet, even when the latter was open to the air, instead of being covered with a valve W.C. apparatus. The same arguments apply to pipes of all sizes up to that of the soil-pipe. It has been shown that with open holes on the trap outlet, siphonage will take place, more or less, when they are under a certain size, and the addition of ventilation pipes does not improve matters, but to the contrary. We need not dwell upon all the smaller sizes, but proceed to deal with those equal in size with the soil pipes. As 4 in. soil-pipes are the commonest in use we will consider their ventilation, still dealing with them in respect to trap siphonage. For an example we may compare the 4 in. vent-pipe with one ½ in. in diameter.

Assuming the soil-pipe to be 4 in. in diameter and the vertical part 10 ft. long, the total capacity of that pipe is equal to a column of air 10 ft. long by 4 in. in diameter. The water that passes though the pipe may be only equal to 2 gals., but, in falling through the pipe this quantity displaces the whole, or nearly so, of the air in the pipe, and the air that enters through the ventilation must equal that displaced. A small size vent-pipe would do this but for the necessity of getting the air in at the same speed that it is displaced by the falling water. This can only be done by having the vent pipe the same size as the soil pipe. Supposing, as an experiment, we were to fix a ½ in. ventilating pipe and kept adding similar pipes until we got the desired result. We cannot do this practically on paper, but we can make calculations and thus arrive at the same results by that means. If we square the diameter of a ½ in. pipe that by ·7854 we find that the area is ·19635 inch. By a similar method we find that the area of a 4 in. pipe is 12·5664 inches. Divide this by the other dimension and we find that a 4 in. pipe is equal to sixty-four ½ in. pipes. But sixty-four ½ in. pipes would not allow so much air to pass through in a given time as one 4 in., assuming them to be the same length, because of the extra amount of friction through the ½ in. This we can find by calculating the internal surfaces of the pipes. If we multiply the diameter of the 4 in. pipe by 3·1416 we get a total superficial inside area, assuming the pipe to be 1 ft. long, of nearly 158·8 square inches, which the passing air rubs against. By a similar method we find that the internal surface of sixty-four ½ in. pipes, each 1 ft. long, is equal to nearly 1206·4 square inches. By working this out we find that by substituting sixty-four ½ in. pipes for one 4 in., the rubbing surface, over which the air passes, is increased by 800 per cent, and this is a very serious item. I am not in possession of the actual facts, but assuming that friction retards the velocity of the air passing through the pipes to the extent of from 5 to 10 per cent, the above figures will show the necessity of having large size vents to soil pipes, and also showing that theory squares with practical experience on this matter.

We have now arrived at the next stage which is, what influence has length of soil-pipes to do with their ventilation? This—water falling down a soil pipe does so at the same speed as ordinary falling bodies, minus the amount represented by the friction of the water against the sides of the pipes added to the air resistance which increases as it becomes more and more compressed before the falling water. After allowing for these, we shall find that the longer the vertical stack of soil pipe the quicker will be the velocity of the falling water through it, and air must enter through the vent pipe at the same speed to keep the water-seal of the trap intact.

What effect has length of vent pipe on the resistance to trap siphonage? If we assume that for an average length of vent pipe the velocity of the air passing through it is retarded to the extent of 8 per cent, it follows that where long vent pipes are used the air cannot pass through as quickly as it is wanted with the result that a portion will pass through the trap, pushing out the water in it, to gain access to the partial vacuum in the soil-pipe. We might take an extreme case where the ventilating pipe was so long that friction would cause the air to travel so slowly as to be entirely useless for preventing trap siphonage. In these extreme cases it may be found necessary to fix the ventilating pipes twice the size of the soil pipes. For instance, a 4 in. soil-pipe with 100 ft. of ventilating pipe may require the latter to be 6 in. in diameter, the relative sizes of the pipes being as 16 is to 36. The 6 in. being two and a quarter times larger than the 4 in. pipe.

Hitherto we have dealt with the pipes under the assumption they were perfectly straight. But in practice we very rarely meet with such cases. We generally have to make bends in the pipes. These bends retard the velocity of the passing air in proportion to their sharpness, hence the necessity of making long easy bends, both in the soil and vent pipes as described when writing on soil pipes and as shown by Figs. 284 and 285.

When cowls are fixed on the top ends of soil vent pipes, these cowls should not be so constructed as to prevent air being sucked down through them when water is falling down the soil pipe. It may be further said that cowls ought never to be fixed on soil vent pipes as, in addition to the extra friction they cause, the passing wind impinging againt the cowl, assuming it is a good one as an air exhauster, will, to a certain extent, prevent air being drawn through it to fill the partial vacuum in the soil pipe when it is being used. To illustrate this, we will take the dip, or water-seal of a W.C. trap as being from 1 in. to 1½ in., representing a resistance to air pressure of 10-10ths to 15-10th inches. If the cowl is a very good one and has a power equal to 2-10ths or 3-10ths, the pulling force of the cowl would partially unseal the trap in a case where the ingress of air into the bottom end of the soil pipe was impeded by any means. Some cowls would have sufficient power, during a high wind, to break the water-seal of a trap should the bottom end of the soil-pipe not be provided with an air inlet opening.

It is not always safe to leave the soil vent pipes open, as birds will place obstructions in them in the endeavour to build their nests. Leaves will also drift into the open ends. A plain wire grating—copper is the best—of a good size, should be fixed on the ends of the pipes as shown by Fig. 332. I have found cases where T-ends have been made on the tops of the pipes and brass gratings soldered in the ends as shown by Fig. 333. This is a very poor arrangement, as the gratings form

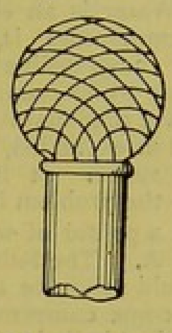


FIG. 332.

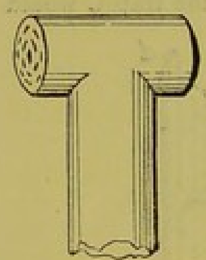


FIG. 333.

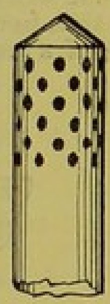


FIG. 334.

serious obstructions to the free passage of air through them. Another stupid arrangement, as shown by Fig. 334, is often found. To explain this I will take a case of one seen at Kensington. The pipe was 4 in., and had six rows of holes 1½ in. apart and ¼ in. in diameter. So we have 8 by 6 by $\cdot25^2$ by ·7854 divided into 4^2 by ·7854 and we find that the aggregation of small holes was equal in area to rather less than 1-5th of the 4 in. pipe. Further comment on this is unnecessary. In this, and previous cases I have reduced the areas of holes and pipe, when working them out, to their actual size, but it is not always necessary to do so in these examples. The shortest way of calculating the last problem is $4^2 \div \cdot25^2$ by 6 by 8, which gives the same results as before. I find it best in the class-room to work out such problems by the longer method for the sake of practice for the students, and also to avoid a multiplicity of rules which often defeats the object in view, that is, of having as few rules as possible and thus saving confusion in the minds of those who have a difficulty in following the lecturer.

We will now continue our subject by taking a stack of soil pipe which has three water-closets attached to it. The closets being fixed singly on the first, second, and third floors of a house, the traps and soil pipe being as shown by Fig. 335, both ends of the vertical pipe being open so that air can freely enter or pass outwards at either end. Before explaining the various actions that take place, it will be necessary to consider for a moment the two elements which have to be dealt with—namely, water and air. Water is an element, which if kept at one temperature is, comparatively speaking, neither compressible nor expansible. Air is an element which can be compressed into a smaller space than that it originally filled, or can be rarefied or expanded, until it occupied a much larger space. It is important to remember this in the problem before us.

Supposing that a pailful of water was thrown down the basin A. The falling water in the vertical pipe would drive the air before it, but this air would become compressed to, perhaps, 8-10ths of its original bulk in the pipe between *a* and *b* before the air in the lower portion of the pipe was set in motion. The result would be, that the water in the trap B would rise, in the inlet side, from ¼ to ⅜ of an inch, and in about ½ to ¾ of a second afterwards the trap C would

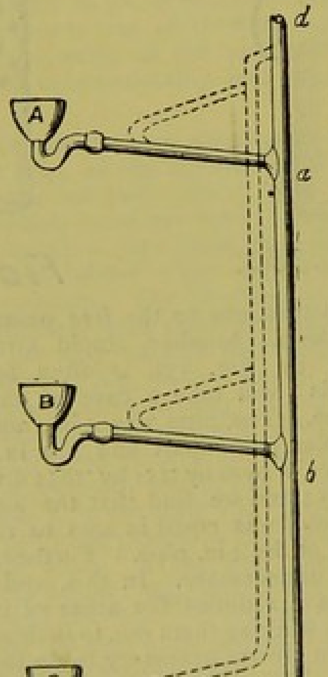


Fig. 335.

be similarly affected by the slightly extra pressure from the air inside the vertical pipe. But after the water from A has passed the branch *b*, a contrary action of the air takes place. Air passing in at the top of the vent pipe at *d* is slightly retarded by friction against the sides of the pipes, with the result that it is rarefied, mostly so close to the falling water, and in the attempt to regain, or keep, its original bulk would take off some of the pressure on the surface of the water on the outlet side of the trap. So we find the water in the trap is first pushed from, and then drawn into, the soil pipe, with the result that a vibration is set up. Although the water may not actually be siphoned out of the trap, the above motion will cause a considerable quantity to "wave" out, as it is commonly called, so that the trap is not properly water sealed. The event described as taking place on the trap B would also occur on that at C, and if continually repeated would in the end, result in the lower traps having the water levels so reduced as to almost break the seals, even when the soil and vent pipes are of the same size and have open ends.

If a pailful of water was thrown down the trap B similar results to the above would occur to the trap C, but to a slighter extent on that at A, as the only air compression that takes place on the trap is from the air driven out of the branch pipe *b*. This air is driven into the vertical pipe, some going upwards and some downwards, thus compressing that already in the pipe.

This action only occurs for a fraction of a second, but, nevertheless, it should not be disregarded. If the experiments had been tried with "valve" closets of the Bramah pattern, the results would have been nearly the same as with the pailsful of water. It is unnecessary to go again through the question of the sizes of the soil vent pipes, but I may add that without vent pipes or with vent pipes of a too small size, and traps similar to Figs. 268 and 331, the greater half of the water would have been siphoned out of the traps in the experiments.

I have endeavoured to explain certain actions that take place on the traps when the W.C.'s are used, and now propose to deal with the methods adopted by several leading sanitary plumbers to prevent the evils pointed out. The reader is referred to the dotted lines, Fig. 335, which represent branch ventilation pipes. These pipes have a treble use. First, to prevent the branch soil pipe acting as the long leg of a siphon and drawing the water out of the trap; second, to relieve air compression when water is falling down the vertical soil pipe; third, to prevent an accumulation of carbonic acid gas, in that part of the pipe, which acts as a corroding agent on the metal used for the pipe. I may add that watery vapor will condense on the upper side of the slanting soil pipe, and this condensed water is as injurious to lead as the above named gas, but a current of air will carry this vapor away. Some plumbers will fix 1 in. and others 1½ in. trap vent pipes, but in practice I find that they should never be less than 2 in. in diameter, and in extreme cases, of very high buildings, a stack of 4 in. trap vent pipe, with 2½ in. or 3 in. branches to the trap is only just large enough to prevent the water seals of the traps being broken

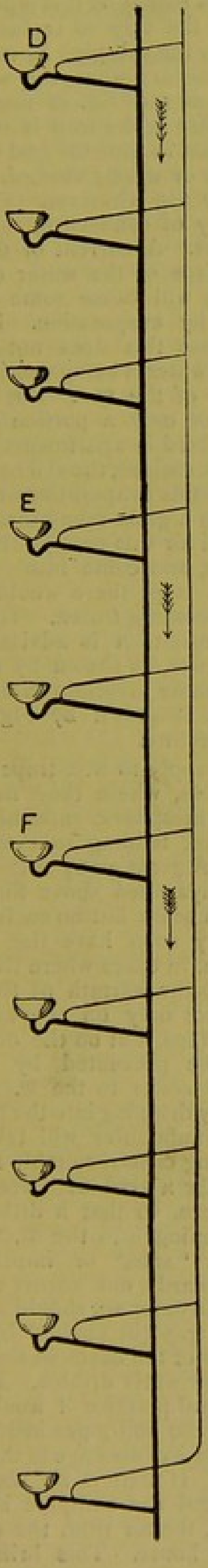


Fig. 336.

either by siphonage or air compression, even when the soil pipe had a vent pipe of equal size. This has arisen from the usage of two or three W.C.'s at the same instant of time, the falling water from each forming a kind of plug, in the vertical pipe, which, in passing the branches, covered the ends of them and thus rendered them useless as vent pipes. Let Fig. 336 represent a stack of soil pipe for a nine storied building, with a 2 in. stack of trap vent pipe and 2 in. branches to the traps. If the W.C.'s D, E and F were used at the same instant of time, the three plugs of water falling down the soil pipe would

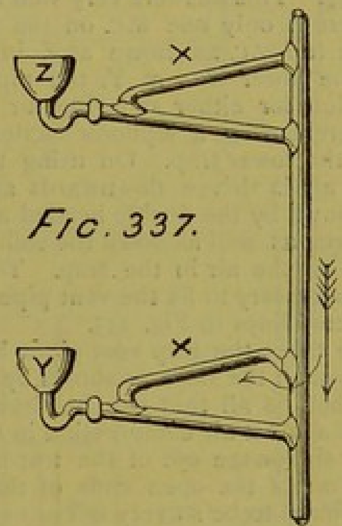


Fig. 337.

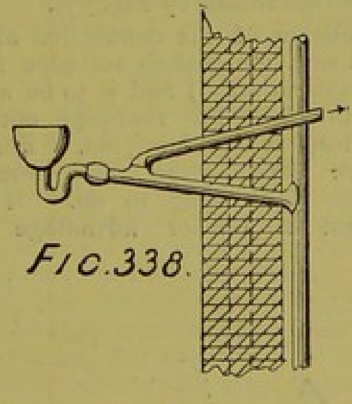


Fig. 338.

so disturb the ventilating arrangements as to upset all calculations on the matter. In this case, if the arrows were to represent the plugs of falling water, it would be found that the arrow under D would increase in speed as it fell, thus pushing the air before it. The air escaping out of the branch trap vents until the plug arrived at a certain stage when the air currents would be so suddenly reversed that the water in some of the traps would either be knocked out through the W.C.'s by air compression or drawn out by siphonage.

The remedies are two. Either increase the stack of vent pipe to 4 in. and have $2\frac{1}{2}$ in. or

3 in. branches to the traps, or increase the size of the vertical stack of soil pipe, so that the falling water would not fill it full bore, and thus allow some of the air to escape past. In this case the water would trickle down the sides of the soil pipe to a certain extent, the remainder of the water falling like rain. This would result in an incrustation forming inside the soil pipe, as the passing matter would not rub against the sides with sufficient frictional force to keep them clean.

Some plumbers will carry a ventilation pipe from the trap into the soil pipe as shown at X, Fig. 337. This answers very well for a case where there is only one W.C. on the soil pipe, or for the top W.C. as shown at Z in the Fig. But for the lower W.C. at Y, the pipe is perfectly useless for either relieving air compression or preventing a siphonic action on the water in the lower trap. On using the upper W.C., the air is driven downwards and would pass as shown by the double headed arrow into the trap vent as well as down the soil pipe, and thus press on the air in the trap. To prevent this it is necessary to fix the vent pipe as shown by the dotted lines in Fig. 335.

In some cases the trap vent pipes have been carried through the walls as shown by Fig. 338. This method is all that can be desired as a preventive against air compression in the pipes, and water siphonage out of the traps, but the air driven out of the open ends of these pipes has been found to be so very offensive that they have had to be continued to other and more suitable places. That is, the alterations made to the pipes have made the ventilation system similar to that shown by Fig. 335.

The position of the connection of the trap vent pipe with the branch soil-pipe requires a little consideration. I find it to be a common practice to solder the vent-pipe onto the top of the trap at A, Fig. 338A. For reasons that have been given this would seem to be the right thing to do. It may be added that a further advantage of thus

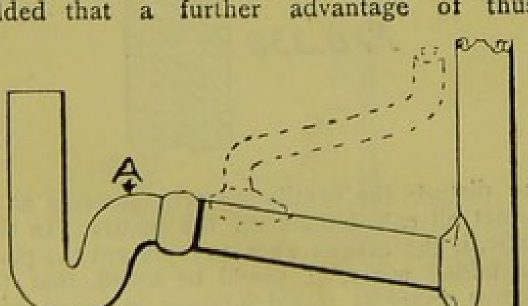


FIG. 338A.

connecting the vent-pipe is this: As there is some considerable difficulty in keeping sufficient water in a round pipe-trap, as described when writing on Fig. 268, the vent-pipe fixed over the outlet of the trap acts in such a way that the water which sometimes rushes up this pipe afterwards falls back into the trap to replace that which has passed down the soil-pipe by momentum. But this only occurs when the work is newly done. Each time the W.C. is used, the film floating on the water in the trap is washed up the vent-pipe, so that in time the end of this pipe becomes partially or wholly choked, when it is no longer of any use whatever. Further objections to this way of connecting the trap vent-pipe are as follows. A current of dry air passing over the surface of the water on the outlet side of the trap, will cause some of the water to pass away by evaporation. If the closets are in daily use this does not much matter, as the waste of water is being continually replaced by the usage of the W.C. But when houses are occupied for only a portion of the year, or the W.C.'s are fixed in apartments which are used only on rare occasions, the evil becomes serious. I have found this evaporation of water out of traps to occur in a great many instances. If a current of icy cold air was passing through the soil and vent-pipes, and came into contact with the water in the trap, there would be a liability of the water becoming frozen. To overcome the above evil results it is advisable to connect the trap vent-pipe, as shown by dotted lines, Fig. 338. The same principle as applied to branch waste-pipes, is shown by Figs. 102 and 103 in an earlier lecture.

The above remarks apply to W.C.-traps when fixed beneath the floors, where they may be said to be beyond atmospheric influences on the outside of the traps, tending to evaporate the water out of them. A great many W.C. basins and traps are nowadays fixed above the floor line and have plain rim seats, but no enclosures. W.C.'s thus fixed very soon have the water evaporated out of them, in cases where they are not frequently used, by the warmth of the surrounding air, acting not only on the exposed water surfaces in the traps, but on the outsides of them. This can be prevented by fixing special pipes and drip cocks to the W.C.'s, so that water is constantly dripping into the basins. Or, perhaps, some manufacturer will take the hint and make a flushing cistern suitable for the purpose, and arrange for a kind of "weeping" attachment to the cistern, so that a dribble of water is constantly running into the W.C.-trap. If this were done, a "safe," or impervious flooring, with a fall towards one corner and a waste-pipe from it to the outer air, should always be fixed in case the trap got choked by any means and an overflow of the basin was to take place by reason of the water dribble. If this should come into general practice it would become necessary to fix the soil-pipes inside the house, so as to avoid an ice blockage in the pipe during frosty weather. If there is no water in the trap of the W.C., and the soil-pipe is connected with the drains, the air from the drains can then pass into the house. This brings us to the problem of fixing a trap at the foot of the soil-pipe, its advantages and disadvantages.

Trapping Soil Pipes.

The disadvantages of trapping soil-pipes at the bottom end are as follows. First—Every trap is an impediment to the free flow of sewage. Second—Every trap, no matter how small, is a filth holder. Certain matters may be washed out of a good form of W.C.-trap, but it generally requires a second flush to force the same matters through a second trap at the bottom end of the soil-pipe. Third—It has been said that the water in a soil-pipe-trap, with an open grating over the top, is liable to become frozen in the winter time, but this I never knew to occur in my own experience. Fourth—By trapping the soil-pipes from the drains, it becomes necessary to fix special drain ventilation-pipes. Fifth—Any bad air driven out of the bottom end of a soil-pipe escapes out of the trap grating, if it is an open one. But for the trap this air would have been driven into the drains and afterwards carried away by the ventilating air currents. This is only an evil where the W.C.'s are not much used. Under ordinary conditions, where all fittings are in constant use, and the sewage flows away before decomposition sets in there is no bad air to be objectionable. The great advantage of a trap at the bottom end of a soil-pipe is this, should the water evaporate out of a W.C.-trap, as above described, the second trap prevents drain-air getting into the soil-pipe to afterwards escape through the W.C. trap into the house. Under these conditions the soil-pipe-trap becomes a necessity. A second reason, which only applies to large mansions or buildings, with several stacks of soil-pipe, is that a guarantee cannot be given that each stack of soil-pipe is properly ventilated, unless it is trapped off from the drain, and its own air flushing provided for, independent of other pipes. As an example, assume a large house with six stacks of soil-pipe, all connected with the drain. Some of these pipes would have air currents passing upwards and others downwards through them. Others again, would have the air inside quite stagnant. This would, perhaps, last for some little time, and then the air currents would become altered by the water discharges down the pipes. It may be argued that it does not matter if the air comes down one pipe, and passes through a portion of the drainage and up another pipe, so long as it is in motion. But it must be much better if air is always passing upwards through each and all of the pipes. And then, again, it frequently happens that the top end of the soil-vent-pipe cannot be fixed in a position where it would do no harm. In these cases a trap at the foot of the soil-pipe would prevent the whole of the drain air being discharged through the soil-pipe vent. Cases have occurred where it was an economy to trap the soil-pipe from a W.C. on the ground floor, and thus save an expensive stack of ventilating pipe to the roof of a very high building. Fig. 339, is one example out of several that could be given, where the W.C. has been placed in an addition built to a house, but some little distance away from it. By trapping the soil-pipe before it entered the drain, it is only necessary to carry the ventilation-pipe through the wall as shown

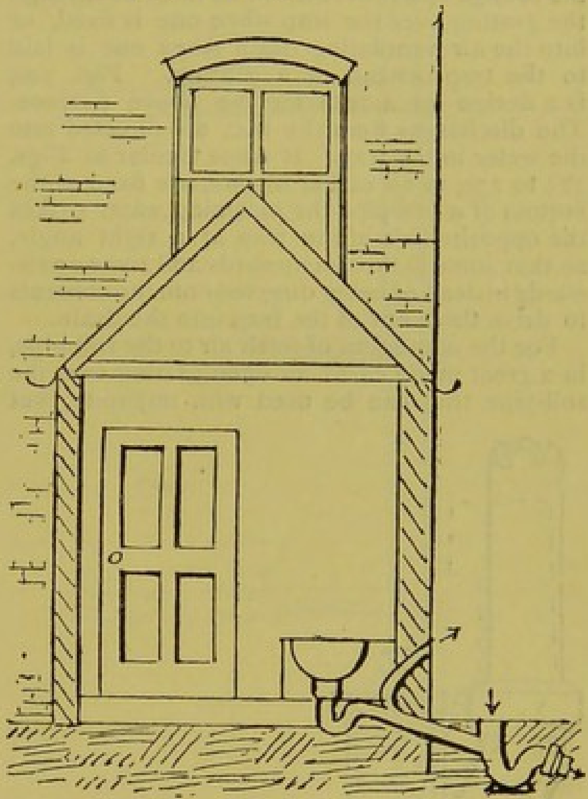


Fig. 339.

in the figure. If the vent-pipe had been continued to the roof of the main building it would have looked unsightly and the cost would have been considerable. Or, if it had been continued to the roof over the W.C., the air escaping from the vent-pipe would perhaps have entered the window shown in the figure. I may add that in cases of this kind, "valve" W.C.'s are the best to use as they keep both the traps and soil-pipes cleaner than any other kind of apparatus.

The question of traps keeping disease germs from passing from the sewers into the house drains was dealt with in an earlier lecture, see *ante* to Fig. 220.

To a small house with only one stack of soil-pipe, I should not think of fixing a trap at the bottom of it; but in some other cases, not all, it is advisable to fix such a trap. From what has been written it will be gleaned that in some cases soil-pipe-traps are of use, and in other cases they should not be fixed. Those cases are a question of judgment for the sanitary plumber to settle on the spot.

When soil-pipes are trapped at the bottom care should always be taken when selecting the kind of trap to use. The trap should not be too large or the contents will give off bad smells every time they are stirred up by the usage of a W.C. The soil-pipe should be so connected to the trap that what passes through has a tendency to keep the trap clean. A great many traps are so made that they are fouled inside by the W.C. discharges splashing over the whole of the internal surfaces. In some cases the sewage splashes so much as to come through the grating over the trap when one is fixed, or into the air ventilating drain when one is laid to the trap instead of a grating. Fig. 340, is a design for a trap for the above purpose. The discharges from the W.C. are directed into the water in the trap. If traps similar to Figs. 224 to 230, in an earlier lecture, are fixed at the bottom of a soil-pipe the incoming water strikes the opposite side of the trap at a right angle, so that some is thrown upwards and some downwards instead of being directed onto the contents to drive them out of the trap into the drain.

For the admission of fresh air to the soil-pipe, in a great many cases an open grating over the soil-pipe trap can be used with impunity, but

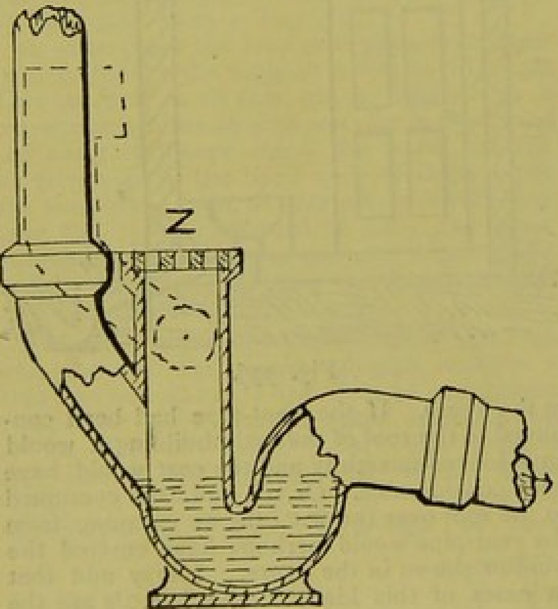


FIG. 340.

sometimes, especially when the W.C.'s are rarely used, smells are driven through the grating. To get rid of these smells, when the trap is near windows or other objectionable places, other precautions have to be taken. The simplest one is to lay in an air drain from the trap to some distant point, where any air escaping would not be a nuisance, and fix a grating over the end of the air drain to keep out vermin. It is sometimes a good plan to hide the ends of these pipes from view, as squeamish people are nearly always under the impression, even when it is not so, that they can smell the drains immediately they catch sight of a drain ventilation-pipe. If the end of this pipe cannot be placed in some unfrequented spot, in a shrubbery or similar position, a few old tree roots, &c., can be placed around it and a few ferns, shrubs or flowers planted to hide the pipe end.

Where this cannot be done the common practice is to fix a "mica" or "talc" valve on the end of the air inlet-pipe, and a solid cover instead of the grating shown at Z, Fig. 340. The dotted lines in the figure show the air inlet-pipe attached to the soil-pipe trap some distance above the water in it, so that the end of the pipe may not become choked with anything that passes through the trap. This liability to chokage is reduced by fixing the air inlet-pipe to the soil-pipe just above the junction with the trap. The air inlet-pipe should not be less in diameter, nor made of lighter substance lead, than the soil-pipe. There are several kinds of "mica air inlet valves," but they all act in the same manner, in that they allow air to pass into the soil-pipe, but prevent any air escaping outwards. The valves used for soil-pipes are slightly varied in their construction. Generally speaking, they consist of galvanised cast iron, or zinc, boxes in which are suspended pieces of mica or talc on small wire hinges. Gratings being fixed over the valves to prevent injury to them, and for keeping out birds and any loose matter, that may be lying about, from drifting into them. Two of the commonest kinds of valves are shown in section by Figs. 341 and 342. Each drawing represents the valves,

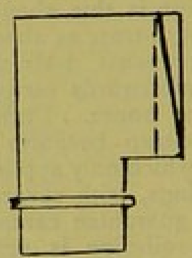


FIG. 341.

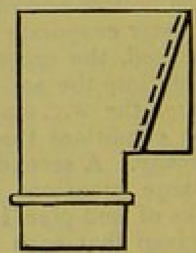


FIG. 342.

shown by dotted lines, in a state of rest. When in this state Fig. 341 has the valve open, but Fig. 342 has the valve closed. When fixed to a soil-pipe both valves are efficient, and answer their purpose very well, but when fitted for allowing air to enter the house drains Fig. 342 is to be preferred. It is always best to take every precaution, so that air may pass through the valves with as little resistance as possible. Hence Fig. 341 is preferred by some engineers, as the weight of the valve keeps it open for the free entry of air; whereas, in Fig. 342 a certain amount of the velocity of the air current is reduced in pushing the valve open. But the same rule applies conversely, and a certain amount of air pressure inside the soil-pipe is necessary for closing the valve. When fixed to a soil-pipe, where violent disturbances of the air inside take place, this valve always closes properly, but when fixed to horizontal drains they are frequently found not to close when a gentle back pressure is exerted. Drains have been filled with smoke, and this kind of valve has been found to remain open and thus allow the smoke to pass outwards. For this reason the valve shown by Fig. 342 has sometimes an advantage.

Steam or hot air in drains has frequently been found to get behind the mica valve and press it so closely on to the seating that all ventilation has been arrested for a time, until the steam had condensed, or the hot air cooled to its normal condition, when the air currents have again resumed their course through the drains.

When soil-pipes are trapped at the bottom, and an open grating fixed over the trap, the air, pushed downwards by the falling water, can freely escape, but when a mica valve is used this air becomes so compressed as to close the valve violently, making a noise so loud that it can be heard some considerable distance away. The talc has been broken, and I have known the front of a valve to be blown out by this violence. To prevent the noise referred to oiled silk has been tried, but in practice it is found that the silk is so soft as to be forced through the grated front of the valve when the air behind has been very much compressed. If the bars of the grated front are placed close together, to prevent the silk being forced between them, the air way is reduced. The air way through an air inlet valve should be larger, rather than smaller, than the soil-pipe.

When a mica valve is fixed, as above described, it becomes necessary to fix a ventilation-pipe from the bottom of the soil-pipe, and either continue it separately to the roof, or connect it to the soil-pipe ventilation above the level of the branch soil-pipe from the highest W.C. on the stack. If the reader refers to Fig. 335, imagines a trap similar to Fig. 240 fixed at the bottom of the soil-pipe, with an air inlet and mica valve, and the trap ventilation-pipe, shown by the dotted lines, Fig. 335, continued downwards and branched into the soil-pipe close to the trap, he will then understand what it is intend to convey. When arranged in the manner described the air driven downwards in the soil-pipe can escape upwards through the vent-pipe. The size of this vent-pipe should be governed by the same reasons that were given in an earlier lecture on trap ventilation.

Some engineers go beyond disconnecting soil-pipes from drains and disconnect all the branches, from the W.C.'s, on the various floors, from the soil-pipe. The principle is illustrated by Fig. 343. Instead of the branches being joined to the vertical stack of soil-pipe they are made to discharge into open heads, as shown in the drawing. In a five storied building seen some time ago, the W.C.'s were arranged as shown, at the back of a house in a kind of well hole, and the open heads had to be covered because of the air that escaped from them smelling so badly. In theory the system appears to be very good, but in practice it has been found objectionable. Windows near the soil-pipe cannot be left open, because of the reasons given above. On using the upper W.C. it will be noticed that the discharges have to pass through all the open heads down to the drain. This could be modified by fixing a vertical stack of pipe with branches into it, and the W.C.'s made to discharge into open heads

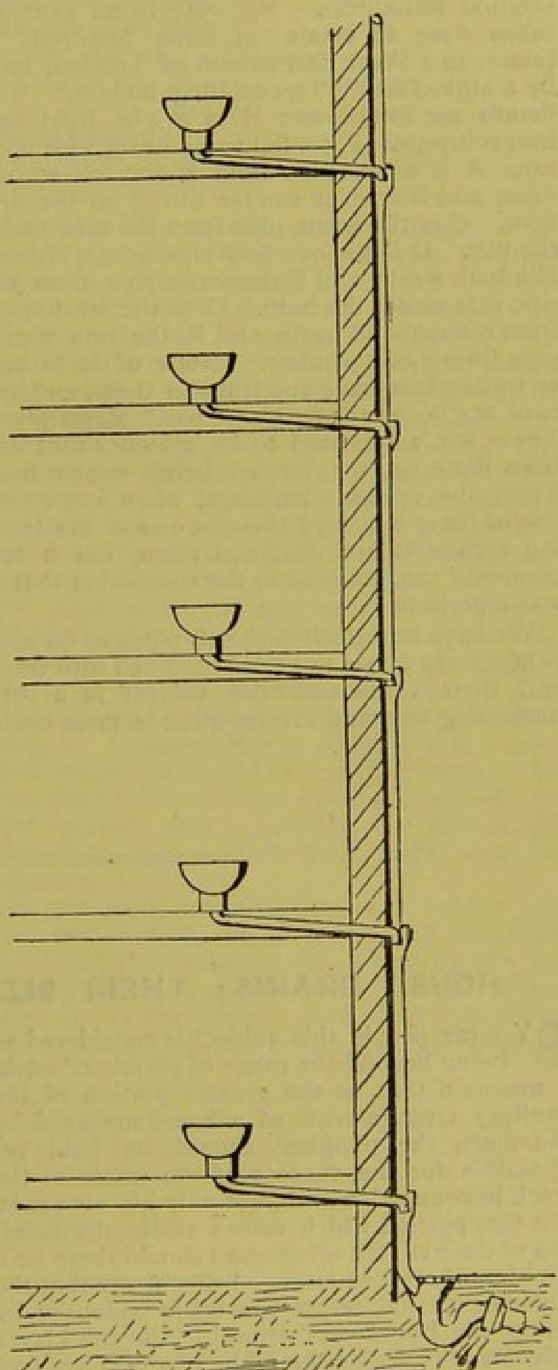


FIG. 343.

fixed on the branches. The principle may be good, to a certain extent, for preventing disease germs getting into the house by means of the soil-pipe, but we must not forget that we can breath air which is free from specific disease germs, and yet be made ill by breathing it. Or the tone of the system can be so lowered by breathing impure air that a person is rendered the more liable to contract disease.

There is such a thing as "Out-Heroding Herod," and believers in the above system have been known to go much further than the original introducer. Fig. 344 is an example taken from an estate of some hundreds of houses in a West End suburb of London, built by a high class (?) "speculating builder." The details are as follows: H is a 4 in. light cast iron soil-pipe. I is a light zinc head, with open top. A is a soil-pipe from a W.C. on second floor, and B from a similar fitting on the first floor. C is the waste-pipe from the safe under the W.C. D is the overflow-pipe from a cistern, E a bath waste, and F the waste-pipe from the zinc safe under the bath. G is the waste-pipe from a washhand basin, and K the rain water-pipe from a bay window. None of the fittings or waste-pipes have any traps to them, and the two W.C.'s are of the "pan" description. These W.C.'s appeared to be old ones that had been done up, the houses being nearly new. From the vendor's language, when inspecting one of these houses, I thought one of our leading architects had designed them, but a few moments' thought lead to the conclusion that it was a gross libel.

We have now dealt with soil-pipes so far as it is necessary for us to go. Combined with traps and their ventilation the subject is a very interesting one, and several more lectures could be given on it. The time for that we cannot afford, so we must pass on to the next in our programme, namely, "Drains; their sizes, materials and construction."

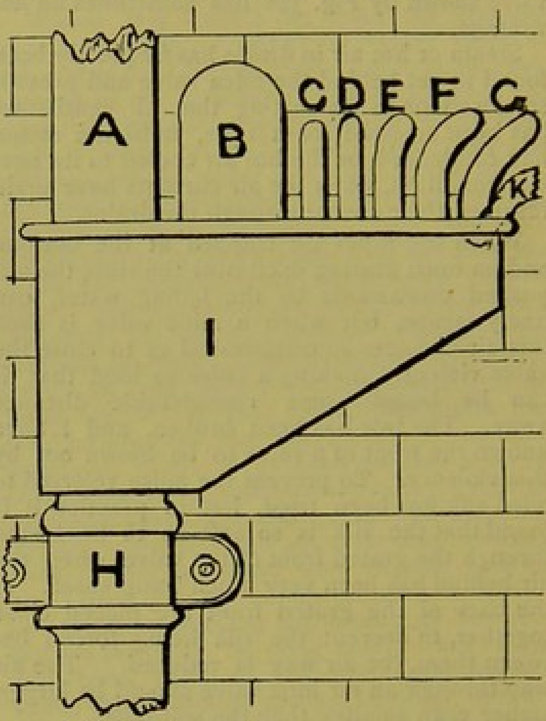


FIG. 344.

HOUSE DRAINS; THEIR SIZES, MATERIALS AND CONSTRUCTION.

BY some people this subject is considered as being beyond the range of plumbers' work. I maintain that as the greater portion of the sanitary arrangements of a house are fixed by plumbers, the plumber should be held responsible for the success of the whole of the work in connection with, not only his own part, but that portion which comes under the heading of drains. On no account should there be a division of responsibility. I do not say that the plumber should create any trade jealousies by using the bricklayers' trowel. The bricklayer who lays the drains should be one who has had a special training in drainage. If he is lacking in that knowledge he is no better than an ordinary navvy. I have worked on buildings where all the drains were laid by ordinary labourers in, what could only be called, a disgraceful way. On other buildings I have known the drain layer to be paid considerably more than ordinary bricklayers' wages, because of his special skill. In my own experience, when superintending sanitary works, the drain layer has always been a selected man, who was often paid better than ordinary men. With the best of materials a poor tradesman fails to make a good job. This applies to all crafts. Although drains, when laid, are out of sight, too much pains cannot be taken in their construction. They may not be seen, but under certain conditions their existence is felt. Hence the necessity of not only laying them properly, but also in arranging them to the best advantage, and selecting the best materials to use. On large works this is usually done by a consulting engineer. But there are thousands of jobs done, without that supervision, by men who have no knowledge whatever of sanitary works, who blunder along without any thought or care as to the results of their blundering. In surveying an old house we expect to find defects in the drains, but in houses of modern construction, and with the present sanitary knowledge, which is supposed to be common to all people who undertake drain laying, it almost amounts to a crime to execute work in the way which is so often met with. The man who is in charge of sanitary works should be well versed in all their details, so that when superintending them he will not make any mistakes. If he is thoroughly master of his business he will not only go right when left to himself, but will more intelligently interpret the superintending engineer's instructions when one is appointed to arrange the sanitary system. To go down into the ranks, the same remarks apply to men working under a foreman. There is very little doubt that these are the ideas which caused the authorities to put "drains" into our syllabus of Plumbers' Work. We will now deal with drains for conveying sewage from houses, but must first consider what is house sewage. The greater portion is water which has been used in the house for some useful purpose, such as cleaning floors, utensils, &c., or the bodies of the occupants. Some of this water has not changed its natural properties to any great extent, and can be dealt with simply as a liquid. But other portions of the water are used as a motive power for removing excreta from the water-closets, mud, sand, and such like matters from yards and certain sinks, such as those in the scullery and kitchen. Water from these latter places has a task to perform, and it will not do that task unless the necessary provisions are made for concentrating its whole force on the work to be done. As an example, if a soil-pipe was made to discharge on to a smooth pavement laid to a slight fall, the water would drain away to a lower level, but the solid, or semi-solid, matters would be left behind. But if the same pipe was made to discharge into a narrow channel, laid to the same fall as the pavement, the paper and other matters would have floated away on or in the water. If the channel had been a wide one, instead of a narrow one, the same results would not have been obtained, as the water would have spread over a larger area, the hydraulic depth would not have been sufficient for floating the other matters away, and they would have stranded on the bottom. This points to the necessity of water-closet drains being made as small as possible, and laid to a, what may be called, sluggish fall, so that fæces and similar matters may be immersed in the water. When testing drains as to their capabilities for floating fæces and paper, potatoes can be sent through them, with a small pailful of water, when the results will be approximately near the actual facts.

But when arranging for draining a house we must provide for other matters, as referred to above, from yards and scullery sinks. Some of these matters are heavier than others, and it is not a question of "floating" them away, so much as having a sufficient velocity for the water to "scour" them away. On referring to one of our text books* on the subject we find the velocity necessary to remove certain solid substances to be as under :—

	ft.	in.	
River mud, semi-fluid ...	0	3	per second.
Brown pottery clay... ...	0	3¼	" "
Common clay	0	6	" "
Yellow sand—loamy ...	0	8½	" "
Common river sand ...	1	0	" "
Gravel, size of small seeds	0	4¼	" "
" " peas ...	0	7⅛	" "
" " beans ...	1	0½	" "
Coarse ballast	2	0	" "
Sea shingle, about 1 in. dia.	2	2	" "
Large shingle	3	0	" "

In town houses, with paved courtyards, we get driftings from streets to deal with, in addition to the other matters mentioned. If we assume that a drain laid so that the velocity of the water through it was sufficient to remove "common river sand," we should then have a moderate fall, which would give sufficient, or nearly so, depth of water in the drains to float lighter substances, such as fæces, away. In practice, this fall would not answer at all well, as we find that, in addition to those matters that have been named, we have grease and sand from the scullery and similar sinks, mud from vegetables when being washed, and also from roofs when the rain water is discharged into the sewage drains. Some of these matters, on getting into the drains, so concrete together, that it is difficult to afterwards remove the accumulation by means of ordinary water discharges. If water were so plentiful that a constant stream could be kept running through the drain the various matters would be removed as they entered, thus preventing the concreting referred to, and a lesser fall would then be necessary.

In practice it is found that drains, which are fairly well flushed, should not be laid so as to have less fall than would give a velocity of 3 ft., or more than 4½ ft., per second. The following table† shows the velocity and discharge from drains of the sizes which are in most common use :—

Diameter of pipe.	Velocity, 3 ft. per second.		Velocity 4½ ft. per second.	
Inches.	Fall.	Gallons per minute.	Fall.	Gallons per minute.
3	1 in 69	54	1 in 30·4	81
4	1 " 92	96	1 " 40·8	144
6	1 " 138	216	1 " 61·2	324
9	1 " 207	495	1 " 92·0	742·5

After deciding the velocity necessary for keeping the drains clean, we want to know the sizes of the pipes to be used in their construction. In this part of our subject we find that theory and practice do not work well together

* Baldwin Latham's "Sanitary Engineering" (Spon)

† Bailey Denton.

Not that the theory is wrong, but in practice the engineer's calculations are frequently upset by the drains being submitted to improper usage. On referring to the table we find that a 3 in. pipe drain laid so that the velocity of discharge shall be equal to 3 ft. per second, 54 gals. are discharged in a minute, or 3,240 gals. in an hour. I do not suppose that our largest mansions or hotels use so much water as the above quantity in the time given. Of

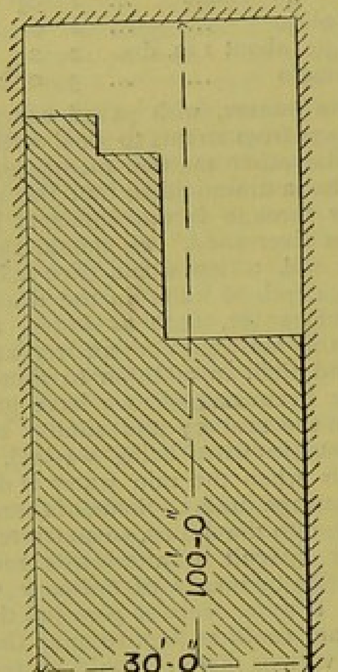


FIG 345

course, we remember that water-closets, baths sinks, &c., are not constantly running water into the drains, and that the discharges into them are intermittent. But we can allow a very wide margin for this, and then find that 3 in. drains are quite large enough for any ordinary house, provided they are used for their intended purpose only, and not as if they were receptacles for all kinds of articles by thoughtless people or careless servants. If the drains are properly laid, and used for conveying sewage only, they very rarely need to be larger than 3 in. diameter. But there are very few houses, especially in sewered towns, where the drains are so used. In most cases the sewers have also to receive the rain fall, and the house drains have to convey all rain water, not only from the house, but all buildings attached to it, as well as what falls on the courtyards and areas surrounding the house. In these cases the rain fall has to be considered as additional to the house sewage, and has to pass away through the drain as fast as possible to avoid flooding the lower portion of the house. To arrive at the proper size for the drains to be constructed, we will first assume, as an example, that Fig. 345 represents a terrace house with a 30 ft. frontage, and the piece of ground on which it stands as being 100 ft. long, from the front area wall to the yard wall at the back of the house. The size of the house is not of much importance, as rain water falls on the yards and areas to the same extent, or nearly so in ordinary cases, as it does on the house. Neither is the shape of the roofs necessarily to be considered. By calculation we find that the total area of the ground on which the house stands, and including the areas, is 3,000 superficial feet. We will further assume that half an inch of rain fell in 10 minutes. This amount actually fell in Camden-square, London, in 1887.‡ To avoid flooding the yards, or house basement, the drains should be large enough to take away the rain as it fell. One square foot of surface, covered with water to the depth of half an inch, represents a ¼ gal. of water. In our problem we get 3,000 ft. × ¼ gal., which gives us 750 gals. of water to get rid of in ten minutes, through the drains. If we refer to our tables we find that if 3 in. drain is used, it should have a fall of about 1 in 30. If the drain cannot have this fall the size must be increased to 4 in. in diameter, and have a fall of about 1 in. in 96 in., which is the nearest our table gives us, to get rid of the above quantity of water in the stipulated time.

If the house is occupied and the various sanitary fittings are being used at the same time that the rain is falling, the drains must be large enough to convey the whole of the water and sewage away as fast as it pours into them. But it is not always right to have the drains just the exact size necessary for conveying the water and sewage away to the sewers or other outfall. If all the inlets to the drains are filled with water, and ample ventilation not provided, or provision made for the pent-up air to escape, the drains become air-bound, with the result that the air confined in them will either burst through the traps fixed in the lower areas, being forced out where there is the least resistance or head of water over them, by the head of water from pipes which come from a higher level, or simply dribble away in proportion to the amount of space formed by the air being compressed to less than its ordinary volume. If this air is compressed to half its bulk the water would then fill or run through the drains at half-bore. Where the drains are properly ventilated by means of special pipes or left open at both ends, the air cannot then offer any resistance, and water will pass through the

‡ Symons's "British Rainfall, 1887."

drains at full bore. It is not at all uncommon to hear complaints of smells escaping from drains during a heavy rainfall, and the above remarks will doubtless account for this.

With these facts before us we may conclude that for small houses, say with 10 to 14 rooms

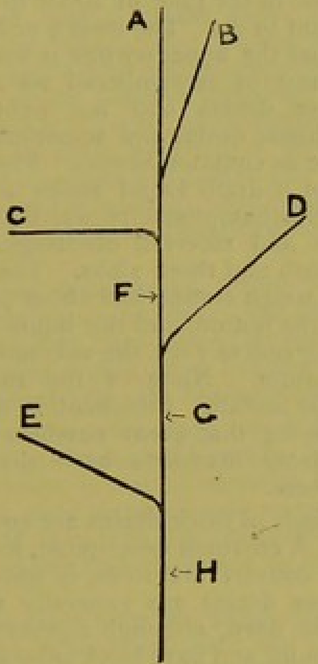


FIG 346

and an average amount of areas and yards—a 4 in. drain i sufficient for most cases. For town mansions of moderate size, 5 in. drains are large enough ; and for houses or buildings of a larger size, 6 in. pipes will take away all the water that may pass into them in an ordinary way.

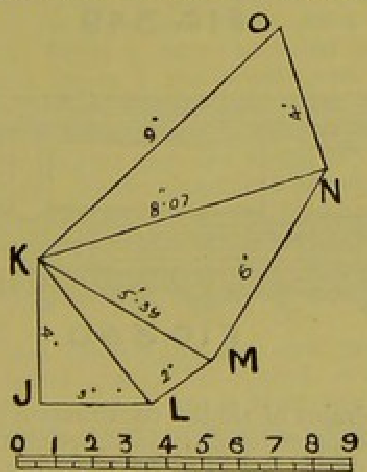


FIG 347

In these remarks it is assumed that the drains are properly constructed and nothing improper passes into them.

Public authorities generally stipulate that all main drains from houses shall not be less than 6 in. diameter. In some cases 9 in. are insisted upon; but with fair usage, 5 in. or 6 in. are much better, excepting in very special cases.

It will not help us in judging the sizes of drains necessary for a house, but the problem will be interesting as showing the relative capacity of different pipes if we take a case of a drain with branches as shown by Fig. 346. Let A represent a 4 in. pipe, B a 3 in. pipe, C a 2 in. pipe, D a 6 in. pipe, and E a 4 in. pipe. Assuming that all these pipes are running full bore, what size should the main drain be at F, G, and H, ignoring the friction, which varies in the different pipes according to their size, and dealing only with their capacity.

There are two methods for solving this problem, one by figures and the other graphically. The rule for the first method is : The square root of the sums of the squares of the diameters of the pipes is the size of the one required. So we proceed as follows—

A = 4 × 4 = 16
B = 3 × 3 = 9
C = 2 × 2 = 4

5) 29 (5 in. ·39 nearly, diameter of the pipe F.
    25

103) 400
      309

1069) ·9100
       9621

Then 29
+ D = 6 × 6 = 36

8) 65 (8 in. ·07 nearly, diameter of the pipe at G.
    64

1607) 10000
       11249

Then 65
+ E = 4 × 4 = 16

9) 81 (9 in. diameter of the pipe at H.
    81

To proceed graphically or geometrically, the rule is as follows—

The hypothenuse of a right-angled triangle is equal to the square root of the sum of the squares of the other two sides. To work this out graphically we take two lines, placed at right angles to each other, representing in length the diameters of two pipes, as J, K, and J, L, Fig. 347. J, K, being 4 in. long, and J, L, 3 in. long. A line drawn from K to L will represent the diameter of a pipe equal to a 4 in. and a 3 in. combined in one. If we then draw a line 2 in. long from L to M, at right angles to K, L, and another to one connect K, M. We then have the diameter of a pipe which has the same capacity as a 4 in., 3 in., and 2 in. combined, and which represents the diameter of the pipe at F, Fig. 346. On the line K, M, draw another one at right angles, and 6 in. long, as M, N, and the line drawn to connect K, N, is the diameter of the pipe at G, Fig. 346. On K, N, Fig. 347, draw a line 4 in. long, as N, O, and the distance from K to O, is the diameter of the drain at H, Fig. 346, and is the answer to our problem.

The same rules apply to service-pipes, waste-pipes or air-pipes, but it must be remembered that in these calculations the friction of whatever passes through the pipes is not taken into account. We need not go into this now, as illustrations were given in an earlier lecture when speaking on trap ventilation.

Materials for Drains.

All materials used in the construction of drains, for the conveyance of sewage, should be of an impervious nature so that sewage will not filter through and thus escape into the ground. They should be strong enough to resist being fractured by any external pressure of earth or other surroundings, or by internal pressure should they become choked and filled with sewage.

The materials should resist the chemical action of sewage, and the gases which escape from it when decomposing. The surfaces should be smooth, so that the matters passing through the drains will not cling to them, and the joint-

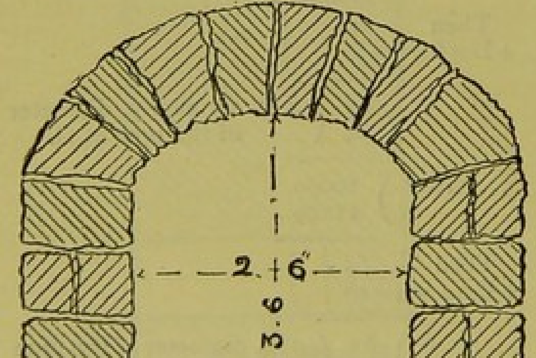


FIG. 348

ings should be so arranged that they can be made watertight. As a rule, house drains are made cylindrical in shape. They are sometimes made of bricks, but these materials are not good for that purpose, especially when drains are laid inside of houses. It is difficult to so construct brick drains that they shall be watertight or stand a water test when submitted to that means for finding defects in their construction. Neither can they be made smooth inside without lining them with an internal coating of cement and, in the case of small drains, this is very difficult to do. The invert, or bottom, can be lined, but the upper portion is not so easy to do. It must be remembered we are dealing with house drains and not public sewers, although house drains are sometimes found to be as large as common sewers. Fig. 348 is an example of a drain found under a parsonage house in Northamptonshire, which passed under the house and received discharges from two w.c.'s, a bath and three sinks. The drain was built with rough stones, had about 9 in. of solid matter in the botton, and the liquid sewage ran in a zig-zag course over the accumulation lying in the bottom. None of the solid matters reached the outfall. Comment is unnecessary beyond saying that great numbers of gentlemen's country mansions have similar drains beneath them.

Some kinds of brick drains are equally objectionable. A common description, found in both town and country mansions, is shown by Fig. 349. These drains are generally about 12in. wide by 9in. deep, although a great many other sizes are found, and have brick sides and bottoms with pieces of stone bedded over the tops.

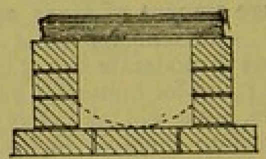


FIG. 349

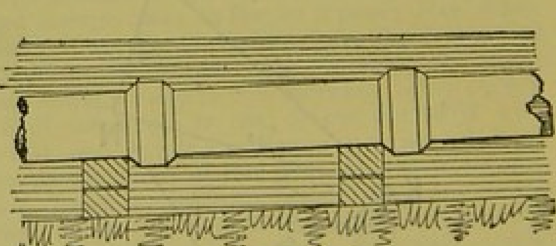


FIG. 350

Other drains of similar construction are sometimes found to have rounded bottoms as shown by the dotted line in the above figure. Common pantiles, as used for roofs, have been used for covering the bottoms of drains. Drains are sometimes found to be made of U shaped channels with cover stones to them. They have been found made of old chimney pots and hosts of other unsuitable materials which, to enumerate, would appear more suitable for a comic journal than these pages.

If brick drains were made cylindrical it would be difficult to make them small enough to be kept clear of sediment by the ordinary water discharges sent through them and neither, no matter how well built, can they be made to stand a water test. We shall have to deal with "drain-testing" at a future time, but I may here say that all drains should stand the "water test," for the reason that should a defective drain become choked with sewage the surrounding earth would become saturated with what escaped from the drain. A defective drain may be choked for years before it is discovered, as the escaping sewage will sometimes filter away through the earth, whereas, should a sound drain become stopped the evil would be discovered at once.

In a great many cases, where brick drains are laid in a house, rats have been found to pass out of holes they have made through the drains. In some cases drains have become choked by bricks, loosened by rats, falling inside.

I have never seen any, but I believe that house drains have been made of concrete. This, no doubt, is a good material to use, and the drains could be made very strong, but it is doubtful if they can be rendered so smooth inside as to offer no resistance to the free flow of sewage.

In some cases terra-cotta and unglazed stoneware pipes have been used, but they are not recommended, especially those that have no sockets to them for properly jointing together.

Other materials used for sewage drains are vitrified stoneware and cast-iron. The vitrified stoneware pipes are very strong, but they should always be enveloped in concrete as a protection against crushing or settlement when laid in soft ground. One of our leading manufacturers make a selection of their wares, test them by hydraulic pressure and mark them with the letter T. From a very extended experience with these pipes I can speak well of them. This description of pipes will resist the action of acids and sewer gases. London made pipes are in 2 ft. lengths and the joints are that distance apart. In Scotland, I am given to understand, they are made in 3 ft. lengths. This is an advantage, as there are fewer joints to make with these latter pipes. The jointing to this kind of pipes will be described under our next heading.

Cast-iron drain-pipes are now much used. They should always be coated, or otherwise prepared, to protect them from rusting. The Bower-Barff process of covering them, by means of super heated steam, with a hard coating of the black magnetic oxide has been spoken well of, but pipes so prepared do not seem to have come into general use for drainage.

Cast-iron pipes coated according to the suggestions made by Dr. Angus Smith, with a mixture of coal tar, pitch, a little linseed oil, and sometimes a little resin, have been found to answer very well indeed. For drains laid inside of houses, especially when beneath room floors, I always use and recommend cast-iron-pipes coated as last described.

Cast-iron-pipes, lined with a coating of porcelain enamel, are doubtless best of all. If the enamelling can be made to expand and contract to the same degree as the iron, by the hot and cold water that generally passes through drains when in use, and the cost of production can be reduced so as to compete with other materials, there is little doubt drain-pipes so prepared would come into more general use.

My reasons for preferring iron drains is that, when laid with leaded joints, they will expand and contract without breaking. Other materials, of a hard and brittle nature, will not do this to the same extent. At all events, this is the only reason that I can give for certain breakdowns, in drains properly laid, that have occurred in my own experience.

Construction of Drains.

The principal points to consider under this heading, and in addition to what was said further back, is, to lay the drains so that they shall not be influenced in any way by their surroundings, and the methods of making the joints.

It is quite as important to have good foundations for drains as for a house, no matter where they are laid, in a field or in a house. Defective drains always smell very offensive. Water is the motive power for conveying certain offensive matters from houses to some place of deposit. If the drains are defective the water will escape out of the defects, but the matters referred to remain in the drain, and, in some cases, will form a stoppage. If drains are laid in soft ground, and the ground beneath them should settle, so as to make them leak, the escaping water or sewage would further aggravate the evil. Some kinds of sandy soil are very treacherous, especially when a small stream of water runs through, and drains laid in such soil require certain precautions being taken to protect them. When the ground is very hard or rocky, the bottom of the trench, in which the drains are to be laid, is generally so uneven that the pipes do not have a fair bearing. Any projections above the bottom of the trench will act as fulcrums of levers, and the pipes laid on these projections are liable to be broken by the pressure of the earth above them pressing the ends of the levers down.

It is always best to prepare the bottom of the trench by laying in a bed of concrete for the pipes to rest upon. Spaces being dug out, or left out when concreting, for the sockets of the pipes, and also for the drain-layer to get his trowel round for making the joint. Where new drains are being laid in the same trenches that old ones were taken out of, and it has been found necessary to dig out a considerable quantity of earth, because of its being contaminated with sewage from the old drains, the whole of the space should be filled with concrete in preference to using dry rubbish, or other material, to replace the earth taken out, and then simply laying a thin bed of concrete for the pipes to rest upon, as usually done. The concrete should be laid to the same fall that is intended for the drains.

Some engineers will have drains laid on brick piers, instead of concrete, built for the pipes to rest upon, as shown by Fig. 350, but, excepting in cases where land water runs into the trenches and interferes with the making of the joints, concrete is the best, as the whole length of the barrel of the pipe is supported by it. The men will sometimes assure you that they have carefully filled in the earth, or concrete, as the case may be, beneath the pipes, but you will be fairly safe in doubting the statement. You may also have a suspicion that, in their efforts to fill the spaces beneath the pipes, they have moved them a little and cracked the joints.

After the trenches have been prepared to receive the pipes they should be laid in their places. If we are using stoneware pipes, each one should be carefully examined, the straightest side selected, marked, and laid so as to be at the bottom, and thus get an even line for the sewage to flow down. A considerable length of drains should be laid, before any cementing is done, and a crowbar, or lever of some kind, used to force all the pipes home into the sockets, so that there shall be no spaces for sewage to lay in. After this is done a pailful of concrete should be put on each pipe, and carefully tucked under the sides to prevent their moving. After allowing a short time for the concrete to partly, or wholly, set, the pipelayer should begin making his joints by forcing cement into the annular spaces between the sockets and pipe ends. He should do this as quickly as possible, making all the joints in succession. He should then go back to the first joint made,

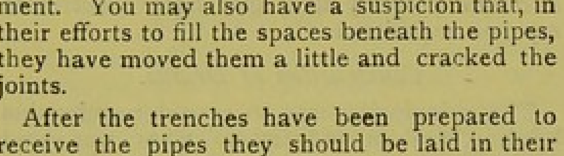


FIG 351

and carefully trowel the cement to a smooth surface, and follow on with all the other joints.

This going over the joints a second time is necessary, because of the water used for mixing with the cement draining to the under sides. This will sometimes cause the cement to drop away from the joint. In other cases, a hole large enough to get a finger in is left on the under side of the joint.

Cases have occurred where the bed, or bottom of the trench, has not been properly prepared by concreting, or the concrete has been put in in short lengths at the same time that the pipes were laid, so that the pipes have not had an even fall. When making final tests, as to fall, of drains with a spirit level, strips of wood of parallel thickness should be laid on each length of pipe and a long "straight edge" cut tapering, the taper being equal to the fall of drains, laid on the above strips so that the straight edge and strips shall touch each other. A spirit level laid on the straight edge would then stand at Zero. The arrangement is shown by Fig. 351. Some men will use tapering stripes of wood to lay on the pipes and level each pipe separately as to fall, but the practice should be strongly condemned as it is not unusual to find drains so laid not to have any fall at all in their whole length. Fig. 352 is drawn to make this more clearly understood. It will be noticed that the spirit level is laid on the pipes, proving the drain to be falling the wrong way, as shown by the the upper arrows, although each individual pipe has a fall in the intended direction as shown by the bottom arrows.

There are certain drain pipes made with patented joints to them, which cannot be laid in

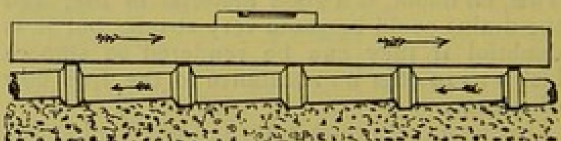


FIG 352

the above improper manner. A section of one joint is shown by Fig. 353. The inside of the socket is lined with a special material so as to make it quite true and concentric with the barrel of the pipe. On the spigot end of the pipe a bead is cast so that when the end of this pipe is socketted into the other the insides of the two pipes are in a line with each other. If laid as shown by Fig. 352 a projection of $\frac{1}{8}$ in. to $\frac{1}{4}$ in. would have stood up at A, Fig. 353, and this, in a sluggish fall to the drains, would be an obstruction to the free flow of sewage, prevent the drains running empty and a pool would be found at each joint. Stoneware drain pipes with the joint shown by the last figure are spoken well of by some engineers for this reason. It is also claimed for these joints that they are water tight without any cementing and can be deflected out of a straight line without causing them to leak.

When ordinary socketted drain-pipes are used some engineers will have the joints yarned so as to get a true annular space between the spigot and inside of the socket for keeping the spigot end of the last laid pipe from being below the barrel of the next pipe. Sometimes white yarn is used, in others the yarn is soaked in tar to prevent it rotting. It is probable that the tar in the yarn, when so treated, will prevent the cement from properly setting.

Portland cement is generally used for making the joints on stoneware drain pipes. Care should always be taken in selecting whose make of cement is used, as some kinds will swell when setting, and burst the sockets of the pipes.

I have been to some little trouble in practically esting Portland cements, and find that even when the cement does not swell when setting, if aid in a wet situation it will sometimes absorb

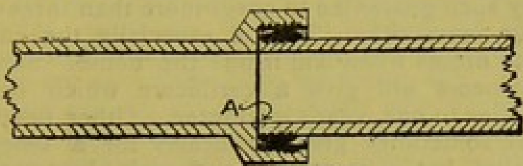
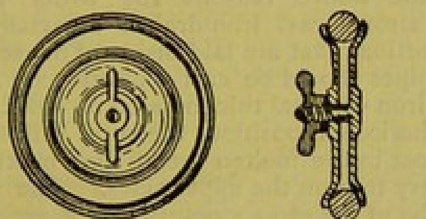


FIG 353



FRONT VIEW SECTION

FIG 354

moisture by capillary attraction and expand sufficient to burst small glass phials.

After the drains have been properly laid, and sufficient time allowed for the Portland Cement, or whatever other cement is used, to set hard, the drains should be plugged by means of a drain-testing stopper, shown by Fig. 354, filled with water to test their soundness, and all defects

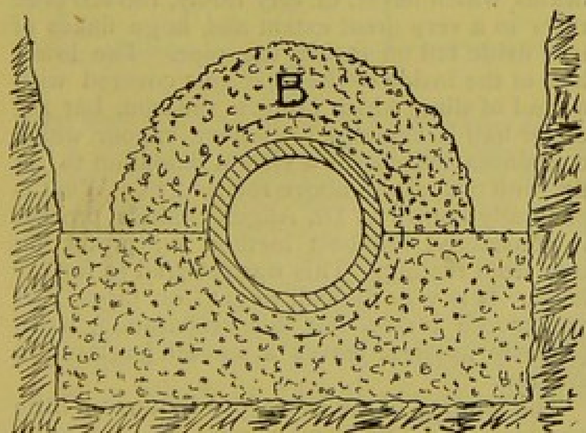


FIG 355

made good. After testing, the drains should be carefully covered with concrete, as shown in section at B, Fig. 355. By rounding the top of the covering concrete the pressure of the earth above is distributed sideways. A word of caution is necessary as to the method of covering the pipes with concrete. First of all the joint holes left under the sockets of the pipes (as shown at C, C, Fig. 351) should be filled up. The concrete should be very carefully lowered into the pipe trench, not pitched in from the ground level, and carefully packed at the sides of the pipe so as to prevent any jarring or movement, which would crack the pipes. For the same reason it is also a good plan to let the concrete set before filling in the trenches, and ramming the earth should be carefully done. It is very annoying, after taking pains to make a good job of the drains, when making a final test on completion of the works, to find them leaking and there are no means of discovering where the leak is situated, to have to take them all out again and relay them.

Even when the pipes shown by section, Fig. 353 are used, great care should be taken when fixing them. Although the joints are so arranged that the pipes may be deflected out of a straight line, and easy curves made with them, the drains are liable to leak at the joints if any local settlement of the ground should take place after they are fixed. To make this clear the student is referred to Fig. 356. Let A, B, represent the extremities of a length of drain laid in soft earth. The drains at the ends beyond, or right and left of A, B, being laid in solid ground so as to be immovable. The pipes laid in the soft

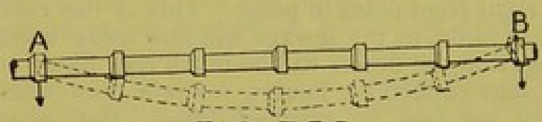


FIG. 356

ground could sink, as shown by dotted lines, and yet not leak, but the joints at A, B, would be pulled apart and thus rendered defective so that sewage or water would escape, as shown by the arrows. For this reason it is always advisable to envelope drain-pipes of this description in concrete, as described for ordinary pipes. It is of further advantage to face the joints with Portland cement, and not trust entirely to their tightly fitting by reason of the specially prepared ends of the pipes.

Portland cement has been referred to as the material for making the joints of drains because it is usually specified by engineers, but other cements can be used if they fulfil the requirements of the case. Some years ago, at a public exhibition, were shown samples of joints made with "Spence's metal," and although this material appeared to answer the purpose very well indeed, it does not seem to have been adopted for general use. Some kinds of asphalt would doubtless make good joints for drains that were used for cold water only, but would not answer for house drains where the water that sometimes passes through them is at a higher temperature than that at which the asphalt melts, or become sufficiently soft to run out of the joint.

The days for clay joints are passed, although there are still a few of the old school of people who maintain that clay is quite good enough for the purpose. The plasticity of that material will allow for a slight movement of the pipes without risk of breaking the joints, but will not resist any internal pressure that may be brought to bear. Neither will clay prevent the roots of trees or shrubs insinuating themselves into the drains.

It may be asserted that as expansion and contraction are almost irresistible forces, the materials used for making drain joints should allow for a certain amount of flexibility in the drains. This becomes necessary in houses where hot and cold water discharges are sent through the drains. It is highly probably that at some future time a cement will be made which will be both strong and flexible. If a length of drains expands only 1-100th part of an inch in its length a fracture is sure to take place at some point or other, even when embedded in concrete. The joint shown by Fig. 353 will no doubt allow for the slight motion referred to without actually causing it to leak, but when looked at from this point of view the cement facing mentioned above should be omitted.

Almost all specifications of modern date stipulate that all drains shall be laid perfectly straight from point to point. This is the right thing to do, as the sewage will flow away much freer and the drains will be much less likely to become choked by foreign matters than when they are laid on crooked lines. But when viewed from the expansion and contraction point of view, it may be argued that drains laid crooked are less liable to break by those forces than when perfectly straight. In one case the whole of the force is exerted at the ends of the drains and in the other the power is divided and expended at the various bends.

When drains are laid near roots of trees it is very necessary that an excess of concrete should be used to prevent the rocking of the trees, during a high wind, disturbing the drains. It is also a good plan to throw common gas tar over the concrete before filling in the trench to repel the small fibrous roots working their way into the concrete or into the drains.

Iron Drains.

The length of time that a vitrified stoneware drain will last is always uncertain and depends a great deal upon the position in which it is laid, and also its usage. It frequently falls to the writers' lot to make retests of drains, and there are several cases where he has standing orders to make annual examinations and tests. In some cases the drains will be found to be perfect for two or three years after they were laid, after which time they will often be found to be slightly defective, but not sufficiently so as to warrant his advising that they should be taken up and relaid. But on the fifth or sixth annual test being applied the drains have been found to leak so much that the above drastic remedy has had to be applied. In other cases the drains have been found to stand the applied tests for several successive years. From the fact that stoneware drain-pipes do frequently break down it naturally follows that one is always in a nervous state of anxiety or dread, that his own work should go wrong. In cases where a client will insist upon a written guarantee being given that the drains shall last a certain number of years it is never safe to give any such guarantee to cover more than three or four years risks. This is especially the case with drains when laid inside the house. Some engineers will give a certificate which only applies to one year's guarantee. Other people will sometimes give certificates for a longer period, but a great many of such documents are not worth the value of the paper on which they are written.

For the above reasons the writer much prefers strong cast iron-drains, especially for those portions that are laid inside of houses.

The pipes should be cast endways so as to get the iron of equal thickness on all sides. If cast in horizontal positions the cores will sometimes float in the molten metal and make the pipes very thin on the upper sides. The pipes should be of the same strength that is generally used for conveying water under pressure by water companies or in the construction of waterworks. Iron pipe of a lighter description is sometimes used for drains, but for really good work the heavy pipe should always be adopted. The iron should be protected from oxidation by a coating applied both internally and externally. When iron drains are laid horizontally the lower portion or invert, even when not coated to prevent rusting, does not rust to any great extent but the upper portion, especially in large drains which never, or very rarely, run full bore rusts to a very great extent and large flakes of iron oxide fall off inside the pipe. The lower half of the inside of the pipe gets covered with a kind of slime which protects the iron, but the upper half is exposed to watery vapour which condenses and causes a violent oxidation to set up, with the results above referred to. What is generally known as Dr. Angus Smith's process is considered the best method for protecting iron from rusting. This was referred to further back. It is very difficult to get iron pipes that are smooth inside, but this preparation, when properly applied, leaves a smooth [surface on the iron.

The jointing of the iron pipes requires a little consideration. Portland cement has been used,

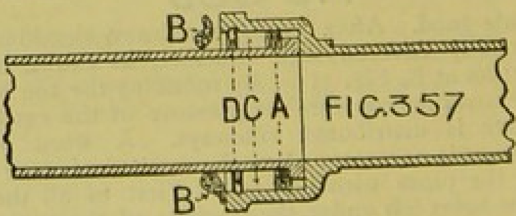


FIG. 357

and makes a very good joint. Joints on iron drains have been made with that material, and stood a great water pressure without the least signs of leaking. But I consider this cement to be too hard and rigid, so that the joints or pipes will break when the drains are moved by expansion or the opposite force. It is usual, and I know nothing better, to make the joints with metallic lead. Fig. 357 shows a section of a joint so made. The joint is first "yarned," that is, two or three rings of yarn are driven into the socket, as shown at A, to prevent the lead running through into the pipe. A roll of clay is then put round the pipe, as shown at B, B, an opening being left on the upper side for pouring in the lead. Molten lead is then poured through the opening until the space C is filled full. The outside faces of the lead are then driven in with caulking tools, in such a way that that metal is made to expand and fit tight to the outside of the entering pipe and the inside of the socket. Joints thus made will stand 300 ft. or 400 ft. head of water without leaking. As lead is a soft metal the joints on the iron-pipes are free to move a little without the risk of breaking, which would not be the case if a harder material had been used. Although lead is the best known metal for making these joints with, it cannot be accepted as being entirely satisfactory where large quantities of hot water pass through the drains. The movement of the pipes, by expansion and contraction, will sometimes work the lead right out of the socket, as shown at X, Fig. 358. The sockets have been

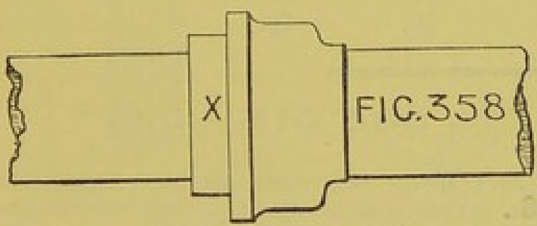


FIG. 358

cast with a groove inside, as shown in section at D, Fig. 357, but in spite of this groove the lead has still been worked out of the socket by the telescopic action which takes place at the joint, from the movement of the pipes by the above forces. In certain cases that have come under the writer's notice it has been found necessary to fix the iron drains on rollers in the trenches, and insert properly constructed expansion joints at intervals. A section of such a joint is shown by Fig. 359, in which E are

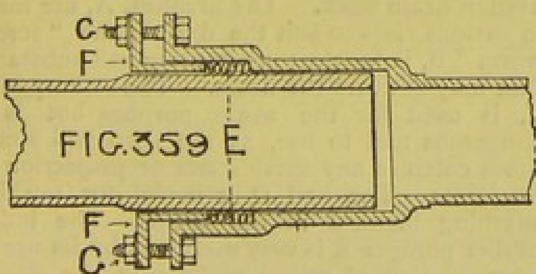


FIG. 359

asbestos rings, kept tight by the "gland" F, and the nuts and bolts G. The spigot end of the entering pipe is cast a little larger than the rest of the pipe, and turned quite true and smooth in a lathe, so as not to have any roughness which would prevent its moving or sliding backwards and forwards in the gland packing. It has been asserted that a serious objection to using lead for caulking joints on iron drain-pipes is because of the voltaic action that sets up between those metals. If the iron is properly coated the lead is not in actual contact with it, hence no action can take place from that cause. If a voltaic action did take place the corrosion of the metals would be so little that it would take several years before any great harm was done. My own experience has taught me that the objection is valueless.

When iron drains are laid underground they should have good foundations, but it is not necessary, but rather an objection, to cover them with concrete in the same manner as described when writing on stoneware drains.

All kinds of drains when laid in or near houses and other buildings should, as far as possible, have no actual contact with the walls or floors. When passing through walls, arches should always be turned over the drains. If the drains are built in the walls, and they should settle, or the ground in which the drains are laid was to subside, a fracture near that point is bound to occur. When drains are laid in places where heavy traffic passes over them it is sometimes an advantage to leave a hollow cavity over the drains to prevent their being injured by the vibration of the earth above them. Drains beneath basement floors in houses are often found to have the sleeper walls, which support the floors, built upon them, so that the least motion above is transmitted to the drains below to their disadvantage.

Lead Drains.

Whenever lead is laid in a damp situation, and in contact with lime, mortar, or cement, a corrosive action takes place, the lead is reduced to a carbonate, and in time will lose its metallic properties. Dry lime does not injuriously affect the lead to any great extent. Lead pipes may be built in walls, or enveloped in lime mortar, but so soon as the moisture has evaporated out of the mortar no further action takes place, although if in a damp situation, or exposed to a constant wetting from any cause, the corrosive action again sets up. For these reasons lead is rarely used for drain pipes, when laid beneath the ground. Where pipes can be fixed on the face of a wall lead is a very good material to use for their construction, so long as no corrosive agents are in their vicinity. A case came under the writer's notice some little time ago, at a country mansion, where lead drains were laid in trenches, the sides, bottom and top of which were lined with wooden boards, to prevent any contact between the lead and the surrounding earth. In spite of these precautions, the drains, which were 9 in. in diameter, and made out of lead about ¼ in. thick, were very much corroded, and had large holes on the upper sides, through which the hands could be passed. The sides and bottom of the pipe were also affected on the outside, but very little on the inside. The assumption is that the carbonic acid gas arising from the woodwork, which was rotten, had acted on the outside of the lead, and the same gas from the sewage had acted on the inside on the upper side only of the pipe, the lower portion or invert being protected by an incrustation of salts from sewage, which prevented the above gas acting on the lead. The same action has been noticed to have taken place on the lead of very old coffins when placed in underground vaults. With this knowledge before us we should be very careful when fixing lead drains, that they are in dry situations, and not exposed to those gases which have an injurious effect on the lead.

In each of the above cases, if the pipes or lead had been exposed to dry air currents, the action referred to would not have taken place. It may be of further interest to state that, so far as could be found out, the drains had been in use somewhere between 50 and 100 years. One of the coffins was probably 200 or 300 years old; the woodwork had rotted entirely away; the nails were of brass, and reduced to a green mass of verdigris, but in spite of these the wollen cloth with which the coffin was covered still kept its original shape and position, although at a touch it crumbled and fell away.

When lead pipes are used for drains, and fixed on to walls, they should not be less than ¼ in. thick, and be supported on a continuous bracket, instead of by tacks, or other fixings, with intervals of unsupported pipe between them. Compared with other metals used for drains, lead will last the longest, provided that reasonable care is taken with the fixings and ventilation. Wiped soldered joints should be made when lead pipes are used.

We have now dwelt on most of the leading points with regard to the drains themselves. A considerable amount of time could be devoted to a consideration of various pipes with specially constructed means for jointing; pipes made oval in cross section; pipes made in sections and with movable sockets; also with chairs or cradles for supporting the pipes, or for further strengthening the joints by surrounding them with cement as they lay in the cradles. Pipes have also been made with flat bases or feet to them. None of the above pipes are in common use so we need not dwell upon them. We will now proceed to deal with manholes.

MANHOLES.

MOST of our leading engineers state in their specifications that at all junctions of drains, or changes of direction, shall be built "Access Manholes." These manholes are a great convenience for access to the drains for the removal of any impediments or obstructions; for periodical inspection and testing or examination as to their condition. As the manholes are intended for use they should be so constructed that they can be used. This remark is necessary for the reason that a great many are built so small that a man cannot get into them for any purpose. Drains had better be without manholes than have useless ones. According to the depth of the drains below the surface the manholes should be large or small. If a drain is only about 1 ft. or 2 ft. deep the manhole should not be more than about 3 ft. long by 18 in. wide, unless there are several branch drains entering the sides, when it may be necessary to increase the sizes in proportion. It is not necessary for a man to get into such a manhole as he can do all that may be required from the surface. But if the drain is at any depth beyond 2 ft. the manhole should be increased in size, so that a man can get into it. Assuming that an obstruction in the main drain has to be removed by means of drain rods, the manhole, if deep down, must be long enough for the workman to couple up his rods. If they are 3 ft. long—some are much longer—with screwed joints or couplings, the manhole should be from 3 ft. 6 in. to 4 ft. long. The width need not exceed 2 ft. 6 in. unless the branches are at right angles to the main drain, when an additional width is sometimes necessary to allow room for using the drain rods. A drain has sometimes to be cleansed by means of rods, with a brush on the end. Fig. 360 shows a bundle of rods, with the various fittings, as used in drain work. The brushes, A, are made in various sizes to suit the drains; the "screw-worm" B, is for drawing out any soft substance that may get into the drain. The "harpoon" C, is used for the same purpose but is a dangerous tool to use, as the barb will sometimes catch in any small space or projection at the joints. The ball D is useful for pushing anything forward in the drains. The india-rubber plunger E is very useful, as by its use an accumulation of mixed matters in the drains can sometimes be removed. The plunger being pushed backwards and forwards when it acts almost similar to a force-pump plunger. Sometimes the drain rods are in 4 ft. lengths; but whatever length they are, they are useless if the manholes are not large enough for them to be used when required. When drains have to be tested by filling them with water, and the stopper, shown by Fig. 354, used for plugging the ends in the manholes, it is difficult to insert it properly if the manhole is too small. It is far from being a laughing matter to be lowered head foremost into a small but deep manhole for fixing the stopper, but there have been cases where this was the only way of getting over the difficulty without breaking up the pavement. So much for sizes of manholes, their construction next occupies our attention. First dealing with the walls and the materials for their construction. As bricks are to be had in nearly all parts of the country they are generally used,

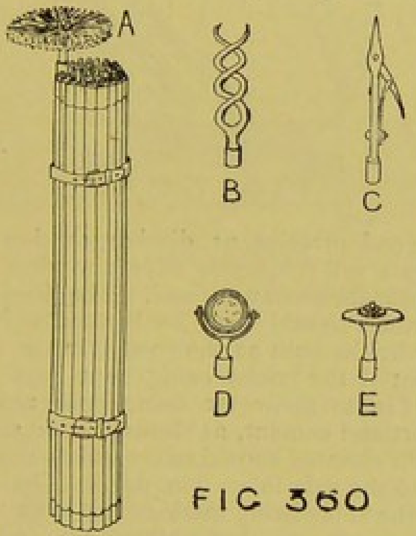


FIG 360

but it is not generally known, or at all events, very little thought is given to the matter that although some kinds of bricks are suitable for the purpose, a great many are far from being so. One test especially should always be applied to bricks, and that is, soak them in water; and if they are found to crack or pieces to flake off the surfaces, they should be at once condemned as being unsuitable for using in manhole construction. Neither are soft spongy bricks good to use. Those of a hard, close description, are much better, although it is not necessary that they should have smooth surfaces, for reasons that will be given further on,

"White glazed" bricks are frequently specified for manhole construction, and a great many engineers use them. At first sight one would think they were the best kind, but for various reasons I have giving up using them for some years past. One reason is that the enamelled surfaces will sometimes flake off in patches, and another is the difficulty of making water-tight manholes with them. The manholes should be as water-tight and air-tight as the drains. Not that the difficulty is with the bricks so much as with the men who lay them, and who are not careful to fill in all the joints or spaces between the bricks with cement. Some other kinds of bricks answer the purpose equally as well, but there is the same trouble with the laying of them. If the joints of the brick walls are to be simply pointed on completion, then it should be a fixed law for the men that they shall never cross-bond the wall. To make this clear, and to show the reasons for the above rule, the reader is referred to Fig. 361, which shows a plan of one course of brickwork as usually laid.

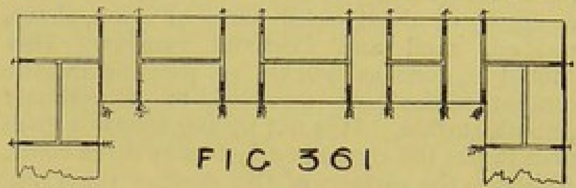


FIG 361

The bricks which extend through the thickness of the wall, are technically known as "headers." The joints at the sides of these bricks extend the same length as the bricks, and, as a rule, have no cement in them, excepting at the ends, as shown by dark parts. The least movement of a brick after the cement has partially set will crack the small portion at the ends of the joints, and no pointing up afterwards is of any use. If the manhole, on completion, is tested by filling it with water, defects will be found in a great many places as shown by the arrows. The proper way for laying the bricks is as shown by Fig. 362, in which it will be noticed that there are no cross-bonds or "headers" used,

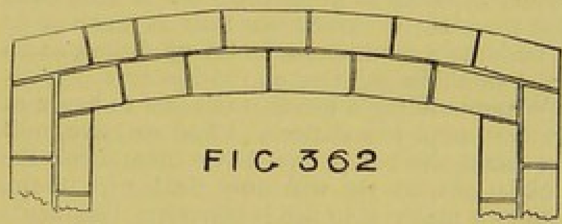


FIG 362

but all the bricks are laid as "stretchers." As the manhole walls are intended simply to keep the surrounding earth from falling into the drain or sewage leaking out, there is no great strain upon the walls, excepting when the manholes are of a large size and very deep. In those cases it is a good plan to build the walls so that the outsides may resemble the extrados of an arch, and so better resist the weight of the earth against them, as shown by the latter figure.

To return to the bricks. I consider there are none better for manholes than good, hard burnt 'stocks" that are partially vitrified. They should have a "frog," or depression, on one side only, and the frog should be laid uppermost. If the bricks are a trifle out of shape and have rough surfaces it does not matter, as the cement will "key" to them better than if they were true and smooth. The manhole should be built with the above bricks and Portland cement one part, mixed with four parts of clean, "sharp," coarse sand, as quickly as possible, the bricks being wetted before laying. The joints between the bricks should be well grouted or filled with the cement. The faces of the joints, outside the manhole, should be flat or "flush"; those inside should be raked out to a depth of half an inch. After the manhole has been built and sufficient time allowed for the cement-mortar to set, so that when the man is working inside he will not disturb the brickwork, he should then wet the internal faces of the manhole and "render" the brickwork with a coating of about equal parts of clean, sharp, washed, sand and Portland cement. This should be done as quickly as possible and the cement worked, or troweled, to a perfectly smooth surface. It is not by any means a good plan to put the cement on in two or three coats. Although the surface of the cement rendering should be left quite smooth (it can be made almost as smooth as glass), it does not necessarily follow that the workman should keep on working it long after the cement has set and thus "kill" it. The reason for pointing the joints outside the manhole is to prevent any water in the ground getting into the walls, or passing through them, and forcing off the cement rendering inside before it has properly set. There may be no water in the ground, but it frequently occurs that a shower of rain may cause the same trouble by getting into the trenches or excavations dug out for the manholes. As the manholes should be both air-tight and water-tight, as pre-stated, every pains should be taken to make them so. I may add that there are workmen who take as much pride in building a manhole, or in laying drains, as an artist would in painting a grand picture.

When building a house it is usual to begin at the bottom or foundations. I find we have built our manhole before we have mentioned the foundations, so we will now deal with them. The best material to use is concrete. Engineers

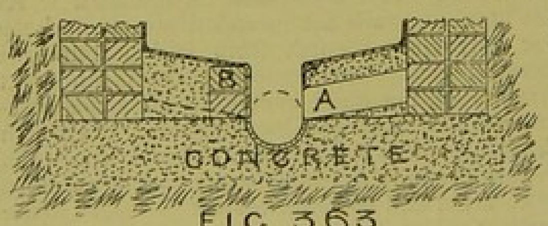


FIG 363

generally specify the depth, or thickness, of the concrete shall be 6in., but in all cases this should be governed by circumstances. Sometimes 4in. is quite enough but in others 12 in. is necessary, especially in some kinds of soft, or boggy, ground. As the drains have to pass through the manholes in channel, or U shaped pipes, those for the main drain should be fixed at the same time that the concrete is laid for the foundations, and the sides banked up as shown by the section, Fig. 363. These channel pipes are very difficult to get quite straight and true longitudinally, so that it is always advisable to give them from ½ in. to 1 in. more fall in their length than the drains themselves, otherwise a pool of sewage will be found to lay in a hollow near the centre, or near the inlet end. These hollows vary in position and depend upon the way that the channels warp when in the clay state or when being burnt in the kilns. If there are any side inlets to be fixed they should be laid on the concrete so as to drip over the main channel, as shown at A in the figure. In some cases the branches are connected near the bottom or invert of the main channel, but this

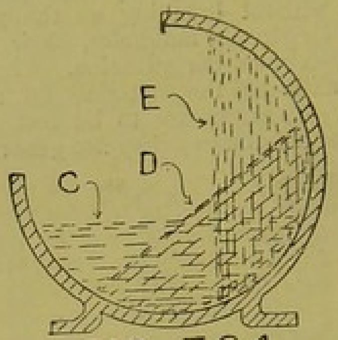


FIG 364

is not good practice, as discharges down the main drain will frequently eddy and flow back up the branches when so fixed. The sides of all the channels should then be banked with concrete or bricks built as shown at B in the figure. The front of the bricks being kept back about ½ in. to ¾ in. to allow for being rendered over with Portland cement, as shown in the section. The main channel should never be less than 9in. deep and the side inlets 6 in. deep. The bankings at the sides being made to fall towards the main channels, so that nothing will lodge on them, but not too much, as that makes them difficult for the workman to stand upon when doing anything to the drains. Great numbers of manholes are found to have the bankings made close onto the channel, as shown by dotted lines. When so constructed they are generally found to have excreta laying on the sides. The manholes then smell very offensive and are nearly as bad as cesspools. Every precaution should be taken to prevent the sewage leaving the channels. A temporary stoppage of the drains will flood the manholes and make them dirty, no matter how deep the channels are made, but with fair or ordinary usage the above depths answer their purpose. If it were not for the many difficulties in the way, and the extra cost it would entail, the channels should be made of the same materials as the drain pipes and to the depths given above. Perhaps some day it will be so, but at the present time we can only deal with the materials placed by manufacturers at our disposal.

We can build manholes, take every pains with them, and place channels for the water to run through, but we can never make the water, even when the velocity is very low, keep in the bottom of the channel when turning a bend. When water is running down a straight channel the surface is as shown by the dotted line C,

Fig. 364, but when running through a bend it will be as shown by the dotted line D.

In some cases, where the velocity is high and the bend sharp, the line E will represent the surface of the water. Channel bends should

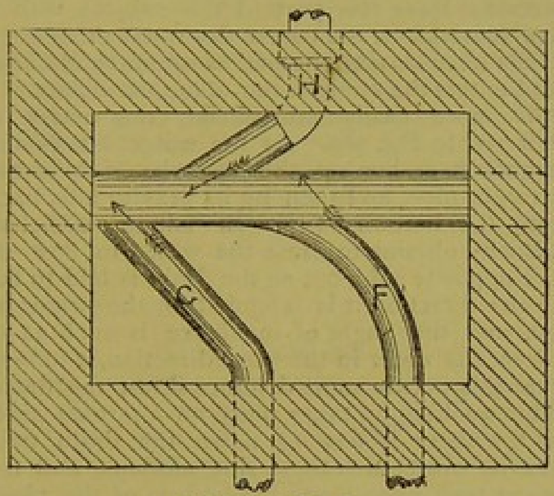


FIG 365

always have the outer side curved, as shown in the section, to prevent the water washing over. This was noticed by the writer several years ago, and in 1884, when writing a series of articles for *The Sanitary Engineer*, New York, he mentioned this fact. Since then, channel bends have been made, by various makers, on the suggestions then made, and are a great improvement on the earlier method of using half-pipe bends, and building up the outer curve with cement. There is still room for improvement in these bends. Although the outer curve will keep water or sewage from splashing over the side, it does not direct the stream in a proper direction down the main channel. Fig. 365, which represents a plan of the bottom of an imaginary manhole, will help to make this more clearly understood. Assuming that a branch drain enters a manhole at right angles to the main channel, an ordinary bend, as shown at F, would direct the current against the opposite side of the main channel, as shown by the arrow. If the bend was made as shown at G, the water would strike against the outside, and then be directed down the straight portion against the opposite side of the main channel at such an angle as to be deflected in the proper direction. If the manhole is made with the inlets on one side only, as at F and G, the main channel can be kept nearer to one side than the other, and so allow for the bends being made as shown by that at G.. But if the inlets were on opposite sides, the manhole would have to be made wider to allow for similar bends being used on each side. An alternative would be to fix a bent pipe in the drain, outside the manhole, and a straight channel used inside, as shown at H in the figure. There is no great objection to this, provided the bend is so near the manhole that a man's arm can reach it to remove any obstruction. I know there are engineers who would call this rank heresy, and protest that all drains outside the manhole should be so straight that they could be seen through from end to end. This is all very well, so far as it goes, but I claim that our first care should be to keep the drains and manholes clean. If the drains can be made as straight as gun barrels they should be so laid, but not at the cost of a dirty manhole.

There are so many details in connection with the side drains into a manhole that I cannot do better than illustrate one constructed a few years ago in a building near the Tower of London, and in which most of the points that come under consideration are shown. Fig. 366

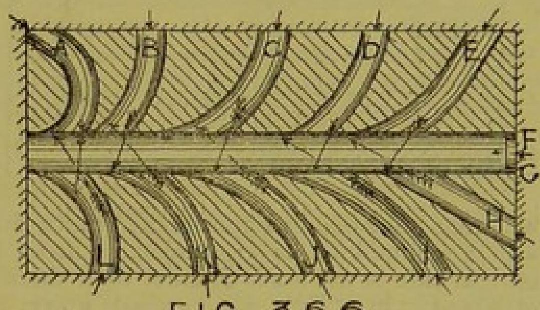


FIG 366

is a plan of this manhole, drawn from memory. The manhole was about 10 ft. deep by 6 ft. long by 3 ft. wide. The drain A was from an interceptor trap which received the waste-pipe from a sink in a chemical laboratory, and a rain-water-pipe. B was from a similar interceptor which received water from a sink and a rain-water-pipe. C was from a large range of urinals. D from an interceptor in connection with a range of washhand basins. E was from a soil-pipe, to which was connected about six W.C.'s on various floors. F was from a range of W.C.'s on the ground floor, and is over G, which was connected to a similar set of W.C.'s. H was from an upstairs W.C. soil-pipe. I was from a trap into which a range of wash-basins emptied. J was from a soil-pipe, and similar to E. K received waste water from the sinks in a large scullery on the third floor, and L was from an interceptor receiving three rain-water-pipes and a sink. The main channel was 6 in. wide, and the branches were 4 in. The drains F and G had a very steep rise from the manhole to the W.C.'s. The whole was very carefully planned and carried out, but, in spite of all the pains taken, it was discovered that discharges down E rushed across the main channel and struck against H, as shown by the arrow. In a similar manner L was affected by what came down A. The other arrows shown in the figure denote the direction taken by the discharges down the other branch drains, and are submitted as a problem for the student's consideration.

Fig. 367, is a plan of an old manhole found in a London house, which is drawn to further show the necessity of properly arranging side inlets to manholes. The main channel was 6 in. across and the side inlet 4 in. The branch was from a W.C. about 20 ft. distant, and this drain had about 1 ft. fall in its length. The W.C. was fairly well flushed by means of a 2 gal. siphon-action cistern, through a pipe $1\frac{1}{4}$ in. in diameter. Such was the velocity of discharge from the

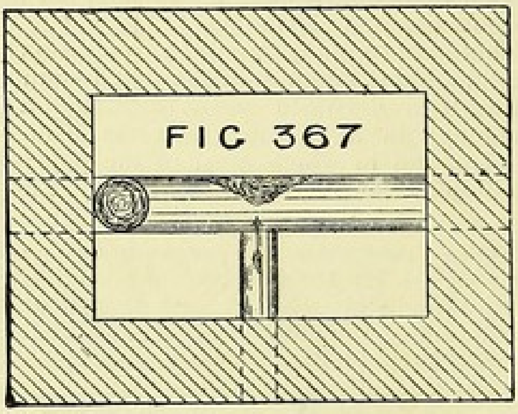


FIG 367

W.C. that immediately opposite the branch drain was a pyramid of paper, projecting from the upright side of the main channel to a distance of about 3 in. This was pushed away and experiments tried, when it was found that every time the W.C. was flushed and pieces of soft or bibulous paper used, the paper was almost invariably thrown against the side of the main channel, where it accumulated until it fell down from sheer weight.

Another illustration is shown by Fig. 368. M is a soil-pipe from a valve W.C. on the second floor of a house. In this case the discharges came down with such violence that they rebounded from the bottom of the channel, and paper and fæces was found to be sticking to the manhole walls, as denoted by the

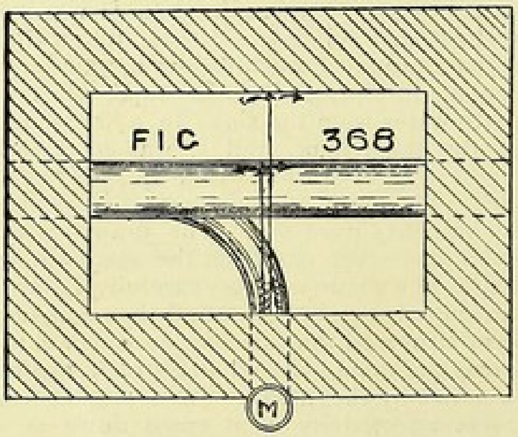


FIG 368

arrows. The manhole was found to be so very dirty that it was deemed advisable to do away with the open side channel and fix ordinary pipe bends instead.

Several other problems could be submitted dealing with bent main channels instead of straight ones; the proper manner of connecting them, and other details that sometimes occur in practice. But from what has been said the student will not have much trouble in properly arranging anything of the kind that may turn up in his own line of business. This being so, we may leave this part of the subject with a few remarks on the course the water or sewage takes after leaving the end of a branch channel and enters the straight run of drains. To make this more easily understood, the reader is referred to Fig. 369. As the water leaves the branch it rushes up the opposite side of the straight pipe, and then by its gravity falls back into the bottom of it. In falling, sufficient velocity obtains to cause the water to flow up the opposite side, but as the drain is laid to fall in the direction it is intended for the water to go, and the angle of incidence is such as to direct the water in the same direction, it follows that this occurs some distance down the drain. This washing up takes place on alternate sides as the water is flowing down the drain until gravity overcomes these side motions, and the water then flows along the bottom of the pipes until another change of direction in the drains takes place, when the above is repeated. In the figure the wavy lines show the course of the water. If a small piece of anything that would float in water was placed at N or O, it

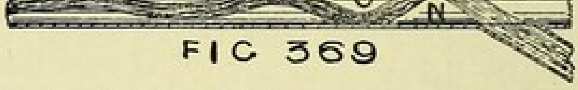


FIG 369

would often be found to remain there until water came down the straight pipe to wash it away, or a very small dribble should come down from the branch at a very low velocity so as to run into the bottom of the straight drain. As an experiment, the students could whitewash the inverts of a manhole channels and note the parts that are washed clean by the water flowing through them.

When iron drains are used the channels in the manholes should be made of the same material. With plain straight channels there is no difficulty in this matter; but when two or three branch drains are connected to the manhole, it is necessary to have special made castings to suit the work to be done. Unfortunately, it happens that there are very few manholes that are similar, every one being in some detail different to any other. A few stock patterns of cast-iron channels could be kept for use, but the very high cost of patterns for special made ones is a serious bar to their being so generally used as they should be. I think the Americans are ahead of us in this matter. One of their leading firms had some specimens of cast-iron channels and manhole floors on show at one of our English Exhibitions in 1881. Although we have two or three English engineers who know the value of such fittings, it is only on rare occasions that they are used.

Another point not generally considered by sanitary engineers or plumbers is the advantage of keeping the sewage in the channels by forcible means, or preventing any bad odours that may be generated in the drains from accumulating in the manholes. One way of doing this is to make covers to fit the channels and bolt them on so as to be both air-tight and water-tight.

A very good channel connection of this kind, which is patented, is shown by Fig. 370. The cover plate is fastened on by means of a hinged

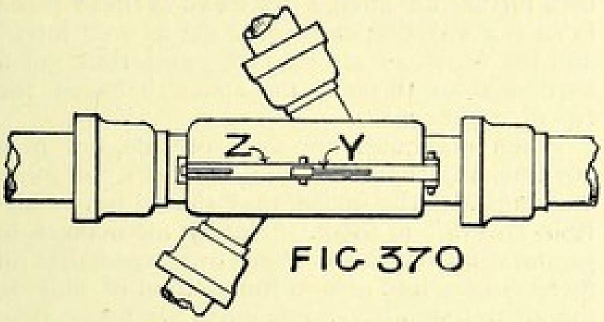


FIG 370

bar Z, and a lever, with a cam arrangement, at Y. On pressing down the lever the cover plate is forced down onto its seating on the edges of the channel. The writer has tested these fittings to drains by means of smoke, and also by hydraulic pressure, and has found them to be perfectly sound. The cover keeps the sewage in the channels, and also prevents any drain air accumulating in the manholes. The only disadvantage they have is, rods cannot be so easily passed up the branch drains as when the ends are open and as shown in Figs. 365 to 369.

Fig. 371 is copied from a drawing of the cast-iron channels designed for a manhole in an

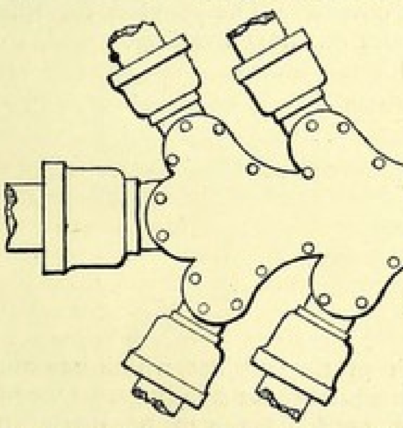


FIG 371

Earl's mansion in London. The side channels, on removing the cover plate, are opened, and it is easy to pass any rods through them. The sketch speaks for itself. The bolts were gun-metal, as iron ones would have rusted in, and after a time become difficult to remove. When such channels are used, it is not absolutely necessary to have air-tight covers to the manholes, but it is advisable to have them. I think it necessary to add that the channels, as above arranged, were for manholes that, of necessity, had to be made inside the house. When the manholes are outside, it is unnecessary to take such extraordinary pains in their construction; and any accumulation of sewage gases in the manhole can be prevented or got rid of by ventilation. This will be referred to further on.

It should be a standing rule, that whenever possible to do without them, manholes should never be made inside the house. Necessity sometimes compels their use inside, but in some cases the same objects can be gained by other means than the one above referred to, and shown by Fig. 371. As an example, we will assume that Fig. 372 is a plan of a piece of drainage where four pipes are connected to the main drain. All the pieces shown in the figure are ordinary stock patterns as kept by some manufacturers. All the "sight-holes" shown at A, A, can be removed, and rods used to push away any obstruction that might get fixed near those points. If these pipes occupied so much space that the access chamber would be considered too large, it would only be necessary to build smaller ones to each cover-plate. In cases where the branches were of a considerable length, the "sight-holes" should be near the highest ends. In a great number of instances the highest ends of the drains are so close to the surface that ordinary paving stones, with a ring attached for lifting, placed over the "sight-holes," would be much better than manholes as the workman could do all that was necessary from the surface of the ground. Let it be clearly understood that, with iron-drains, some means of access must always be provided, as a hole for removing any obstruction cannot be

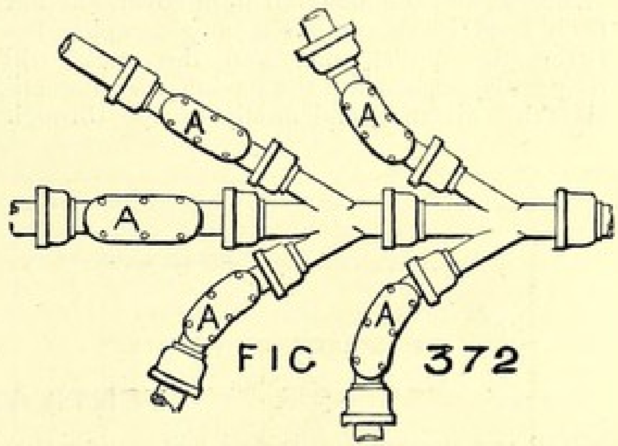


FIG 372

made in iron so easily as stoneware. This may be looked upon as an advantage in favour of iron-drains, as they cannot be mutilated in the same manner as the other kind by those pests of society, the "handy-man."

Where convenient, a ventilating-pipe or air drain should be continued from the space surrounding the sight-holes to the open air.

With manholes, built in the ordinary way with earthenware channels, inside the house it is always advisable to make doubly sure against any escape of drain air by fixing two air-tight covers, one over the channels and one over the manhole at ground level. A simple method is shown by Fig. 373, which is a section of a manhole. In the sketch, B is an ordinary galvanised cast-iron air-tight cover, embedded in

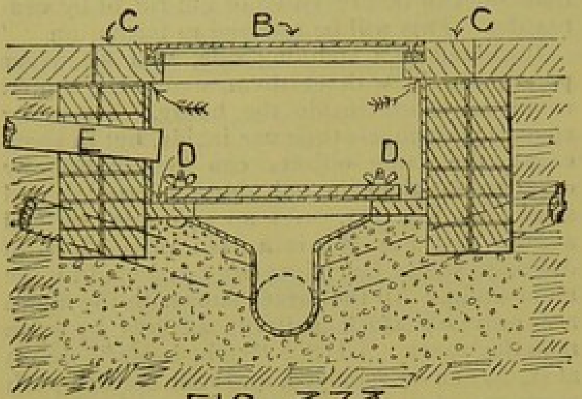


FIG 373

a large piece of York stone C, which lays on the walls of the manhole from 4 in. to 6 in. all round. D is a piece of 1½ in. slate slab of the same size as the inside of the manhole, and cemented down air-tight. The centre of this piece of slate is cut out and another piece larger than the hole, but small enough to pass through the upper cover, is bolted down with a washer between it and the fixed piece so as to make it air-tight.

When bedding the stone, C, great care should always be taken to ensure its being air-tight. The man should get inside the manhole and point with cement those parts to which the arrows direct. When testing drains by means of smoke, and the lower air-tight cover has not been fixed in the manhole, any escaping between the York stone and the walls will frequently get beneath the paving, travel a considerable distance, and finally escape through the joints of the flooring at some distant place. A case of this occurring comes to memory where, when testing the drains at a large public school, the smoke escaped as above described and passed into one of the scholars' private studies, the scholar at the time being laid up with scarlet fever.

When a manhole is constructed as Fig. 373, an air or ventilating-pipe should be fixed as shown at E, so that if by any means sewage gases should escape through the lower cover they could pass away to the open air. It would be a further advantage to fix two of these pipes in such a way that one would act as an "inlet" and the other as an "outlet," and thus get a current of air through the space between the two air-tight covers.

When manholes are fixed outside, but in a position adjacent to doors, windows, or other openings into the house, they should have "air-tight covers" to them. Nearly all makers of sanitary fittings have their own speciality in these covers, and also in the method of making the air-tight joints. Some kinds are better than others, but nearly all the writer has seen labour under the disadvantage of not being perfect after they have been disturbed or opened, unless the packing or lutings, as the case may be, has been properly attended to. Over and over again it has been found that a cover has been removed for some purpose or other, and simply replaced, without due attention having been given to the jointing; with the result that it has been found defective when a smoke test has been applied to the drain.

In some instances the manholes can be, and are, constructed some distance from the house. If in unobjectionable positions, large wrought iron gratings should always be fixed, instead of the air-tight covers. The reasons for this will be given under our next heading.

VENTILATION OF DRAINS.

FOR our present purpose we will assume that the drains are properly trapped and disconnected from the sewer, cesspool, or other outfall.

We have already given one reason, when speaking of sizes of drains and the duty they have to perform, for taking means to prevent their being "air bound," especially during a heavy rainfall, so we need not dwell upon that branch of the subject. Neither need we deal with siphonage of drain traps, as the arguments used on soil-pipes and their traps will also apply to this. What we have principally to consider is the arrangements for ventilation, and any branch of the subject which has not been referred to under other headings. One of these is, "How ventilation can be made to prevent decomposition of any matters that may be in the drains?" The popular idea is that ventilation is intended to get rid of sewage gases out of the drains instead of how to prevent their generation, and which should be the primary consideration. We all know that a piece of animal matter can be kept in an air-tight vessel, and from which as much air as possible has been extracted, for an indefinite period of time without its decomposing. But if a small quantity of air can gain access into the vessel the contents will slowly putrefy, and in so doing will give off the same gases that we get from sewage when decomposing. Now, if the same animal matter had been exposed to a brisk current of dry air, the moisture would have evaporated out of it and decomposition would have been arrested. These are natural laws, and we should make use of them as our guides when arranging for the ventilation of drains.

The first thought should be to flush all offensive matters through the drains, but this we cannot deal with now without getting our subject mixed, so we will confine ourselves to their ventilation. In some cases, it is not at all objectionable to have all manholes, even when quite close to the house, with open gratings over them, and, in long lengths of drainage, the more openings and gratings the better for their ventilation. We all know that a short chimney to a fireplace does not draw so well as one which is much higher. If we approach our subject from this point of view, we should come to the conclusion that stacks of "upcast" ventilation-pipes would cause a brisker air current to pass through the drains than would occur with plain open gratings at the ground level. Where expense and opportunity do not stand in our way this is the better plan.

Before dealing with the sizes and arrangement of the drain vents we will assume, 1st, that the drains are so well laid that all matters can pass freely through them, and that there are no parts in which sewage can accumulate; 2nd, that the drains are well flushed, and that sufficient clean water passes through to float all W.C. and such like matters away; 3rd, that all traps under fittings, and all gully traps are so small that their contents are changed each time they are used; and 4th, that all the sanitary

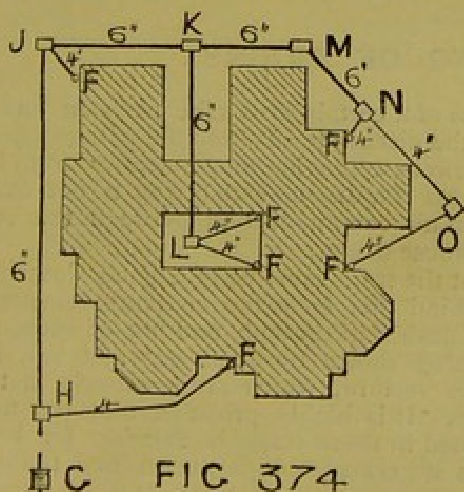


FIG 374

fittings are in constant use at such frequent intervals of time that the contents of the traps beneath them had not time to become offensive.

If these assumptions could be obtained we should then only require to thoroughly dry the insides of the drains so far as they had been wetted by the discharges sent through them. It may be thought that the above assumptions are placed on too high a standard, but there is no reason why things should not be as stated. The only bar, perhaps, is what is thrown down the scullery sink, but by a proper arrangement even this evil could be modified.

The sizes of the vents should always exceed in sectional area that of the drains. To help us in this matter we will refer to the block plan of a house, Fig. 374, which shows the soil drains and manholes only. There are other branch drains from sinks, baths, &c., but they are not shown as they are not necessary for our purpose. At F, F, are 4 in. lead soil-pipes continued to the roofs for ventilation. In our problem we have six 4 in. pipes acting as drain ventilators on a 6 in. drain. If the manhole over the main trap has a large grating, equal in area to the size of the manhole, only as much air will pass through as would be equal to that passing through a 6 in. pipe. If all the soil-pipes were trapped at the bottom ends, and each had a separate provision for ventilation it would be necessary to fix independent ventilation-pipes for the drains, and these pipes should be large enough, and so placed, as to ensure a brisk current of air through the drains to thoroughly dry them inside. In our problem we have assumed that the soil-pipes are acting as drain vents, so we will now proceed to work it out on those lines. The manhole G has a large grating over it, but all the others have air-tight covers. A column of air 6 in. in diameter passes from G to manhole H, but at this point we have a 6 in. and a 4 in. drain to supply with air. We have enough for the 6 in. from the first manhole but must provide another inlet at this point to supply the 4 in. drain. So that the drain beyond the manhole J may have its requirements satisfied, it will be necessary to admit sufficient air into that manhole to supply the soil-pipe which is connected with it. At the manhole K, there are two 6 in. drains connected together. One of these is supplied with air from J, but an air opening equal in area to a 6 in. pipe must be provided to supply the other one. The manhole L receives two 4 in. drains which are connected to two 4 in. soil-pipes. The proportion of the 6 in. drain to the two 4 in. pipes is as 36 is to 32, so this part of the system does not call for any special treatment with regard to fresh air supply. The drain from manhole K, through M, N, and O, has two 4 in. upcasts, and these are nearly equal in area to the 6 in. drain, so neither does this section of drainage require any additional fresh air inlets. To ensure that the ventilation of the soil-pipes and drains shall be equally distributed, and so that one section shall not rob another of its air it becomes a necessity to feed the various points as above described. By carefully arranging the fresh air inlets and the top ends of the ventilation or soil-pipes a brisk air current can be kept passing through the drains which would have a tendency to dry them or anything that may lie in them; always

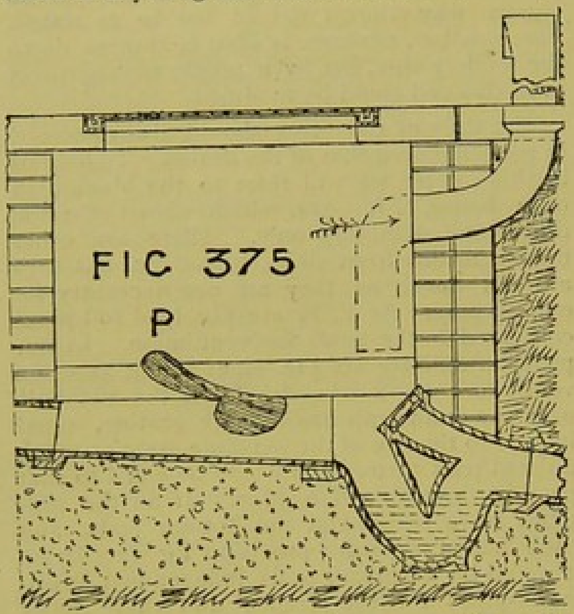


FIG 375

provided that everything is arranged on the assumptions above described. Perfection on this matter may not be obtained, but every effort should always be made to attain the highest point of excellence. It is an open question if it would not be better to have no drain ventilation at all than have some of the arrangements that are frequently met with.

The air inlets, when arranged as above described, should be connected to the manholes in such a way that the air in them is in constant motion. The manholes should be ventilated as well as the drains.

In what has been said on drain ventilation we have assumed that the manholes were so situated that open gratings could be used for the admission of fresh air. In some instances it may be found necessary to prevent any reversals of the air currents. In these cases it is sometimes advisabe to use one of the valves illustrated by Figs. 341 and 342. When one of these valves is used attention should be paid to the way it is connected to the manhole.

In practice it has been found that steam from any hot water in the drains has passed into the inlet-pipe and pressed the mica valve so close onto its seating, that all ventilation has been arrested until the steam had condensed. Fig. 375 represents such a case. The branch drain, P, was from a scullery sink only a few feet away, and the steam from the hot water passed into the air inlet, as shown by the arrow, and pressed the valve back onto its seating. To prevent this it may sometimes be necessary to connect the air drain near to the bottom of the manhole, as shown by dotted lines. Fig. 375 will be referred to again under our next heading of Disconnection of Drains.

DISCONNECTION AND TRAPPING OF DRAINS.

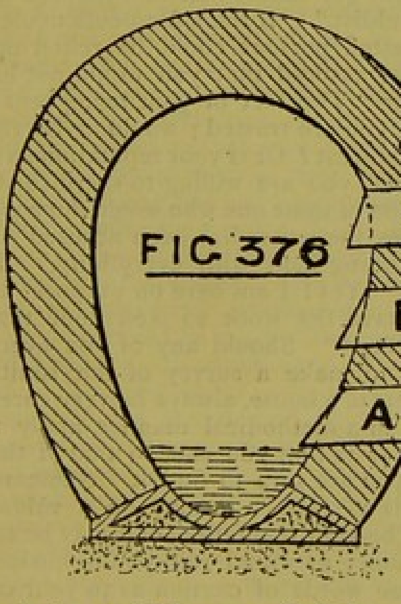
OUR last figure shows a "disconnecting trap" and manhole. This arrangement should always be fixed at or near the discharging end of the main drain, from a house or building, for the following reasons. When the drain discharges into a cesspool, the contents of the cesspool are continually being stirred up by what passes into it, thus setting free the gases which arise from the decomposition of the sewage. As the cesspool is generally, or should be, situated some distance from the house, it would be very unwise to allow any air in the cesspool to pass through the drain and up to the house where any defective fittings would allow the air to escape and poison the inmates.

If a cesspool is not used, but the sewage is discharged onto the land, it is still advisable to have a disconnecting trap fixed near the outlet end. When the drain is connected to a sewer, which is common to several houses, or streets of houses, the probability is that should any illness of a certain kind take place in one part and the disease germs from the patient pass into the sewers, contagion may be spread from house to house if a disconnecting trap is not fixed to cut off air communication between the sewers and house drains.

But the traps must be of a good description, of a kind that have the contents removed by each flush sent through, and not of such a size as those shown by Figs. 220 and 221, in an earlier lecture, which are cesspools in themselves. It is highly probable that the matter retained in these traps is suitable for certain kinds of germs to propagate in, and thus form a breeding centre for disease. It is not necessary to dwell on the sizes and shapes of disconnecting traps, as an earlier lecture was devoted to that branch of the subject. Neither need we re-open the question of mechanical traps or those for preventing a back flow of sewage into the house drains.

CONNECTION OF DRAINS WITH SEWERS.

IT is beyond our province to deal with public sewers, yet it is necessary to consider a few points in connection with our heading. Firstly, all drains should be arranged so that the matter passing out of them would fall into the "invert," or bottom of the sewer, and not run down the walls so as to foul them. Neither should the ends of the drains project so far into the sewer as to form obstructions to the free flow of sewage during an extraordinary flush after, or during a heavy rainfall or other cause; in which case, the ends of the pipes would sometimes be covered with water and solids would cling to the projections. Secondly, the position of the connection of the drain to the sewer. Fig. 376, is a section of an ordinary-shaped sewer, and for our present purpose we will assume that water is running through it at the depth shown in the figure. So long as this depth of water is not exceeded, discharges from the drain marked A, would flow freely away. But, if the level of the water was to rise so as to cover the end of this



drain it would become "air-bound" between this point and the disconnecting trap. The writer has found the air, pent up as explained, to become so compressed as to blow out the stoppers placed in the cleaning holes shown at C, in Figs. 233 and 234, and other traps of similar construction. The removal of these stoppers, by any means, renders the disconnecting traps perfectly useless, as air from the sewers can then pass freely into the house drains through the openings left.

If the drain had been connected as shown at B the water would have had to rise considerably higher before the above could have occurred and the sewer would have had to be nearly three parts filled before the drain fixed as shown at C was similarly affected. But in this latter case another evil would sometimes occur. As a rule, sewers are very rarely properly ventilated, so that should they become nearly or wholly filled with water, the air in them would be forced out, and, so long as the branch drains had open ends in the sewer, this air would be pushed through the branches and disconnecting traps. It may be said that this is not of much importance, as the escaping air would pass up the house drain ventilation pipes to where it could do no harm; the water would afterwards fall back into the trap, and everything be reduced to its original condition. But this is not an end of the matter. If the gorging of the sewers was caused by a sudden rain storm, and all waters had dribbled off roofs and pavements after the storm, and before the sewers had run themselves down to their ordinary level, the air necessary for filling the void left by the subsiding waters would have had to pass through the disconnecting trap to gain access to the sewer. In doing this the passing air would have pushed the water out of the trap into the sewer, and there would have been no means for re-charging it with water. In the case of an empty house it is possible for the trap to be some considerable length of time partially unsealed if affected in this matter. Even when a house is occupied, the trap could be rendered useless for a time, if the above events were to take place during those hours that the sanitary fittings were not being used. With these varying aspects of our problem before us it is really difficult to decide which is the best position for connecting the house drains to the sewers, although one feels disposed to think that the one shown at C would be the best, provided the sewers were properly ventilated. As a matter of fact engineers do not have much choice in this matter, as most local authorities have certain rules which they insist upon being carried out.

There are certain "flaps" and "valves" which are sometimes used for preventing the air in the sewers being forced into the house drains. Some of these are very good under certain conditions, but others are very untrustworthy and cannot be depended upon to answer their intended purpose. These fittings were described some time ago, and are illustrated by Figs. 239, 240, 241, 242, and 243.

Our third point is the importance of having the connection of drain with sewer made perfectly sound and water tight. Cases have been known where sewage has passed through such defective joining, then by the sides of the drain pipes, and flooded the lower parts of houses. Also of cases where the drains between the disconnecting traps and sewers have been so badly jointed that every time an extra rainfall came so as to flood the sewers and fill these branch drains, the earth beneath basement floors was saturated with the sewage that escaped out of the joints of this part of the drainage. Quite recently the writer superintended some works where the drains had to be relaid because of this evil, although flap valves were fixed on the sewer end of the drains.

METHODS OF TESTING DRAINS.

THIS is an important branch of our subject, and it is necessary to enter fully into its various details. No one of limited experience can really appreciate how essential it is that all drains shall be thoroughly tested. Very few know how to apply the tests, and most people are in total ignorance of the responsibility they assume when they undertake anything of the kind. To begin with the responsibilities; how often does illness occur through undiscovered defects in drains, and who has to take the consequences of this? Any one who has not been thorough in any examination or testing that he has done is liable to be sued in a court of justice for damages for any illness that may arise, and which could be traced to the drains. A sixpenny smoke rocket, or sixpennyworth of essence of peppermint, is not by any means a test of the soundness of any drain, and yet how many people have issued a certificate as to the healthy condition of a house on no better evidence than what has been given by those tests. Next, the moral responsibility. No one should undertake any work of the above description until he has been thoroughly trained, and had some practical experience, any more than a doctor of medicine, or a surgeon, can practise in either of those professions until he has passed certain examinations, both theoretical and practical. People who lack the necessary knowledge frequently make fearful blunders, and, although they may in some cases escape the law and its penalties, it must be admitted that they are morally responsible for any evils that may result from their ignorance in the details of what they undertake to do.

But there is another side to this question. A man may be so earnest in his undertakings that he may prove too much. Or, he may be so careless, when testing the drains of a house, that he will get false results and condemn works that are free from defects. To do this would be to libel the house and, perhaps, be the cause of a purchaser or tenant being lost. In this case, too, there is always a liablility of the law being appealed to, to adjust any pecuniary loss that the owner may have suffered, through an incorrect statement having been made with regard to the drains or sanitary arrangements of a house or dwelling.

Hemmed in as sanitary plumbers or engineers are by the above considerations, it becomes a necessity, when making a sanitary survey, to always give a plain, unvarnished description of what is found. Never hide a defect, no matter how trivial, nor make any additions so as to exaggerate the facts as they actually exist. Further than that, never listen to the statements made by interested persons. Make your own examinations, apply your own tests and draw your own conclusions. In a great number of cases you will get abused if you do this. Sometimes you will get sneered at and taunted with being a "faddist." If the statements made by these interested persons could be relied upon you may rest assured that you would not have been sent for. The fact of your being sent for implies that you are trusted; would it be right to betray that trust? Or is your reputation so unimportant that you are willing to sacrifice it at the instigation of some one who would dupe you? Several times the writer has been accused with "You are finding fault with everything." The reply being, "Yes! I am here on purpose; it is for you to have the work so well done that I cannot find fault." Should any of you ever be called upon to make a survey of the sanitary arrangements of a house, always be very careful. Go about it in a methodical manner, apply the most severe tests that you can, so that if there is a defect you are sure to find it. Remember what there is at stake. It may be a valuable life, it may be your reputation, or it may be such a sum of money as would ruin you in business.

After these words of caution as to your conduct we will now proceed to describe the different ways of testing drains. First dealing with their construction and then with their soundness. When drains are laid perfectly straight, and have access manholes at the bends and junctions, they can be looked through to examine if they are free from obstruction. If the channels in the manholes are so deep, or so narrow, or if the manholes are so small, that a man cannot get his head down so as to be able to look through the drains, he can use a small hand mirror and by holding it in a suitable position can see a considerable distance into the drain. A light at the other end of the drain, or a second hand-mirror held to reflect the sun's rays, if the day is suitable, will help to expose any irregularity or partial stoppage in the drains.

If it is not convenient to examine the drain by the above means, and if there is no manhole at, or near, the lower end, it is then necessary to expose the drain at that part, and break an opening into it so that the inside can be seen. Or, better still, take away a length of the pipe and dig a hole so that a pail could be placed to catch anything that came out of the drain. A pailful of water, emptied through a gully trap, W.C., or other fitting, near the highest end of the drain, would pass through and fill the pail placed beneath the lowest end, provided there was nothing to obstruct the flow of water and the drain was not so very defective as to allow the water to escape out of it. Drains are sometimes found to be so defective that no water at all has reached the lower pail until a considerable quantity has been discharged into the drains at the highest end. Another test for freedom from obstructions is to throw a few apples or potatoes into the highest end of the drains and then notice how many pailsful of water are necessary to float them to the outlet end. It is interesting to sometimes cut notches or otherwise mark the potatoes or apples, so as to be able to recognise them, and throw them into the drains one at a time with about as much water as is used by any ordinary W.C. discharge, and note if they come out in the same order they were put in. This test sometimes gives very strange results. The vegetables used should not be too round so that they would roll down the drains. Another test which sometimes gives strange results is to put a piece of paper in a W.C., and pull the handle so that the paper is floated into the drains. This to be done several times in succession. Different coloured pieces of paper should be used. The results will be found to vary very much, especially if the drains are not in good order or have many bends in them. If the length and fall of a drain is known and a stop-watch is used to take the time that a known quantity of water takes to pass through, and the proper time is exceeded there is always reason to suspect the presence of some obstacle in the drain. If a pailful of clean water is sent into a drain at its highest end and fouled water is found to pass out at the bottom end, this is positive proof that the drains are either improperly laid with bagged parts, or have obstructions, or else they are not properly flushed. Cases have come under the writer's notice where several bucketsful of water were thrown into the drains before clean water was seen to pass through the outlet end.

One of the commonest, and at the same time most misleading tests for soundness of drains, is known as the "peppermint test." Other essences, such as cloves, &c., are sometimes used in the same way as the mint. In unskilled hands this kind of test is very misleading. Some people will pour the essence into the drain through a gulley-trap, down a soil-pipe, or into a W.C., and in doing so will fill the surrounding air with the odour. Others will empty a small phial of the essence into a can of boiling water and then empty the mixture into any opening they can find in connection with the drains. In addition to the steam escaping from the mixture in the can being wafted by the wind into all sorts of places, the can itself is sometimes carried about, and, of course, the test is at once rendered worthless by this proceeding. In the first place the test should never be applied in, or near, any place where there is reasonable cause to suspect there is a defect, but at some distance away from it. In the next place the hot water and essence should be mixed inside the drain or soil-pipe, and not outside. If the test is being applied through a soil-pipe, a bundle of old rags, a worthless sponge suspended on a piece of string, or a piece of paper shaped into a cone, like a sugar paper, should be placed a few inches inside the top end of the soil-pipe and a small phial of the essence then poured down. The bottle should be left where the test is applied or shied as far away from the house as possible. The top end of the pipe should be covered with a wetted flannel immediately after the essence has been thrown down. A water can, with a lid and small-sized spout, should be at hand filled with boiling water. The nozzle of the can spout should then be inserted beneath the flannel and the hot water poured into the pipe so as to fall onto the rag, sponge, or paper cone, as quickly as possible; and as soon as the can has become empty the flannel should be tightly jammed into the end of the pipe. The lid of the can should not be opened; neither should the can be removed from the place where the test is applied. When applying the test, vapour or steam, will fill the can; hence the necessity of not taking it inside or near the house. Essence of cloves is applied in the same manner as above described. If any serious defects exist in the drains or soil-pipes of a house and they are not built in recesses in walls or covered with impervious paving, the above test will soon make the defects known provided that the air-currents are in the right directions. The writer has applied this test down a soil-pipe as above described, and found the odour of peppermint escaping from a grating over the sewer in a street, but could not find the least trace in the house, although there were known defects. The test also varies in its results between empty and occupied houses. When fires are burning in a house the results generally come quicker than when there are no fires. When the soil-pipes and drains are covered up, the peppermint test frequently fails to betray any defects that are in existence. In other cases the test is so long in finding a means of escape after passing through broken pipes, &c., that it has been thought there were no defects. Such an example occurred at a gentleman's mansion in Devonshire. The test having been applied one morning and no defects exposed, it was assumed that if there were any they could only be trivial. But on going the next day the odour seemed perceptible all over the house, even in the bedrooms, especially those which had had fires burning in them over night. On enquiring of the servants when they first noticed the smell of the mint, they said it was about supper time and after all outside doors and windows had been closed for the night. This explained the whole matter. Fires burning in various parts of the house required a certain amount of air to feed them and to replace that which had passed up the chimneys. After all windows and doors had been shut this air had to come from anywhere, and, amongst the rest of the places, from defective drains and soil-pipes.

There are other ways of applying this test, such as in gelatine capsules, which can be thrown into the drain, to be followed with sufficient hot water to melt the casings and allow the mint to escape. The apparatus of a "smoke machine" has been used to drive the peppermint vapour into the drains and soil pipes. There are also patented apparati for applying this test. After several years' experiience the writer has come to the conclusion that the peppermint test is not at all trustworthy for either drain or soil pipe testing, and he only uses it when he has no other means at his disposal.

It sometimes falls to the writer's lot to find if any connections between bedrooms and W.C.'s exist. Some of these examinations are made prior to midwifery cases; others where a recovery from an illness has been retarded presumably from certain bad odours being present in the bedroom; and in scores of cases because of the local smells, which arise during the time the W.C.'s are being used, being noticed in various apartments in the house. To apply a peppermint test for finding if smells from a W.C. can pass into other places, great pains have to be taken to make it reliable. The first thing to do is to prepare several strips of paper by pasting them. Then place a bowl of boiling water in the closet and empty a small phial of the essence into the contents of the bowl. In some cases it is best to break the bottle instead of spending three or four seconds in slowly emptying it. The capsules above referred to are very good to use for this purpose. Immediately the peppermint is mixed with the boiling water the closet door should be closed and the strips of pasted paper placed over the joints of the door and any other openings not forgetting a small piece over the keyhole. In most cases, the odour of the test will be found to pass through defective partitions or floors, sometimes through pipe casings, and be found in the rooms. A piece of very dry brown paper, sprinkled with ground sulphur, and made to smoulder by burning, is another good test for this purpose.

Sulphuric ether is another vapour test for applying to drains and soil-pipes. A good-sized sponge suspended in a drain or soil-pipe by means of a piece of string, and saturated with ether is an easy way of applying this test. The sponge should not be allowed to touch any water, and neither should any light be exposed near the pipes being tested. Mixed with atmospheric air, ether is very explosive, hence the necessity of great care being taken when using it. The vapour of ether can be driven into drains by means of a smoke machine. This test is a little quicker in finding its way through any defects than peppermint.

Burning brimstone or sulphur in the drains is another test sometimes applied. An old iron bucket partly filled with red-hot coals, placed in the drain, and powdered sulphur thrown onto the fire will soon fill the pipes with the vapour. Another way is to have a vessel of methylated spirits of wine placed in the drains, set on fire, and a stick of brimstone stood on end in the vessel so that it will burn freely. The writer generally applies this test in the following way: Take three or four dry newspapers, or an equal quantity of any kind of wastepaper, saturate it with petroleum or any mineral oil, sprinkle powdered brimstone over the mass, roll it up like a miniature bolster and place it in an opening made in the drains or in a manhole if there is one over the drains, set fire to it, and close the opening so that no fumes can escape. This test is much better than any that have been described, in that a thin smoke is made and can be seen provided it is not filtered by passing through the ground or other covering over the pipes. In houses that are occupied this test should not be applied if there is reasonable cause for thinking that there are any serious defects in the drains or soil-pipes, as the fumes from the sulphur will render the place unbearable for living in.

Smoke "rockets" as they are called, have been much used these last few years for drain testing. One is shown by Fig. 377. This test can easily be applied. If the drains have manholes there is very little trouble in setting fire to the rocket and placing it in the end of the

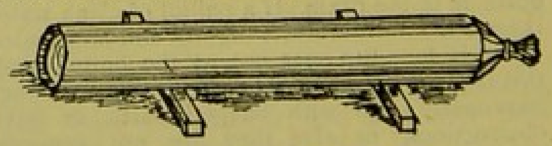


FIG 377

drain it is intended to test, or three or four can be used if the drain is a large one. If the test is applied in this manner the user should be very careful how he goes about it. The writer was once overcome when testing drains at a house near Bournemouth with four of these rockets. The fumes so filled the manhole, which was about 5 ft. deep, that he could not find his way out; and but for an assistant dragging him out by his hands in an almost insensible state and laying him on the grass, these lines would never have been written. The trouble arose through one of the rockets going off before the others were fairly lighted. If there are no manholes the test can be applied through a hole made in an exposed part of the drains. Another way is to bale the water out of a gulley-trap, have a piece of board cut to fit over the trap, and bed it down air-tight with putty, clay, or other suitable material. The board to have a hole through the centre for inserting the end of the rocket. After firing and placing it in the hole, a piece of putty or soft clay, should be folded round the rocket to keep any smoke from escaping between it and the hole through the board. If the drain or soil-pipe ventilator is made of lead it will sometimes melt if the rocket is placed in the top end. For this reason, and also because the smoke from the rocket will pass upwards better than downwards, the rockets should be inserted into the drains in preference to the ventilators. Sometimes this test answers its purpose fairly well, but in others it will prove a total failure. As it is important that all tests should be reliable, it would be very unsafe to trust to this method of discovering defects. Another objection is that the rockets last only a short time. Some will burn out in less than five minutes, but others, made to order, will last from ten to fifteen minutes. If there is a defect in any drain, or pipe connected with it, bad air can escape through the opening continuously. This air may pass very slowly through pavements, floors, wooden casings, or mortar, before it is free to mix with the air in the house. But as the air is escaping always, that is, night and day, the applied test should also be long and extend over a period of some hours. It is possible to keep on burning rockets in

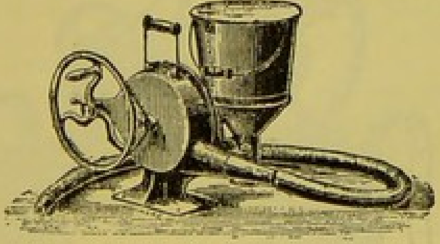


FIG 378

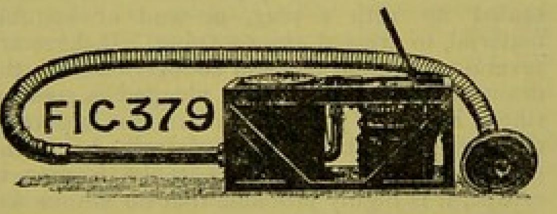
succession, but this is a tiresome task, and in the end very expensive. The writer uses large numbers of rockets, but only when it is not convenient to use a "smoke machine." We will now refer to machines for making smoke and forcing it into the drains.

We may premise any further statements by saying that an advantage of smoke testing is the visibility of the results. Smoke can be seen as well as smelt, whereas, when using vapour tests, one can hunt by scent only.

One of the oldest, if not the oldest, machines made for smoke testing is shown by Fig. 378. The apparatus consists of a chamber in which is burnt specially prepared paper. A piece of bent pipe connects the combustion chamber to the body of a casing in which is fitted a centrifugal fan which is driven at a high rate of speed. The revolution of the fan draws a current of air into the combustion chamber, and, on being converted into smoke, then impels it into the drains through the necessary tubing, or other connection. This apparatus can be kept working continuously for any number of hours at a stretch, it being only necessary to feed the combustion chamber from time to time, and empty the ashes after the paper is burnt. A piece of flexible indiarubber tubing is generally used for connecting the machine to the drains or other pipes to be tested, but I find this to be a frequent source of bother, and so use a piece of lead pipe instead. When applying the test, the machine should be connected properly to the drains, and as soon as smoke is seen to issue out of the ventilation pipe the end should be sealed up with a plug, or wad of suitable material, to prevent any escaping. If there are several ventilation pipes in connection with the drains, they should each be plugged as soon as smoke is seen to pass outwards. It is important that this should be done as described. If the pipe ends are plugged before smoke is seen to escape, it is highly probable that no smoke will get into the vent pipes or soil pipes if they are connected with the drains, so that actually these pipes do not get tested. In some cases, where there are serious defects, the pent up air will escape through the holes, and smoke will, of course follow.

Where there is a considerable extent of drainage to be tested, it is sometimes advisable to have two of these machines at work at the same time. If this is not convenient, the drains should be tested in sections. As a matter of fact this test is not at all reliable as a drain test. Results may be given, and defects found, but, on the other hand, the drains may be in a very bad condition, and nothing discovered by its means. Not that I am going to condemn this kind of machine, on the contrary, I have used them for several years, and, for certain purposes, I consider them invaluable. To take one example out of some hundreds that could be given; where a smoke machine has rendered good service. At Eastbourne, when endeavouring to find if a case of typhoid fever was likely to have occurred through defective drains, the use of a machine exposed a big blunder that had been made in the sanitary and rain water arrangements of a house. The house had been built about three years. On driving smoke into the sewage drains the writer was surprised to find, after the test had been at work for about five hours, that smoke was getting into the bedrooms on the attic floors from the rain water pipes. These pipes were connected with drains leading into an underground tank, the overflow from which was connected to the soil drains. Although a trap was fixed in the overflow drain there was no water in it, so, of course, it was perfectly useless. Whether the water had evaporated out of the trap, or if any water had ever been put into it, is not known. The use of a smoke machine proved that air from the sewage drains was passing into the rooms on attic floors, and it would have been difficult to have found this out by any other means, unless all the drains had been exposed. Defective drain traps, bad connections between soil pipes and drains, and hosts of other defects, are frequently found by the use of this machine.

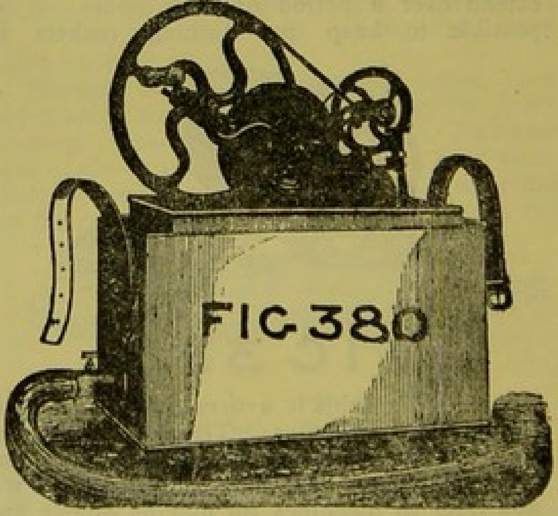
Another kind of smoke testing apparatus is shown by Fig. 379. Much as I like the one last described, I must say that I prefer this one for all round work. The machine consists of a small double action bellows, which forces air through a combustion chamber, in which oily cotton waste is made to smoulder. A pipe is fixed to convey the smoke from the machine



into the drains. Some years ago the cotton waste used was had from the engine sheds at railway termini, but as this oily waste is always liable to take fire by spontaneous combustion (this did actually occur in a luggage van at Oundle Station, when the writer was journeying to a country mansion), clean waste is now always taken, and a tin can of oil, so that it can be prepared as wanted. It takes some little practice to get used to this machine, and, unless its action and working are thoroughly understood, the tests are liable to be rendered unsatisfactory. In the first place, a pressure of from 10-10ths to 30-10ths can be applied to the pipes being tested, and that is sufficient to burst through the water seals of the various gullies and traps under W.C.'s. In the case of a drain, with only one ventilation pipe, it would be unwise to plug the end of it, as, by doing so, the air inside would become so compressed as to break the water seals of the trap. Where there are several drain vent pipes, they could all be plugged at the top ends, with the exception of one, which should be left as a relief pipe. Then, again, the machine should not be worked too fast, or flames would be driven into the drains, and set fire to the smoke in them, with the result that it would explode and blow the water out of the various traps, or else the top off the machine. By constant practice one gets to be able to form an opinion as to the foulness of drains, simply by watching the action of the machine. If the machine is being slowly worked, and the top keeps blowing off, or the water forced out of the outer jacket of the combustion chamber, it is always safe to assume that the drains are foul and badly ventilated. The explosions occur through the gases from decomposed sewage catching fire. Another point to remember is, the machine must be worked at one particular speed, which varies at different jobs, otherwise the water in the traps will start vibrating, the motions corresponding with those of the machine bellows, and eventually sufficient will wave out of the traps to allow the smoke to escape through them. Those traps that are nearest to the machine are generally found to be the most affected.

As a pressure can be applied by this machine a more severe test can be made by plugging all ventilation pipes, and sealing down all gully traps, or those under any fittings that are in direct communication with the drains. In some instances this is difficult to do, but, by a little consideration, it is generally found possible to gain this object. A pressure can then be applied equal to a column of water 2 in. or 3 in. high, with the result that if there are any defects in the work they are found much sooner than if no pressure had been applied. When applying the test in the manner described, it is necessary to place weights on the cover of the combustion chamber, otherwise it would lift off by the internal pressure. An air pressure test, minus the smoke, can be applied by the same machine. Another kind of smoke testing machine is shown by Fig. 380. This is spoken well of, but never having used it, or seen it used, the writer is not prepared to say anything about it.

All the machines named should be used some distance from the house, as it is almost impos-



sible to prevent any smoke that may escape from the machine itself, being wafted by air currents into the house. This occurs mostly when the machine is being started, or fed with a further supply of material. It is also important that all windows should be closed, and where there are floor or other ventilating gratings in the walls, near where the machine is to be used, they should be covered with pieces of pasted paper to prevent any possibility of smoke passing through and getting into the house.

In towns, one often has to test a house which has no "out of doors" parts in the basement. The house entirely covering the whole of the ground, or if there any areas they have skylights over them. If the drains of such a house are "constructed on the latest and most improved principles," a smoke test can be applied through the "fresh air inlet" opening, which is accessible outside the house.

But if an arrangement of this kind is not provided, and it is not possible to attach the machine to the drain or soil pipe vent, it becomes imperative that the test must be applied inside the house, in which case, the machine shown by Fig. 379 is the best to use, as it can be charged and lighted in the street, then carried into the house and connected to the drains. The servants' W.C. is generally found to be the most convenient place for applying the test, the water being dipped or swabbed out of the trap, so that smoke can be driven through it into the drain.

Drains can be tested by means of compressed air. The process was described in "Plumbing Practice," so that it is not necessary to dwell upon it here.

There are a great many other ways for testing drains; in fact, anyone who has had any experience in this kind of work can always invent some method when in an emergency. Peat, tar, waste-paper, or straw can be burnt in a cesspool or drain manhole. Petroleum, naphtha, or any liquid which has a distinguishing odour can be thrown into the drains. None of the tests that have been described can be considered thoroughly satisfactory, and he would be a rash man indeed who vouched for the soundness of any drains or soil pipes because any of the methods that have been described failed to prove that there were any defects.

The only test that can be at all depended upon is the "water test," sometimes called the "hydraulic test." By plugging up the ends of the drains and filling them with water any defects are sure to be discovered. If the drains are newly laid they should be tested and examined from end to end before they are covered up. On completion of the work the test should be again applied, but in this latter case the only way of knowing if everything is sound, is by watching the surface of the water in the manholes, or some other place which is accessible to view. When testing drains with water the manholes should also be tested, as it is quite as important for them to be sound, as the drains. At first sight, this method of finding if the drains are defective, appears to be quite easily applied. Under certain conditions it is so; but there is a great deal to be considered beyond what appears on the surface of the subject. We will now deal with a few points that are found to crop up in practice.

It is always a good plan to keep a record of the quantity of water that is discharged into the drains. This can easily be done by measuring the contents of the cisterns and reducing them to gallons. Or, if the water is being drawn from a branch from a main, instead of from cisterns, the time the water is running should be kept, and the quantity discharged in a given time should be measured as a basis to work upon. The length and size of drains should also be measured and their capacity worked out. If by this method it is found that sufficient water has been sent into the drains to more than fill them, further efforts in this direction would simply mean a waste of time. To make this quite clear, we will assume, and work out a problem. The drains of a house are of the following lengths—

9 in. pipes = 50 ft.
6 in. " = 100 ft.
4 in. " = 200 ft.

and three manholes, each measuring 3 ft. 6 in. × 2 ft. 6 in. × 3 ft. 6 in. average depth.

To find the quantity of water necessary to fill them we proceed as follows: 3 ft. 6 in. × 2 ft. 6 in. × 3 ft. 6 in. = 30 ft. 7 in. × three gives the cubical capacity of the manholes × 6¼ = 574¼ the total number of gals. that they will hold.

For the pipes we have—

9 in. × 9 in. × ·034* × 50 = 137½ gals. in 9 in. pipe.
6 in. × 6 in. × ·034 × 100 = 122½ " " 6 in. "
4 in. × 4 in. × ·034 × 200 = 109 " " 4 in. "

369
Add ... ... 574 " " manholes

Total ... ... 943 gals.

necessary for filling the drains and manholes.

If, on measuring the capacity of the cisterns, or more properly speaking, the quantity of water in them, it is found that they hold more than 943 gals. and yet the drains are not filled by this quantity, it tends to prove that some has leaked away.

When the water is drawn direct from the main service, the water can be measured by means of a tub or a bucket. If a bucket is 12 in. deep and the mean diameter 11 in. by the rule used before we get 11 in. × 11 in. × ·034 = 4·114 gals. that the bucket holds. If it takes, say, eight seconds to fill the bucket, we find that it would take 30½ minutes to fill the drains if the pipe was kept running at the same speed without any interruption. If the drains are not filled in this time it proves that they are defective, and it would be a waste of time to proceed further with the testing. Indeed, if the water was kept running the earth round the drains would, in some cases, get so charged with it

* *Rule.* Diameter squared and multiplied by ·034 = gals. per foot run of pipe.

that earth and drains would all fill up to the same level and thus lead to the false conclusion that the drains were perfectly sound. In these cases water will be found to run out of the ground into the drains for some hours after they have been emptied.

When drains are to be submitted to the water test great care should be taken when selecting the kind of pipes to use. It is always advisable, when ordering pipes, to insist upon the manufacturer giving a guarantee that they will stand the test. There are a great many pipes made that look fairly good, but on testing them they will be found literally to leak like a riddle. Others are so porous that on filling them with water they will be found to be covered on the outside with small globules similar to a deposit of dew. Other pipes, although they may not actually leak, are spongy in texture and will absorb a certain quantity of water, the result of this being that when a drain has been filled, the water will be found to subside at the sight hole or point of observation, and lead to the conclusion that it is leaking away. When makers will not give any guarantee as to the quality of the pipes, it is then best to test them on the works before using them. One bad pipe in a length of drainage is sometimes a serious matter, as it is so very difficult to take it out to fix a better one. If once a drain is mutilated it cannot be made satisfactory again without a great deal of trouble, and would probably lead to relaying the whole length. Of course, the defect could be "botched," but some people would consider this to be almost a crime. In addition to testing the pipes they should also be examined as to their straightness and to their smoothness inside.

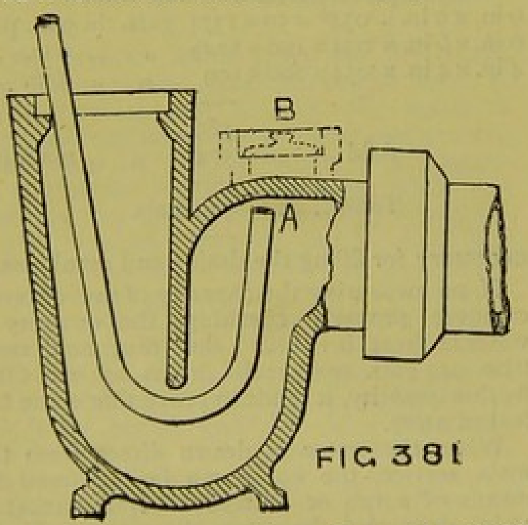
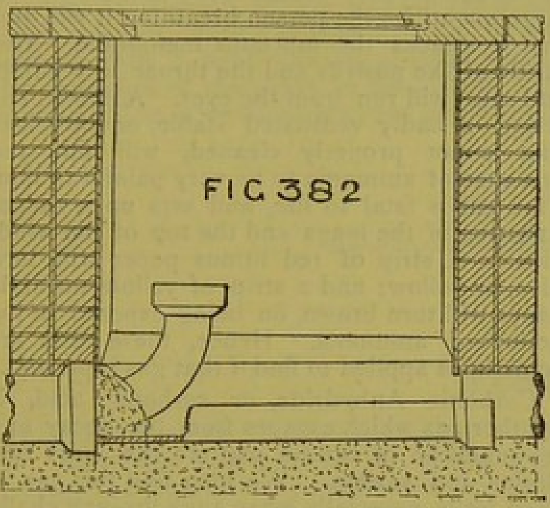


FIG. 381

A difficulty often presents itself, when testing drains, in getting them filled with water, especially those branches that have gully or intercepting traps at the extreme ends. No matter how the water is run into the drains, air will be driven up to those parts, and it is difficult to get rid of it. The water may be baled or swabbed out of the traps to allow the air to escape, but the whole of it cannot be got rid of by that means. A bent tube can sometimes be passed beneath the dip of the trap, as shown by Fig. 381, but this cannot be efficiently applied without first baling the water out of the trap and fitting the tube before the testing water has risen up to that level. The tube cannot be fixed when the trap has water in it, or some would get into the tube. A piece of ½ in. lead pipe is best for the purpose, as it can be bent a little at a time when passing it through the trap, so as to get to the highest point shown at A. Some traps are made with an opening, as shown by dotted lines at B. With this kind the pent-up air would escape on removing the stopper from the opening. When traps of this kind are used, care should be taken to properly seal down the stoppers after the testing is completed. Cases frequently occur where this has not been done. Neither should these openings be covered with the pavement, in which case a stranger, who had to test the drains, would not be aware of their existence. A hole made through the pavement, and covered with an iron plate, would give access to the stopper, either for letting out the air in the drain or for passing a flexible rod through for cleansing purposes. In some cases where this has been done, and the trap has been used for throwing dirty water into, it has been found that some of this water was splashed onto the pavement and ran into the space between the iron plate and the stopper over the drain-opening, so that when the plate was removed an offensive smell was discovered. For this reason it is best to add a short piece of drain-pipe so that the stopper can be fixed level with the pavement, and thus avoid having any hollow space as described. The stopper should be bedded down with common putty, and then flushed up to the pavement-level with Portland cement, so that on chipping away the cement the stopper could be got out without breaking the pipe-socket, and be easily rebedded afterwards.

When a length of drainage has a manhole at each end, and the water is run into it very quickly, it will frequently occur that the water will vibrate between the manholes for a considerable length of time. By careful watching it will often be found that the water in one manhole will subside perhaps 2 in., and rise to the same height in another manhole. After an interval of two or three minutes the water will gradually rise again to its original level in the first manhole, when the same motions will be repeated several times before the water will stand steady. As soon as the drains have been filled with water a mark should be made on the manhole walls to denote the water surface; or the depth of the water at some particular place should be measured with the same object. The time should also be noted, and a record kept, if the water is found to waste away, of the results. If a considerable stretch of drainage, with several branches, is being tested, and they are found to leak, it then becomes necessary to test in sections, so as to locate where the defects are, as it would not be right to condemn the whole of the drains of a house because of one or two leaking places. Frequently it is



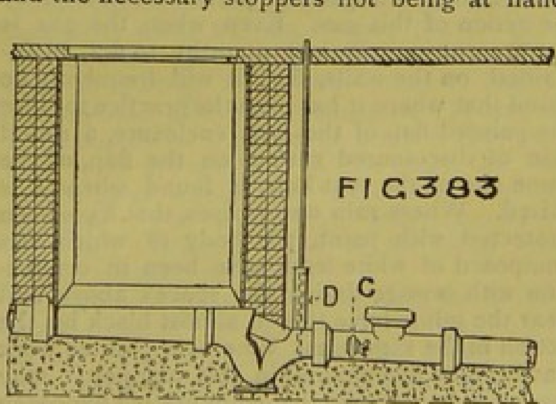
found that the drains themselves are perfectly sound, but the manholes are defective. To make sure as to which is so—the drains or the manholes—the bottom end of the drain should be plugged and a bend fixed at the highest end, in the next manhole, as shown by Fig. 382, the joint being made in a temporary manner with clay. The drain being filled to the top of the bend, and found to remain so, will prove it to be all right. The other portions being tested in a similar manner, and found to be water tight, would lead to the conclusion that the manhole or manholes were defective. If on examining the manholes no defects can be seen, it is best to hatch the inside faces of the walls and coat or recoat them with cement, as predescribed. If it is found that the drains are at fault, they should be exposed for examination, the defects made good (if it could be done without botching), or the pipes relaid, as may be found necessary.

A difficulty always presents itself when testing the drains of a town house, in applying a water test to the lowest manhole in which is placed the disconnecting trap. This manhole being similar to Fig. 375 in a previous lecture. A plug can be fixed in the trap easily enough, but after the test is completed it is not so easy to remove it when the manhole is filled with water. And then again, there are no means of knowing, excepting in very rare cases, if the plug itself is leaking and allowing the water to run away into the sewer or other outlet. This may occur and lead to the assumption that the drains are defective. Where the manhole is not very deep, a square junction can be fixed near the outgo of the trap, as shown by Fig. 383. The branch should be the same size as the drain, or, if larger, it would be better still so that the testing stopper would pass through and be fixed in the position shown at C. On completion of the testing, a permanent stopper should be securely cemented in the socket of the branch. When the drains are being newly laid there is very little difficulty in fixing the stopper as described; but for re-testing in after years it would be necessary to excavate the ground for access to the branch pipe for inserting the stopper or plug. Where the cost would not be a bar to its being done, a second manhole could be constructed for giving the necessary access to the branch pipe. In this latter case open channels could be used, but this is not to be recommended, as the manhole would always be charged with foul air from the drains, which, generally speaking, would be difficult to get rid of by ventilation or any other method. If iron drains were used, the air tight channel, shown by Fig. 370, but without the branches, could be fixed, but the manhole would still be necessary for giving access to it.

There is very little doubt that at some future time someone will invent a "disconnecting trap," with a kind of "sluice valve attachment," as shown at D, Fig. 383, with a long spindle from the valve to the pavement-level. As this could not very well be made in stoneware, the trap and valve should be made in cast-iron, with brass or gun-metal faces to the sliding valve or its seatings. Another way for making an arrangement for this purpose would be to have a hinged flap-valve inside the trap outlet, with necessary gearing for opening and shutting the valve. A sight-hole, with a shaft to the surface, should also be provided, so that it could be seen if the valve was fitting so tightly that no water was escaping past it during the time the drains were being tested.

None of these arrangements would be necessary when testing the drains of an isolated country house, as the extreme end or outlet, would, generally speaking, be easily accessible for both plugging and examination.

Sometimes drains have to be water tested, and the necessary stoppers not being at hand,



other means have to be taken to plug them. A tapered piece of wood with some brown paper wound round it makes a good plug. A ball of stiff clay pushed tightly into the pipe will resist any ordinary amount of water pressure. A brown-paper bag, about the size of the inside of the drain-pipes when distended, filled with dry sawdust and jammed into the drain about 6 in. to 10 in., will fit tightly when the sawdust begins to swell, which it does on being moistened by the water. Sometimes the end of the pipe has been sealed up with plaster of Paris, as this material is easily applied; and on setting, which it quickly does, will resist a great water pressure for some considerable length of time. But, if a large quantity of plaster is used, it will sometimes swell with sufficient force to split the end of the pipe. When this material is used it is best to cut a disc out of a piece of common roofing slate or other suitable material; place it in the end of the drain-pipe and then make a plaster fillet all round the edges in the same manner that glass is face puttied in a window sash. It the piece of slate is so loose that it will not remain in its intended position, two or three loose bricks can be pushed into the drain for a backing to the slate.

The Use of Chemically Prepared Papers and other Tests.

The air that escapes from sewage drains is generally mixed with certain gases that arise from the decomposition and fermentation of vegetable and animal matters. Some of these gases can be detected by their odour, but others are almost entirely free from smell, although under certain conditions their presence may be said to be felt.

One of the most offensive smelling sewage gases is sulphuretted hydrogen, SH_2. The odour from rotten eggs is because of the presence of this gas. Sulphuretted hydrogen has the peculiar property of turning the colour of lead paints. It is of common occurrence to find the walls, doors, seats, and other parts of a water closet that have been painted white, or stone colour, to have the appearance of having been black-leaded. Open privies attached to houses, especially in country places, are often found to have the painted parts discoloured by the action of this gas. Even when the gas is not present in sufficient quantity to act, as described, on the walls, &c., it will frequently be found that where it has been the practice to close the painted flap of the W.C. enclosure, a round disc of discoloured surface on the flap, of the same size as the seat-hole, is found when it is raised. Where rain water pipes, that have been protected with paint, the body of which was composed of white lead, have been in connection with sewage drains, the spaces above and near the joints have turned almost black by the action of the same gas. Wherever painted work has become discoloured in this manner it may generally be assumed that sulphuretted hydrogen is present, and as this is a very poisonous gas it cannot be considered safe to breathe the air that is mixed with it. If a strip of white blotting, or bibulous, paper is dipped in a solution of plumbic acetate and exposed in the presence of the above gas, it is turned black. Hence, this is a very good test for discovering if the air is charged with sulphuretted hydrogen.

The gas of ammonia, or spirits of hartshorn as it is sometimes called, is another constituent of sewage gases. Where this gas is present in large quantities the person breathing it will find that it attacks the mucuous membrane. The inside of the nostrils and the throat will smart and tears will run from the eyes. A person entering a badly ventilated stable, or an urinal that is not properly cleaned, will find the presence of ammonia to be very painful to him. This gas is fatal to life, and sets up a violent irritation of the lungs and the top of the windpipe. A strip of red litmus paper will turn blue, or yellow; and a strip of yellow turmeric paper will turn brown, on being exposed to the action of ammonia. Hence, these tests are sometimes applied to find if that gas is present.

Carbonic Anhydride, or carbonic acid, is another gas which escapes from the decay and fermentation of certain matters that pass into drains and sewers. We also find this gas in deep wells, especially when sunk through chalk. This gas will not support life, and any quantity in excess of 4 parts in 10,000 of atmospheric air is positively injurious to animal life. The presence of this gas can be best described as giving a stufly smell. The odour is not so distinct as either ammonia or sulphuretted hydrogen. If a place is highly charged with carbonic anhydride it would be found that a candle would not burn if placed in it. Where not so highly charged, or the gas was not present in too large a quantity, a candle would burn with a pale blue flame. When searching for an escape of bad air from drains, a test of moist blue litmus paper can be used, and if carbonic acid gas is present the paper will be turned red, although it will recover its colour again by exposure to the air. Another test for carbonic anhydride is to place a bowl, or dish, of limewater in the place to be tested. If this gas is present in any considerable quantity a kind of scum will be formed on the surface of the lime water, and any slight motion being given to the vessel will cause this scum to sink to the bottom. If a person were to breathe through a tube into a vessel containing lime water, this water would become milky or cloudy in appearance, from the carbonic anhydride from the lungs combining with the lime in solution in the water.

The decomposition of sewage gives off a great many gases, in addition to those that have been mentioned, all more or less dangerous to health; but only a chemist, or a man with a good chemical knowledge, could separate them into their component parts. Not only are they prejudicial to health, but some of them are highly explosive. The writer has frequently thrown a light into a cesspool, immediately after the removal of the cover, when the gases have exploded, and the flames have gone up into the air several feet. Twice in his experience he has taken off a cap and screw in the side of a D-trap, fixed under a sink, and, on holding a lighted taper inside, the gases have caught fire and burnt with a pale blue flickering flame. It is not at all uncommon to find that the pent up gases in the centre pipe of a running trap in a drain, similar to Fig. 222 in an earlier lecture, have exploded with great violence when a light was taken near them. This explosion of the gases in the drains was also referred to when describing the application of the smoke machine test. Let me impress upon you the necessity of being careful when using naked lights near foul drains, especially when they have only just been opened. A bricklayer who was assisting me to make a sanitary inspection at a house in St. John's Wood, London, was slightly injured by a gas explosion of this kind, and narrowly escaped being injured for life through it.

It is not necessary to dwell longer on this branch of our subject, and we will now proceed to deal with another, namely, Flushing Drains.

FLUSHING DRAINS.

WHEN writing on "Drain Ventilation," reference was made as to the necessity of keeping the drains clean by copious discharges of water through them. We all know that in some places the supply of water is very limited, and it is only reasonable to assert that in such cases the drains should be constructed so that the available supply would keep them clean. As an illustration, assuming that the drains are used for sewage only, the rain water being discharged elsewhere, if the water supply is only sufficient to flush 100 ft. of drain, the same quantity could not reasonably be expected to keep 200 ft. clean. If two water closets were fixed in a house, the supply of water would perhaps keep one clean, but by dividing this supply so as to flush two W.C.'s, neither of them would be properly cleansed, with the result that, under certain conditions, the drains would always have sewage laying in them. In a case of this kind it would be very much better to do away with one of the W.C.'s, and substitute an earth closet, to be fixed clear of the house.

A water closet should never be fixed if the water supply is not sufficient to keep it clean. A W.C. without water is as useless as a steam engine without a fire.

And then again, when the water supply is ample for all requirements, all the sanitary fittings and drains of a house are frequently found to be in an abominably foul condition, because of the bad arrangements made for utilising the water to the best advantage.

In the first place, all waste water from a house should be sent into the drains with a certain amount of force or impetus and in as large volumes as possible so long as they are not flooded too much. If a pailful of water is thrown down a sink it should not be strained through a small grating in the sink and then allowed to slowly dribble into the drain through a small-size waste-pipe which discharges over the grating of an intercepting, or gully trap. If a bath holds about 40 gals. of water, and takes about fifteen or twenty minutes to empty, this amount of water is not nearly so useful for cleansing the drains as it would be if the bath was emptied in two to three minutes. A valve W.C. is much better than any other kind for doing its share of duty in keeping the drains clean. Rain-water is of very little use for this purpose, and light showers do more harm than good by bringing a great deal of matter into the drains which concretes together and causes a stoppage. Even the small quantity of water from a wash-basin should be made to contribute its portion of the work of drain cleansing. For this purpose the waste-pipe and the connection should be so large that the basin can be emptied in two to four seconds. And so on with any other fitting to which a water-supply is attached.

Some plumbers, and sanitary engineers, will arrange for collecting the waste water from all sinks and baths into a tank with an attachment for discharging the water in large volumes into the drains and thus help to keep them clean. Other engineers will object to this, and state that dirty water will not cleanse the drains so well as clean water, and if the tank is a long time in getting filled the contents become decomposed and smell offensive. Where the water supply to a house is limited the waste may be so utilised, but in this case the tank should be of a small size so that it is frequently emptied. But where the water supply is unlimited it is much better to use clean water for the purpose described.

There are a great many methods for flushing drains. Some act automatically and others have to be done by hand. In the latter case a tank has a water supply, with a ball valve, laid onto it, and a large plug or valve fixed in the bottom, over a pipe connected to the drains, so that on removing the plug or opening the valve, the tank is quickly emptied and the drains flushed. Another arrangement, which is automatic in its action, is similar to that often applied in country places where the water is raised by means of a hydraulic ram, the supply to which is so limited that the ram has

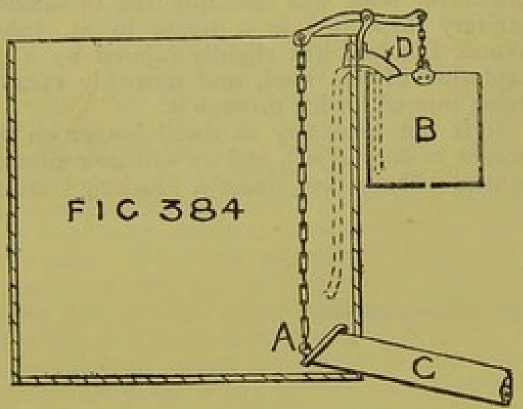


FIG 384

to be stopped until the drive tank is filled, on which the ram is started again. This is shown by Fig. 384. On the top edge of the tank a lever is fixed. One end of the lever is connected by means of an iron chain, or rod, to the valve A, and on the other end is suspended a square iron bucket, as shown at B, which has a small hole in the bottom. When the bucket is empty the valve A, being the heaviest, falls down and prevents any water running down the pipe C. But so long as the water comes into the drive tank so as to run out of the overflow D, and keep the bucket filled the valve is kept

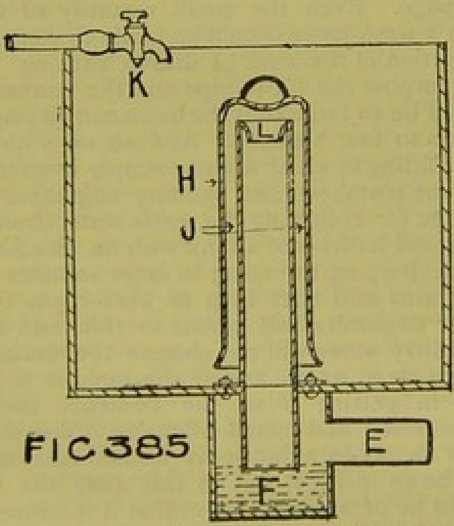


FIG 385

open. If the supply fails the bucket empties through the hole in the bottom, when the weight of the valve causes it to close again and remain so until the tank is again filled to overflowing. This method, when applied to flushing drains does not answer very well unless the water supply comes into the tank much quicker than will run away through the small hole in the bucket. It is also necessary to make a provision for this dribble to be carried away.

A modification of this arrangement, which I think is patented, is to fix a small syphon, as shown by dotted lines in the figure, for emptying the bucket, instead of having the hole in the bottom, as the tank is discharged. This prevents any waste of water and avoids any splashing made by the dribble from the bucket.

Another patent automatic acting flushing tank for drains is shown by Fig. 385. This was invented and patented by one of our leading engineers some years ago; but for some long time past other makers have made copies, or modifications, of the same description of appliance. Amongst the many advantages of this kind of flusher are its simplicity and the absence of any mechanism or working parts to get out of order, or wear out. To describe the working: E is the outlet for connecting to the drain, or for joining a pipe for the same purpose; F is a small chamber for retaining a small quantity of water, in which is immersed the end of the inner, or discharging, leg of the syphon; H is the cap over the leg. A space is left between the cap and the top of the leg, and a space of about 2 in. to 2½ in. between the bottom of the tank and the cap of the syphon. An annular space, equal in area to the inside of the inner pipe, is formed at J. A water supply, with a dribble cock, K, is fixed for filling the tank either quickly or drip by drip. As the tank fills with water the air is confined in the annular space by the water in the tank and in the small chamber F. This confined air prevents the water rising in the annular space as quickly as it comes into the tank. When the tank gets nearly full the head of water is sufficient to so compress the air in the syphon as to force a small quantity through the water in the lower chamber. The relief given by the escape of air allows the water to ascend inside the syphon and flow over the top of the inner leg. This has an inverted frustrum of a cone, as shown at L, which causes the water to fall vertically, instead of running down the sides of the pipe, into that in the lower chamber, and displace it

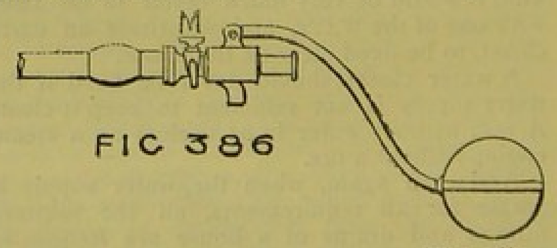


FIG 386

sufficiently for more air to escape. This allows the water to flow freely down the leg and thus start a syphonic action which does not stop until the tank is nearly empty, when air rushes in and destroys the action, after which the whole of the proceedings are repeated. The intervals between the discharges are regulated by the speed at which the water is allowed to run into the tank. By opening or closing the cock K the tank can be made to fill quickly or slowly, as may be desired. In cases where it is found that a very small dribble of water will not start the syphon it is found to be an advantage to fix a reversed action ball-valve, as shown by Fig. 386. This is similar to an ordinary Underhay's equilibrium ball-valve, excepting that as the ball rises the valve is opened instead of being closed, and allows the water to pass through full bore. When the water comes in full bore it heads up so quickly that a small dribble down the syphon has little or no effect upon the ultimate results. So that the tank may fill slowly a small dribble, or "pet" cock is fixed, as shown at M, and the ball-valve does not come into play until the water has risen high enough to float the ball.

Another syphonic-acting drain flusher is shown by Fig. 387. Any plumber can make this syphon out of ordinary lead pipe, but if not carefully made there is sometimes a little difficulty in getting it to work properly. Tanks of this kind can be made in any size, from one large enough to flush a good-sized drain to one small enough to flush a urinal basin. It is necessary in most cases, to fix a reversed action ball-valve to this description of drain flusher.

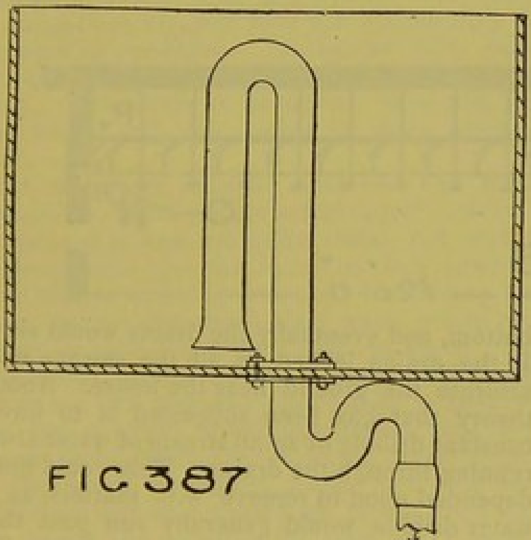


FIG. 387

In addition to the tank with working parts, shown by Fig. 384, there are others with sliding valves over the outlets, worked by means of a crank, with levers and a float. Another kind, which is patented, has a system of compound levers, with a float attachment, acting on a valve over the discharging pipe. This is very good, both for flushing drains and also for shutting off the water supply to a hydraulic ram when, through shortness of water, the driving tank sometimes runs nearly or quite empty, and for re-starting the ram when the tank has filled again.

It is unnecessary to further describe the working of flushing tanks, but it is important that we should have a few words on their size and arrangement.

Taking their size first. It is necessary that the tank should do what is required of it, and at the same time not to overdo it. The size of the tank itself should be governed, 1st, by the quantity of water that is available, and 2nd, which only applies to some places, where the disposal of the sewage has to be considered. In neither of these cases should a greater amount of water be used than is really necessary. Then, with regard to the size of the syphon or discharging apparatus, this should never equal the size of the drains. A 4 in. syphon is quite large enough for a 6 in. drain, and a 3 in. syphon for a 4 in. drain. If the syphons are too large, they will flood the drains, which is quite a different thing to "flushing" them. To illustrate this: the writer, a few years ago, was sent to inspect and test the drains of a nearly newly built convalescent home for invalids, amongst whom was an outbreak of erysipelas. On walking round the buildings he found pieces of excreta lying on the gratings, on the gravelled surroundings, and inside nearly all of the gully traps. On pouring water down the gullies it was found to run away quite freely, thus proving that the drains were not choked, and on opening the various manholes everything appeared to be in good condition. One of the flushing tanks just at that time discharged itself and the water came pouring out of all the gully trap gratings, bringing with it those matters that have been described. The W.C.'s had very poor flushing arrangements, so that what came from them was left in the drains to be afterwards washed back as has been stated. A further evil was also discovered. All the rain water from the roofs was discharged into gully traps, which, in a great many instances, were close to those used for receiving waste water from sinks and baths, so that some portion of what overflowed from the latter ran into those for rain water, and into special drains leading to a rain water tank in the laundry, about 150 yards from the main building. The result being that diluted sewage was being used for washing the linen used in the hospital. The primary cause of this trouble was in having the flushing tanks, which held 200 gals. each, too large, and the syphons, which were 5 in. in diameter, with the discharging legs 6 ft. long, vertically, the drains being made with 5 in. cast iron pipes, laid with a fall of about 1 in 150. The flushing tanks were arranged to discharge once in 24 hours. This was a further mistake, as, so soon as the drains had been flushed, sewage began again to accumulate in them, so they could only be said to be clean, even if the flushing tanks did their work properly, for about a quarter of an hour in the 24 hours. I know a great many engineers do not agree with me, but I maintain that 20 gals., or even 10 gals., sent through the drains, when of ordinary length, as in terrace built houses, every three or four hours will keep them cleaner than 200 gals. in every 24 hours. Violent flushing will also flood the drain manholes, and frequently leave a quantity of solid matter on the sides of the channels fixed in the floors.

With regard to the arrangement of the tanks it is always advisable to fix them out of doors, and enclose them as a protection against the influence of frost. They should also be fixed at the highest ends of the drains, and all long branches should have a tank to each of them. They should also be connected directly with the drains. When tanks are fixed inside a house, they should be made to disharge into an "interceptor" trap, so that, if they failed to act and the water evaporated out of the weir chamber, air from the drains could not pass through the tanks and escape into the house. The trap shown by Fig. 214 in an earlier lecture is of the right kind to use, as the force of the water is not broken so much as it would be with some other shaped traps.

In some cases it is an advantage to so arrange the flushing tank that it will scour out any gully traps which receive nothing but dirty water. Fig. 388 represents such a case. This is a plan of a 20 stall stable at a large mansion which the writer had to make sanitary. The drains fell towards the centre, where they were made to discharge into a trap in a manhole, which had a fresh air inlet valve, outside the stable walls. From the highest end of each drain, as shown at O, a ventilation pipe was fixed to the roof. A rod hole was also provided near the ventilation pipe, as shown at P, for passing rods through the drains whenever it was found necessary to do so. In recesses built in the walls at N, N, were fixed 10 gallon flushing tanks, with syphon actions, and the necessary water supply with reversed action ball valves. The syphons were similar to that shown by Fig. 387, and were 3 in. in diameter. A 3 in. pipe was fixed from the tank to the third gully trap, where it was reduced to 2½ in., further on it was again reduced to 2 in., and afterwards to 1½ in. The gully traps in the stalls were specially made, were 3 in. in diameter, and had inlet arms 1½ in. in diameter. To each of these arms was connected a 1 in. pipe, which was branched into that from the flushing tank. By thus arranging the pipes each gully trap was flushed with 1 gal. of water at each discharge of the flushing tank, and this was set so as to empty once in every two hours, so that there could not be any accumulation of horse's staleings to smell offensive, and which is a frequent cause for complaint in stables. Gully traps in houses, especially those which receive waste water from scullery, pantry, and bedroom slop sinks, are kept much cleaner if they have a flushing attachment to them, and the drains are also less offensive if the contents of the traps are flushed out and clean water left in them instead of sewage.

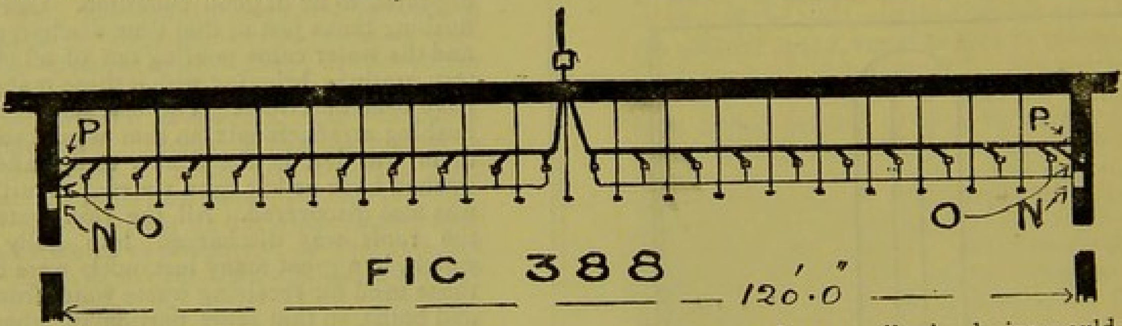


FIG 388

Amongst the many principles for keeping foul air from accumulating in drains that have, at various times, been advanced, was one for always keeping them filled with water, so that there was no room for any air. This would not work at all well in practice, as the drains would have sewage, not water, in them, and the low rate of speed at which it would travel would allow some portion of the solids to settle to the bottom, and eventually the drains would silt up. If the drains leaked at all the sewage would saturate the ground near the house. Another theory that has been suggested is to have a constant dribble or small stream of water always running through the drains. This could not be depended upon to remove W.C. matters, as the water dribble would generally run past them. If these matters lay in the bottom of the drain and formed a kind of weir, the water would perhaps accumulate behind them until there was sufficient to force the matter a little further on when the water would break away and run to the outlet, leaving the other matters stranded in the drain.

For a drain to be thoroughly flushed it is necessary to have sufficient depth of water in it to float excreta and such like matters away. By a careful arrangement of the various waste pipes a great deal can be gained, but to make a thorough success it is important that flushing tanks should be connected to all sewage drains.

WATER SUPPLY TO HOUSES.

WATER is a compound body and consists of two gases, namely, oxygen and hydrogen in the proportion of 1 part of oxygen, by measure, and 2 parts of hydrogen. The symbol used by chemists to represent water being H_2O or OH_2. Next to air, water is the first in importance for supporting life and is of more consequence than food. An animal would live longer on water alone than on dry food. Most of the food that we eat contains a large percentage of water. Milk and liquid foods are nearly all water. Green vegetables are about 9-10ths water; and bread, when in ordinary condition, contains about 2-5ths by weight, of water. A pound of animal, or flesh food, is 3-4ths water: and a pound of potatoes contains about the same quantity. The human body is nearly three parts water. Not only is water necessary for supporting life, but also for maintaining it in a healthy condition. The human body cannot remain healthy if it is kept in a foul condition. The abode or habitation must also be kept clean, and this cannot be done without water.

But the water must be clean and free from impurities. Some people would object to drinking water that was not quite clean, but would not hesitate to give the same to their cows or cattle that were being prepared for killing for meat. A cow that drank dirty water would not be kept in such a healthy condition as to give good milk; and we have it from very high authorities that unhealthy cow's milk is answerable for a great many complaints that the human race, especially children, suffer from. By the same reasoning, cattle that are not healthy cannot be accepted as proper food for man, hence the necessity for pure water as an article of their food. It is an open question if impure water is suitable even for clothes-washing purposes. By boiling water, certain matters are destroyed and rendered innoxious; but in the case of clothes, after being washed and boiled they usually undergo the rinsing process, and this is done in water that has not been boiled. So, for this purpose, we find that clean water is of great importance. If impure water is used for scrubbing house floors it may have mischievous effects on the dwellers. To all appearances the floors, or whatever is washed, may be quite clean, but the small quantity taken up by capillarity, in the material the floors are made of, will afterwards evaporate, and the residue in the form of dust be wafted about by air currents and eventually get into the human system, either by inhalation or lodging in or on articles of food. Even a pool of dirty water near a house will often lead to illnesses amongst the inmates. "Have they been playing with or near any dirty water?" was the first question my doctor asked when he came to visit three of my children who had caught scarlet fever. Inquiries were made, when it was discovered that they had been swimming little toy boats on a stagnant little pool of water on a London common.

We need not dwell on the other uses of water, such as for cooking food, washing vegetables and salads, flushing drains and watering roads. Chemically pure water is unknown, except in the laboratory. All we can do is to get the best we can, which, in a great many cases, although not quite pure, is free from anything which is actually injurious to healh. Next to quality, quantity claims our attention.

It is impossible to give an exact statement as to the actual amount of water necessary for use under all conditions, but we can make an approximate calculation. It is not difficult for any individual person to take note as to the amount of water he uses in a day, and assume that his own experience is a fair average for other peoples. As an example, most people are tea or coffee drinkers, and would drink about two pints of water each day in the form of those beverages, and a similar quantity, making half a gallon in all, in other forms, or mixed with his food, or forming a constituent part of food. In hot weather a man would use more, and in cold weather less, than this quantity. A great deal of difference would also be made between a man who worked very hard, and one who had a sedentary occupation, as to the quantity of water used. But half a gallon may be accepted as an average quantity swallowed each day by each person, age or sex not necessarily being taken not of. We may next assume that a gallon is used for preparing and cooking food. In very large establishments it may be necessary to double or treble this quantity but for small households a gallon per head per day is about the average amount used for this purpose.

For house cleaning we may take, as an example, a ten-roomed house inhabited by eight people. All the rooms, passages and staircases being washed once a week, and the kitchen and scullery daily. Based on the number of pailsful, as an average, we should find that the quantity used is 2½ gals. per head per day. This may be taken as being excessive in those houses that are entirely covered with carpets which are only taken up once a year. Such houses cannot be healthy for living in.

Where the washing is done at home, the quantity required is about 150 gals. for eight people's washing, and this works out at about 3 gals., as an average per day for each person.

A person who washes himself in the ordinary way twice a day and his hands at midday, in addition, will use about 2 gals. Where a sponge bath is used every morning, and it ought to be by every person, a further quantity of 3 gals. is necessary, thus making a total of 5 gals. for each person's daily use for body cleansing.

Some people, but very few, will have a plunge bath, using about 35 gals., daily. Others will have this bath only once a week, using that quantity of water, or an average of 5 gals., daily.

In towns, and other places where water-closets are fixed, we may assume that each person uses these places twice daily, with an expenditure of 3 gals. each time, making a total of 6 gals. of water daily, for this purpose.

We may go on further and allow for waste, which in some cases is equal to or exceeding that actually used, for watering roads, and several other purposes; but we will confine ourselves to the actual household requirements. To sum up the actual quantity necessary for each person we proceed as follows :—

Water for Drinking	½ gal.
" " Cooking and preparing food...	1 "
" " House cleaning	2½ "
" " Domestic washing	3 "
" " Personal do. including a sponge bath	7 "
" " Water-closets	6 "
Total about	20 gal.

We find from this method of calculating that at least 20 gals. per head for each day must be supplied, so that the house and household may be kept fairly clean and have sufficient for all ordinary purposes. Some authorities will ask for more than this quantity, but there are a great many places where a lesser quantity is available. Where water is scarce, and an economy has to be practised, we should commence with the W.C.'s and fix earth closets instead. This would save 6 gals. per head daily. As stated in an earlier lecture, a scarcity or limited supply of water to W.C.'s means foul drains and the consequent evils.

We will deal with the sizes of cisterns for holding water later on, and now proceed to consider a few details in connection with the sources from which water is had. Beginning with rain water, which we may say is the fountain head of all water supplies. In some cases we make arrangements for collecting and storing what falls on our roofs. In others, provisions are made for filling reservoirs, which sometimes are large enough to be called lakes. Some of the rainfall runs into surface channels leading into brooks, streams, and rivers. A great deal soaks into the ground to some depth and fills our wells, or, flowing as underground streams, eventually comes so near to the earth's surface as to burst out, and these we call springs. Vegetation takes up a great quantity of water which falls as rain, and a great deal by evaporation returns, in the form of vapour, to the skies to again come to us in the form of dew or rain.

If it was possible to collect rain water before it became contaminated, it would be better than any other kind for household use. But this is almost impossible, as, especially in the neighbourhood of towns, the air is generally loaded with impurities which combine or mix with the water, and thus detract from its purity. And then, again, the collecting areas are generally in such a dirty condition that the water is frequently rendered so foul as to be almost unfit for domestic use. When lecturing on rain drainage this was referred to, and means described for partially cleansing and filtering the rain that fell on roofs.

The rain which falls in the open country, especially in hilly places, is much more pure than what falls near habitations. It is also better than that which falls on cultivated land, or in fields occupied by cattle. Swift running streams, provided they are free from injurious matters, are better than slow running or sluggish streams for keeping water pure, and cascades or water falls are a decided advantage for ærating the water. Oxygen in the air will combine with, and burn up, certain impurities in the water, and by allowing it to fall through air the process is more effectually carried out, hence the advantage of waterfalls. The water in lakes and reservoirs which are supplied from streams of this kind is generally found to be very good.

In some parts of the country we find streams supplying ponds and lakes with water drained from cultivated land, and, although we have a Rivers Pollution Act, the same streams are often used as open sewers; receiving filth from houses, farms, cowsheds and piggeries. The lake water being afterwards pumped into the

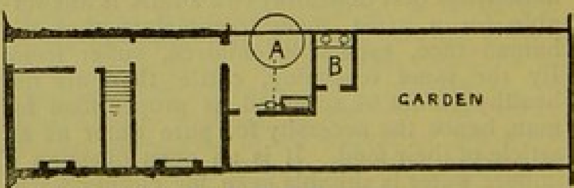


FIG. 389

house for domestic use. It is scarcely necessary to say such water is totally unfit for drinking, and it really is a wonder that there are not more illnesses in some country places than there are, where the water supplied is of this description. The rainwater which filters through the earth and supplies our wells, would be pure if the filtering material were good. But it is a well known fact that when the wells are shallow the water is rarely found to be good. The surface of the earth is generally mixed with decaying vegetable or animal matters, which are dissolved in the water as it passes through, and thus get into the wells. Where these wells are near habitations they frequently become fouled by leakages from sewage drains, privies and middens. Fig. 389, is a plan of a house the writer and his family had to live in for a twelvemonth, as he could not get another, at a small-sized town in Sussex. There are thousands of houses which have no better water supply. The well A, was beneath the scullery floor, and at B, was a common privy. The vault had cemented walls but they were cracked, and the well-water was fouled by what escaped. None of us had any illness because we went about a quarter of a mile to fetch water that was known to be pure; but the obstinate people who lived next door, and who kept a young ladies' school, would persist in using the water from their pump, which drew from the same well as our own, with the result that the school had to be closed because of the amount of sickness in it. In the ordinary course of his business the writer is frequently coming across similar cases of well pollution and the same class of obstinate, stupid people, who will persist in doubting any statements that tend to show their water is unfit for drinking, even when shown the results of a chemical analysis. An analysis of a sample taken from a newly dug, shallow, well in the middle of a field a few miles from Carlisle, proved the water to be unfit for drinking. The nearest house was 1-8th of a mile away, but the next field was cultivated as vegetable gardens, and being at a higher level the rain that fell onto it drained into the well. In practice it is always safest to suspect the water drawn from shallow wells and advisable to submit a sample, when the water is to be used for dietary purposes especially, to a chemist for an analysis to be made.

Generally speaking, water drawn from deep wells is found to be the best, so far as freedom from contamination with sewage goes, but such water is frequently found to be very hard, especially when drawn from wells sunk in or through the chalk.

The purity of water is one of primary importance, but chemistry only can tell us when water is fit for drinking. There are certain signs, but they are very untrustworthy, by which we can form an opinion of the suitability of water. In the first place it should be clear and colourless, although turbidity of the water does not necessarily prove that it would injure any one's health. It should be entirely free from taste or smell. The water should be ærated, but by natural means. If water is not in this condition it tastes sickly. Some waters sparkle very much as if they were highly ærated, but they are unsuitable for drinking, as the bright sparkling appearance of well water is sometimes caused by the presence of carbonic acid gas. If this gas is from decomposing animal or vegetable matter, which most probably it is, the water is totally unfit for use.

If water is contaminated with sewage, two or three drops of Condy's Fluid in a glassful of it will sometimes prove the fact by the pink colour disappearing and leaving a brown tint behind. My suggestion to you is this, never attempt to advise anyone as to the purity of water, as you may make a serious mistake. This matter should always be placed in the hands of a specialist; that is, a chemist who has a reputation for skill in this subject.

CISTERNS, THEIR SIZE, POSITION, MATERIALS, &c.

Size of Cisterns.

THE question of having cisterns has two sides to it. If water is drawn from a waterworks main, or from a reservoir, a house cistern in some cases is unnecessary, and the water can be had fresh from the main instead of from a cistern, which may, perhaps, be dirty, or of such a large size that the contents do not get changed so frequently as they should be. On the other hand, the use of cisterns has many advantages. The water supplied is not always so clean but that it will deposit a sediment in the bottom of a cistern. It is difficult to get water at all times which is free from turbidity, and this water, if stored in a cistern and allowed to remain perfectly still, will frequently clarify itself, all, or most, of the suspended matters settling to the bottom. Even when the water is thoroughly filtered before delivery a red deposit, which sometimes turns black, is frequently found in the cisterns owing to the rusty condition of the iron mains through which it has passed. Where no cisterns are used, but all water is drawn from the mains, the excessive pressure will cause the various fittings to leak sooner than if they had been supplied from cisterns in the house and thus worked under a reduced pressure.

Water closets should always be supplied from a cistern and not directly from the common main service. Where there is a hot water boiler a cistern should be provided for supplying it as there is always a liability of a break down of the pipes or fittings, and some little risk of the boiler bursting when the water is again turned on. In the case of an intermittent supply, cisterns are imperatively necessary.

Generally speaking, cisterns are an advantage provided that they get proper attention. This we will refer to later on. Where the supply is constant it is sometimes an advantage to have special valves fitted to the pantry, scullery and housemaid's sinks, for drawing water directly from the mains, as mentioned above.

The sizes for cisterns vary very much. If the supply is constant the cisterns need not hold more water than is sufficient to last a few hours, during which time any ordinary repairs can be made to the main pipes or fittings, but if the supply is intermittent, that is, turned on for an hour or two daily, the sizes of the cisterns should be so increased that they will hold enough water for 24 hours consumption. The number of people living in a house has to be considered, although the size of the house also affects the quantity of water necessary to be stored for use. If 10 people lived in a house and we were to assume that 20 gallons per head per day to be a fair average for their requirements, we should at once arrive at the conclusion that the cistern should hold 200 gallons. But if the reader refers back to the method this quantity was arrived at, he will find that "domestic washing" is one of the items. People do not do their washing daily. Some do it monthly, others bi-weekly, but with a great many it is a weekly operation. Taking the latter as an example, we deduce that instead of 200 gallons the cistern should hold 363½ gallons, the cistern being made to hold sufficient for the largest quantity that may be required in any one day. If a cistern of this size were used, the water would have become stagnant during the time between washing days, and, although not perhaps quite unfit for drinking or similar purposes, would have lost its freshness. This points to the necessity of having two cisterns, a large one to hold water for all ordinary, and a small one for dietary and cooking, purposes. With a larger description of house a greater amount of cleaning has to be done than in a small house and a greater storage of water is necessary.

In country mansions where the water is pumped directly into the cisterns, they should be arranged to hold about two days supply, so that if the pumps or engine became out of order there would be no shortness during the time that the necessary repairs were being made.

In very large mansions, in either town or country, the water storage should always be ample. In a great many cases the 20 gal. basis is not at all applicable to house cisterns on account of the difference in the habits of the people. As examples, we will take two noblemen's mansions of about equal size, with an equal number of servants, for comparison. One has fourteen fixed baths, and the other has only one fixed, besides portable or sponge baths. This shows a wide difference in the quantity of water necessary for baths only. Some families put out their washing, and thus use less water than others who do not. Even the class of servants makes a difference in the quantity of water used. One will use three pails of water where another would use only one to scrub the floor of a room; and so on throughout the household. I do not mind, from a sanitary point of view, if all the taps in a house are in a leaky condition, especially where it is occupied during only portions of a year, because of this keeping the traps all charged. But this amount of waste will sometimes equal, or perhaps exceed, the total quantity used, and, where otherwise the storage has been ample for all requirements, shortness of supply has arisen through sheer waste. Where the water has to be raised by machinery this waste sometimes means an expensive item in the course of a year. All this tends to show that in some instances it is as much a question of judgment as calculation as to what size the cisterns should be, but in others an approximate estimate can be made.

Hitherto we have assumed that the supply of water to the house has been unlimited from a source which was constant. In towns, this supply is generally provided by private companies or public corporations, with which we have nothing to do. But in country places we have sometimes to provide the supply, and to adopt means for sending it to the house. There are a number of ways of doing this. I do not intend dwelling upon this now, but to make a few remarks, in continuation of our present subject, on sizes of reservoirs. Assuming the source to be a spring with a plentiful supply, and the elevation is sufficiently high, all we have to do is to confine what issues in a basin and fix a pipe from it to the house cisterns. If the spring is a very small one, or is intermittent, a larger reservoir must be constructed to hold all the water that passes out of it. If the mansion is occupied, say half the year, it is sometimes found that during the other half, when little or no water is being used, the storage accumulates sufficiently for all purposes when a larger drain is made upon it. In some instances, several small springs can be tapped, and the necessary pipes laid in to convey the water to one reservoir.

Where the springs or water supplies are at a lower level than the house, machinery has to be used for forcing the water up to a reservoir. If the supply is plentiful, and the fall sufficient, a hydraulic ram is the simplest and most economical form of power to use, and the reservoir need not necessarily be of a very large size, although where fire mains are laid from it the storage should be increased so as to allow for any excessive quantity of water that may be wanted in an emergency.

Where the spring or supply is not very large, but will work a small size ram, it is then advisable to have a large size reservoir, so as to store all water that may be sent up during times when the house is only partially occupied, and thus have a good reserve by the time the house is again in full swing. As an example, assuming that a ram is forcing up 1,200 gals. of water during 24 hours, but 2,000 gals. are required daily when the house is occupied, and 200 when two or three servants only are living in it, each period of time being for half a year. By calculation we shall find that the reservoir should hold not less than 182,500 gals. If the house was in occupation all the year round, the reservoir then need be but very small, and would only require to hold the ram's delivery during the night time or when no water was being used. In a case of this latter kind the supply would be only equal to half the requirements of the house, and would have to be increased in some way. The readiest way, if a greater quantity of water could not be had, would be to run the "tail water" from the ram into a lower reservoir, and by means of a steam-power, horse-power, windpower, or other kind of pump, raise it to the upper reservoir. Or the ram could be done away with, and the whole of the water raised by mechanical means. If steam power is used, and any large quantity of water not required, say only 2,000 gals. a day, the reservoir should hold about a week's consumption, and thus avoid having to pump daily. Windmills can only be used at certain times. Where fire mains are connected the reservoir should be of an ample size—although only the above quantity is used in the time named—so as to have a reserve in case of fire.

In computing the quantity of water necessary, and the size of the reservoir for storing it, for a house, the 20 gals. daily per head basis should be looked upon as being the minimum quantity which should be allowed for, and this should be doubled whenever circumstances would allow it to be done.

In some parts of the country there are no springs or other available sources for getting water from, and in others the water is of a kind that cannot well be used owing to its contamination with deleterious matter. Near Windsor the writer had a job to find a better water supply owing to the well water being charged with magnesium salts to an unpleasant degree. In these and similar cases the use of rain water was the only means of getting over the difficulty. The first thing to consider about a rain water supply is getting the water clean. Remarks on this were made some time ago when writing on rain water drainage, filtering, and storage. The next is the size of collecting area, and then the storage of the water after collection.

Before settling these we ought to first consider the amount of rain fall available. Our greatest authority on this is Mr. Symons, who tells us that our average yearly rainfall is 32 in., but the amount varies in different localities, and in different years and seasons. We may then assume that 24 in. is a minimum depth that rain falls in a year. All of this cannot be collected, as a certain portion is lost by evaporation and waste, thus reducing the total quantity to 20 in. This amount of rainfall is equal to a little over 10 gals. per superficial foot of area on which it falls. If the roofs of a house are equal to a horizontal surface measuring 50 ft. by 50 ft. we have an area of 2,500 ft. which multiplied by ten will give a total of 25,000 gals. of rain water collected. In a house continuously occupied by 10 people, 2,500 gals. per head would be available for the year's consumption of nearly 7 gals. a day. This quantity should be economised by using the best local supply for ordinary purposes, the rain water being reserved for special use. In a case that came under the writer's notice, a large wooden outbuilding about 60 ft. by 40 ft. was constructed and covered with corrugated galvanised sheet iron, the primary object being to increase the water catching area. This was equal, on the basis assumed above, to 24,000 gals. per annum, and would, when added to that caught on the house, be, as above quoted, equal to about 13½ gals. per head for the same number of persons. To catch enough rain water so as to allow an average of 26 gals. daily for each person the whole of the above areas would have to be doubled, although in a very wet year they would sometimes be found sufficient.

The reservoirs should be constructed so as to retain the larger quantity. The capacity can be found by dividing the total number of gallons by 6·23 and the result will be in cubic feet.

The usual practice of allowing all the rain water to be stored in one tank is far from being good. It is a much better plan to construct several tanks with the necessary arrangements for each one to be filled and used from separately, so that when one has been emptied it can be cleaned out ready for use again at the next rainfall. This also saves the water from being wasted. When the water becomes so very dirty that it cannot be used, and when of necessity the tanks must be cleaned out, the whole need not be done at the same time. The writer frequently finds underground tanks in gentlemen's country mansions that, probably, have never been cleaned out since they were first built, some of them, perhaps, 40 or 60 years ago, and, it need scarcely be added, the water totally unfit for use. Under the best conditions it is difficult to store rain water and keep it fit for use, but if no pains are taken with it, it will become very little better than sewage, and highly dangerous to use for domestic purposes.

Positions for Cisterns

next claims our attention. There is no more frequent cause of water pollution than placing cisterns in unsuitable positions. The Metropolis Water Act, 1871, contains a very wise provision, and prohibits any cistern being buried or excavated in the ground. It seems a pity the same regulation does not apply to cisterns fixed in cellars. Thousands of cisterns are fixed in vaults under roadways, or under area steps, with no provision for keeping out coal dust, street driftings, slugs and a host of other matters which get into them. Some of them have a dustbin at the side, into which all the house refuse and sometimes the garbage, &c., from the kitchen is deposited. In some cases the butler's pantry and housekeeper's room sink taps are supplied from these cisterns, and very frequently the dinner bottles are filled from the same cisterns which are also, sometimes, connected to servants' W.C.'s.

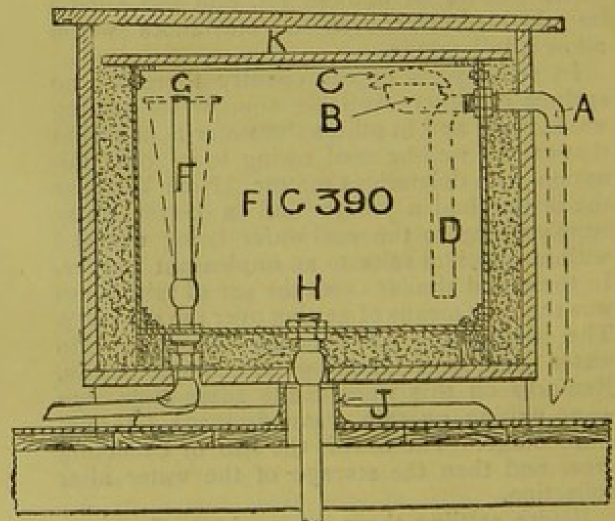
A case came under the writer's notice where the water used for cooking, preparing salads, &c., was fixed in a dirty, tumble down stable. Cisterns are frequently found beneath a basement staircase, without sufficient room for a man to get inside and cleanse them, with results that can readily be imagined. Feed cisterns to low pressure kitchen boilers are often found to have a quantity of black beetles in them. These pests on being drawn with the water out of the boiler tap, being found to have been bleached quite white by the process of boiling. Cisterns are also very common in water closets which does not matter so long as the W.C.'s only are supplied from them. But in most cases the same cistern supplies a lavatory on the ground floor and a tap for filling toilet bottles on the upper floors. In both cases the water being used at times for drinking. When W.C.'s are fixed on floors over each other, and each W.C. has a cistern above it, which also supplies other fittings, an overflow of any kind, such as from bedroom slops when thrown down the W.C., or if any leakage occurs from any defects in the trap or soil pipe, it will fall into the cistern below and thus pollute the water. In one case, the writer found the screw cap of a trap under the floor, beneath a washbasin, had been removed, as the waste pipe was choked, so that when the basin was emptied the dirty water ran into the cistern below, until the water became so offensive that a search had to be made as to the cause.

Great numbers of cisterns are found beneath bedroom floors, where the accidental upsetting of a *pot-de-chambre* would give results unpleasant to think of. In a recent examination of a house, it could be seen that when a bedroom floor was washed the dirty water ran through the joints of the flooring into a cistern beneath.

Inside a roof is a favourite place for fixing cisterns. These are generally in some far away corner where there is not a single ray of light, and one has to crawl over the ceiling joists, through cobwebs and soot, to find their whereabouts, with a candle in one hand and at the risk of falling through the ceilings below. Where cisterns are fixed in bedrooms they are found to be very convenient, and it saves the servants' time going downstairs to draw it in the proper manner, for dipping the water out with any jug or can that is at hand. In one case it was found to be advisable to put padlocks on the lid of such cisterns, as it was suspected that a man-servant used them for bathing in.

When no other place is convenient cisterns are often fixed on house roofs. If these cisterns have no covers fresh water algæ will grow to a considerable extent, and as this weed dies it contaminates the water. Soot, dust, and impurities from the atmosphere also get into the water and detract from its purity. No doubt a great number of readers could add to this list of unsuitable places for fixing cisterns. It only remains to suggest something better. Cisterns for domestic purposes should always be placed in positions where there are no foul smells, and where they can be seen and easily accessible for examination and cleaning without the use of any artificial light. They should have covers to them which are mouse, spider, and dust tight. This is not easily done. Covers are frequently fitted to cisterns, but the parts cut out to fit round the ball valves are left open, whereas they should have a small box casing fitted to them. Even when covers are properly fitted, careless servants and workmen will frequently leave them out of their position. This points to the advisability of having the covers hinged, but the hinges should be made of brass, and the pins should also be of brass to prevent them rusting, which would result in their being broken after they had been fixed some little time.

Where circumstances will admit it is always best to have a small room set apart as a cistern room, and this room should be well lighted and kept scrupulously clean. The door should be locked, otherwise it will get converted into a lumber room for spare or crippled furniture,

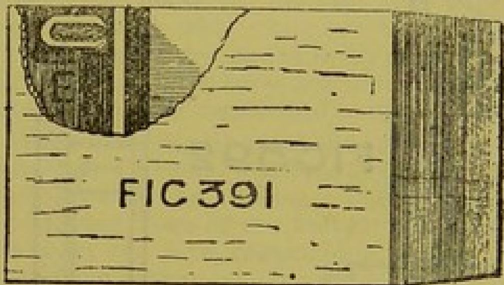


old portmanteaux, travelling boxes, hats, boots, and the usual accumulation of material that is found in similar places.

There is no great objection to fixing cisterns on roofs, provided they are properly protected from both heat and frost in addition to liability to contamination of the water. The best plan is to make a deal casing large enough to allow a space of 2 in. to 3 in. all round, between the cistern and the inside, and well pack the space with clean sawdust, slag wool or other suitable material; but on no account should dry hair felt be used. Particular attention should be paid to the protection of the cistern bottom and the pipe connections leading into the house. These should pass through a larger pipe soldered to the roof, as shown in section at J, Fig. 390. The coverings to the cistern should be doubled, with an air space between them, as shown at K. If the outer cover is air-tight, the frost will not penetrate through the confined air and the second cover.

Their Arrangement and Material.

All cisterns should have overflow pipes attached to them and we will dwell for a short time on this small but important detail. In the first place, it should not be in a position where bad air could pass through and get into the cistern. In the second place, the outer end should be turned downwards as shown at A in the last figure, to prevent wind blowing through it, although, if the cistern is fairly well enclosed this would not occur, but it is as well to take precautions to prevent it. Some plumbers will fix hinged flaps on the outer ends of the pipes, but this should never be done, on account of their becoming fixed during frosty weather. The writer has seen the injurious effects of this in a great many cases, including in his own house. When the overflow pipe is fixed to the side of the cistern, as shown in the figure, any inward current of cold air would play on the surface of the water and tend to freeze it. To prevent this some plumbers will put an elbow on the pipe, the open end looking upwards, so as to direct any air-currents from the water. If this is done the elbow should be made with a very large entrance, or trumpet-shaped mouth to it, as shown by dotted lines at B. A further advantage of this arrangement is, more water would pass through this overflow pipe than if it had simply projected through the side of the cistern. The enlarged overflow B would take away more water still if a cap, with the edges just dipping into the water, as shown at C, was fixed over it to prevent air being sucked in. But in this case the cap would act as a deflecting plate and direct any incoming air onto the surface of the water, which should be avoided if possible. A further arrangement would be to fix the pipe as shown by dotted lines at D, and thus prevent some of the evils alluded to. This pipe should be a little larger than the projecting overflow in those cases where an allowance for friction should be made. The diameter of the overflow pipe should always be in excess rather than less, of the requirements of the case. A 1½ in. pipe of this kind would discharge about 8 to 9 gals., and a 2½ in. pipe from 18 to 19 gals. per minute. In some cases the pressure on the supply to the cistern is so great that even with a ½ in. service-pipe a 2 in. overflow will not take away the water fast enough, when the ball-valve gets so much out of order that it will not shut off at all. By adding to the length of the overflow pipe, as shown by dotted lines below A, more water would run through in a given time, but if this were done the pipe D would have to be omitted, otherwise the water would sometimes be syphoned out of the cistern. In this case it would be better to retain the cap shown at C and use a smaller size overflow pipe. If this pipe was of such a size as to fill full-bore when the cistern was overflowing, it would act as a syphon and have a better effect than if it had been so large that the water did not fill it. The overflow pipe should be connected to an iron, or slate cistern, by means of a long thread and back nuts; but, sometimes, when a lead pipe is used, a leaden flange is soldered onto the pipe, the end then passed through a hole in the cistern and tafted over inside. This, although often done, is but a poor job, and is not so good as when the screwed connection is used. When the cistern is a lead-lined one the overflow hole can be cut



to an enlarged size and oval-shape, as shown at E, Fig. 391. This being better, not reducing the cistern's capacity for holding water, and at the same time will discharge more water in the case of an overflow than a pipe of the same capacity which has a round orifice.

As the pressure in a main supply-pipe is always less at the top than at the bottom of a building, it follows that the overflows to the lower cisterns are required to be larger than to those on upper floors. In Fig. 390, the cistern is supposed to be on the roof, and enclosed against any action by heat or extreme cold. Other cisterns are sometimes fixed on the lower roof, and others inside the house. Wherever they are fixed the overflow should discharge into the open air and not into any other pipe, either for waste or rain-water, and above all, should not be connected to any soil-pipe or drain. The great blunder of continuing the overflow-pipe to discharge over a gully-trap is frequently made. Out of four houses surveyed this week, three were found to have the overflows so arranged. Fig. 392 is a sketch of one, but illustrates the principles of the whole. Two cistern overflow-pipes, a sink-waste, and one from the W.C. safe, all discharged over of a grating of a gully-trap. The sink-waste was trapped, but any bad odours near the discharging ends could be drawn through the cistern and W.C. safe overflow-pipes, into the house. All these latter pipes have now been altered so as to empty onto the pavement some feet away from the gully-trap.

In addition to the overflow-pipe, every cistern, especially when holding drinking water, should have a provision made for emptying it, when necessary, for cleansing purposes. Such a pipe, which need not exceed 1 in. in diameter, is shown at F, Fig. 390, the top end at G being soldered over. In this example the pipe is shown as discharging onto the roof, but there is no great harm if it is made to empty into a rain-water pipe or a gully-trap. In some cases this may be thought unadvisable, as for instance, where houses are unoccupied during the winter months and the cisterns and pipes are emptied to prevent freezing. When this is done and the pipe F removed, air can pass through the cleaning out pipe; and, although there is no water in the cistern to become contaminated, this air had better be kept out of the house. If a cleaning out pipe

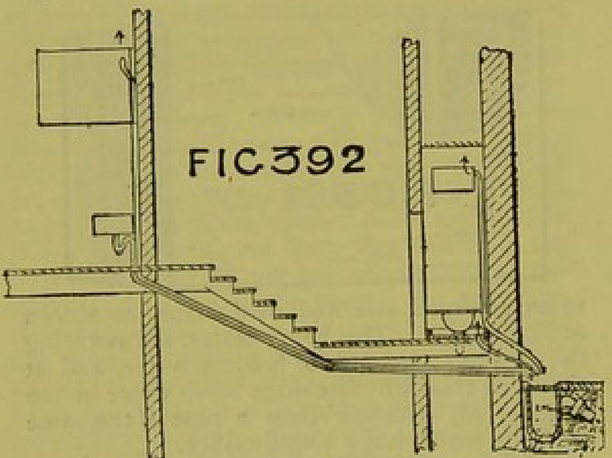


FIG. 392

is not fixed the cistern has to be emptied through the various cocks and valves, which are frequently injured by the mud and sediment in the cistern bottom, when stirred up, getting into them. Neither can the whole of the water be emptied out of the cistern through the service-pipes. The ends of these should project through the cistern-bottom, as shown at H, Fig. 390, to prevent any mud getting into the service-pipes. The cistern can then only be emptied to this level. The remainder has to be dipped or swabbed out; but the cleaning-out pipe saves all this trouble. It is generally best to have this pipe and that for the overflow distinct—some water companies insist upon it—but in such cases as that shown by Fig. 390, the two need not be fixed, one being made to answer for both purposes. If this were done the pipe F should have an open end at G, and be made trumpet-mouthed, as shown by the dotted lines.

In the case of a very deep cistern the standing waste, if made as shown by the dotted lines, would have a tendency to float, and on being lifted out of its socket would fall sideways. In a case of this kind the trumpet-mouth should only extend about from 8 in. to 12 in. down from the top, which would reduce its buoyancy. Some water companies will object to the pipe F, as shown by firm lines, on the plea that an ignorant tradesman would perhaps cut off the soldered end and thus convert it into an overflow-pipe. To meet these views the pipe can be cut short, so as to extend only about 1 ft. above the bottom of the cistern. Ground in brass plugs, with a chain attachment, are sometimes fixed instead of the stand-pipes; but when not often used these plugs will become fixed by corrosion, when it is found to be difficult to remove them. The chains will also often break and it is then difficult to get out the plug.

The various kinds of ball valves will be described under another heading, and it is only necessary here to remark that the position of the ball valve should be as far away from the overflow as possible, and a "silence" or "hush" pipe should be fixed to the nozzle to prevent the incoming water making an unpleasant noise. Even the monotonous drip, drip, drip, from a ball cock, when nearly closed, is often found to be unpleasant, especially when the cisterns are near bedrooms. When a silence pipe is fixed it is necessary to make an air hole in it, near the top end. Otherwise the water will sometimes be syphoned out of the cistern back into the main when the supply is turned off.

All cisterns fixed inside a house should have safes under to catch any water that leaked or overflowed from them, and thus save from any serious injury to rooms beneath. Cisterns made of iron, either galvanised, painted, or plain, or slate, or stoneware, should have safes under them for the further reason that a great deal of condensation takes place on their sides and bottoms. This has been known to occur to such an extent as to show stains on ceilings, and lead to the assumption that the cisterns were leaking. If the cisterns are enclosed condensation does not take place. Even thick brown paper, if pasted on to the outside of the cisterns, will prevent a great deal of this condensation, the paper being a non-conducting material. The safes should always be at least 4 in. larger all round than the cisterns, and have good-sized overflow pipes projecting a few inches beyond the house walls or roofs, as the case may be. It is not a good plan to fix hinged flaps on the ends of these waste pipes, for reasons that were given when describing those for cisterns. It is often found that the turned-up sides of the safes get trodden down by workmen hence the advisability of having wooden curbs fixed for their protection.

The bottom of the cistern is the best place for connecting the service pipes, as, in an emergency, plugs can be driven into the ends; this being difficult to do when the pipes are connected to the sides. In some cases it is necessary to block the cisterns up so that when the pipes come out of the bottom it is not necessary to bend down the sides of the safe for them to pass. In other cases it is advisable to solder a short piece of pipe of a larger size into the bottom of the safe for the service pipes to pass through, as shown at J, Fig. 390.

When a cistern has to supply baths and sinks, and, in addition, the hot water cistern or boiler, it is generally considered to be a good plan to connect the service to the latter near the bottom of the cistern. The service to baths, &c., to stand up above the bottom 6 in. or 8 in., according to the depth and size of the cistern, so as to reserve a certain quantity for the boiler, and thus reduce the risk of its becoming emptied. Water-closets should never be in direct communication with cisterns that retain water for domestic use.

These being the principal leading points on this part of our subject we may now pass on to

Materials.

Cisterns should always be made of materials that will resist the action of water. Because of decay and corrosion rendering them into a leaking condition, and also because the water may become contaminated with matter injurious to health. Where the water is very soft and highly ærated it will act on lead, dissolving some portion of it; and this water on being drank will have an injurious effect on the human system. If only 1-100th part of a grain of lead is taken dissolved in water no great harm would be done; but if water so charged is constantly drank serious results will follow. Lead is what is sometimes called a cumulative poison, and small quantities constantly taken will remain in the system and eventually afflict the person with palsy, colic, &c. One eminent doctor has been heard to state that certain cases of insanity have been attributed to lead poisoning.

Zinc is a metallic poison, and some authorities maintain that it is nearly, if not quite, as bad as lead. Hence the unwisdom of using this material for cisterns in cases where the water has a solvent action on it. Galvanised iron cisterns are quite as bad as those made of zinc. Indeed, it is an open question if they are not worse owing to the voltaic action that takes place if the zinc coating is disturbed so that the iron is exposed. Such cisterns are frequently found to have holes eaten through, although the other portions have appeared to be as perfect as when quite new.

Hard waters, such as those from the chalk, do not have an injurious effect on lead, but rather protect it from corrosion. When lead is pure it is not so much affected as when it is mixed with other metals. The greater portion of the lead used nowadays is alloyed with antimony, tin, zinc, &c., which results from old lead being re-used without first extracting those metals. This kind of lead is known to plumbers by its hardness. Plain iron cisterns soon become very rusty by the action of the water on them. Although the water from such cisterns is not actually poisonous it is generally very much discoloured. A coating of freshly slaked lime-wash acts as a preservative. If this is applied yearly the cisterns will last much longer and the water not be discoloured. A coating of Portland cement wash will also protect iron cisterns from corrosion.

Slate cisterns are looked upon with favour by some people, but they forget that the slabs are jointed together with oxide and carbonate of lead. If the angles of such cisterns are coated with pitch the water does not then come into contact with the lead cement used for joining. When slate cisterns are used extra care should be taken in protecting them against frost, as the water, on freezing, expands and breaks the slate slabs.

Cisterns for special use, for holding drinking water, are now made by manufacturers. Some of these are made of the same kind of materials and have glazed surfaces, similar to drain pipes. Others are made of fireclay and have the insides coated with white, or tinted enamel. These cisterns are undoubtedly good for holding drinking water, provided the enamelling is done without the use of lead compounds.

When iron cisterns are used and fixed on joists or bearers a wooden platform should always be made beneath the cisterns. This will prevent the bagging down of the bottom and also any strain on the pipe connections, which would make them leak.

Cisterns should be cleaned out at least once in three months, monthly would be better. Some people think yearly is quite sufficient, but if they took the trouble to see for themselves the amount of mud that accumulates in their cisterns they would alter their opinion.

The injurious effects of having different kinds of metals in connection with the water supply is not generally known. A very broad illustration of this came under the writer's notice in some nearly new houses—about twenty, on a west-end of London estate. Fig. 393 is a section of an angle of one of the cisterns showing the connection of the cold water service which supplied the hot water cylinder fixed in the kitchen about 50 ft. below. The cisterns were lined with 7 lb. lead and were 10 ft. long by 7 ft. broad. They had not been in use more than a year when they all began to leak at the same position. A minute examination showed the lead not to be in the least corroded excepting for a few inches round the above pipe. The piece of pipe A, in the Fig. was made of lead, because of the necessity for a soldered joint to the cistern, B being a gun metal union for connecting to the galvanised iron pipe C. The serrated lines represent the surfaces of the lead in the cistern and the inside of the lead pipe that were eaten away. Several days were spent at odd times in pondering over the cause of this, apparently, phenomena, and fellow tradesmen consulted. The unanimous opinion was that the lead was corroded by a voltaic action between zinc in solution in the water and the lead, caused as follows: At night when the kitchen fire was out and the water in the cylinder and boiler had cooled down so as to shrink to its ordinary bulk, the water in the cold service-pipe attacked the zinc lining of the iron pipe and dissolved some portion of it. On lighting the fire in the morning, no water having been drawn from the hot water pipes, the water expanded, so that some was forced back into the cistern. This water being saturated with zinc was a trifle heavier than ordinary water,

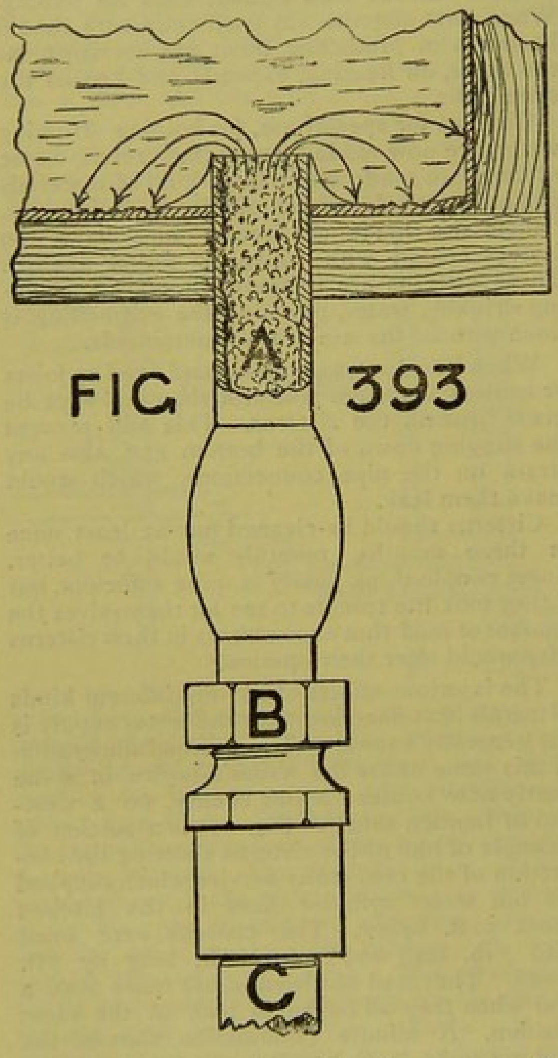


FIG. 393

and fell down as shown by the arrows. The side of the cistern, as shown by the upper arrow, was very slightly affected on the edge of the soldering, but the lead on the bottom was eaten almost entirely away for a distance of about 6 to 8 in. all round the pipe. Here we have zinc, iron, lead, and tin in contact with water, and there is not the least doubt that a voltaic action was set up, with the results described. Ever since this experience the writer has always used lead services to the hot water cylinder when the cisterns were lined with lead, and galvanised iron pipes when the cistern was made of that material.

It is highly probable that a frequent cause of corrosion of lead cisterns is the presence of some other metal, either in a solid state or in solution, in the water. Iron rust is often found at the bottom of cisterns, having passed from the iron mains with the water. From the fact that, generally speaking, the bottoms of lead cisterns are affected more than the sides, we are led to assume that the corrosion takes place from matters that gravitate to the bottom, thus tending to show that their specific gravity is greater than that of water. Metals, and some other matters, when dissolved in water, make it heavier. Mention was made in some of the earliest of these lectures as to the action that takes place, especially with soft waters, at the edges of the angle soldering in lead cisterns. Galvanised iron cisterns are also very much affected by the presence of other metals in the water; even plain iron cisterns are often affected in some parts more than others.

The practice of painting iron cisterns inside with preparations of lead cannot be too strongly condemned. Cisterns thus treated will often rust with more violence than if they had not been painted at all. Iron oxide paint is much better in this case than lead paint.

It has been suggested that if glass cisterns, made all in one piece, were used for holding water and fixed in suitable positions, there would be no difficulty in seeing when it was necessary to have them cleaned out. Neither is glass so liable to corrosion as the metals usually used for cistern work.

In places where the water is such that no corrosion takes place, metallic cisterns are the best to use for all-round purposes; but where such action sets up it is highly dangerous to use either lead, zinc, or galvanised iron cisterns for storing water for dietary purposes.

To prevent the sides of cisterns being forced out by the pressure of water in them it is important that they should be well braced together. This part of the subject should be under a separate heading. Not that we shall deal with the whole question of hydrostatics at the present time, but only so far as is necessary for our present purpose.

BRACING CISTERN SIDES.

TO make this part of our subject clear we must first consider certain physical properties in connection with water.

Water is composed of a number of molecules which can be separated from each other, and to such an extent that they may become so small as to be invisible, thus showing their diminutive size. These small atoms, although they have an affinity for each other, are each free to move in any direction, and will do so on the application of force. But if no force was brought to bear upon them they would remain stationary so long as they were supported, in any position. In this case force is not referred to as a mechanical power, but simply a natural property by which all matter is attracted to the earth's centre. This is called gravity. If an attempt were made to pile water up in a heap, or in the shape of a pyramid, it would be found to be impossible; for the water being composed of atoms which, quite independently of each other, are attracted by gravity and each atom is drawn downwards. But as two atoms cannot be in the same place at the same time, it follows that they roll over each other until they get to a something which stops them from going any further. If a boy were to attempt to make a pyramid with marbles he could do so, provided those on the margin of the base were "scotched," or placed on something so rough that they would not roll. But it is not so with water. The atoms may be as round as marbles, but water has no form of its own, and only adjusts itself to the shape of anything with which it comes in contact. A piece of polished glass has a rough surface, when seen through a microscope; but if water was poured onto it, when placed horizontally, all the small cavities would be filled with the water, the surface of which only would be smooth. If the piece of glass was fixed perfectly level the water would also be level, and of an equal depth throughout if we omit the depth of the cavities in the glass, which are too small to be measured. If the piece of glass had one end slightly raised the water would then run off at the lower end, being drawn downwards by gravity. Not that all the water would run off. The glass, if clean, would remain wetted by a small quantity remaining and kept there by the force of "adhesion." If the edges of the glass were slightly greased, more water could be placed upon it than if the glass had been perfectly clean; not that the grease acts as a "scotch," although it is so to a certain extent, but rather to the fact that there is no cappillary attraction between grease and water, with the result that the water is repelled instead of being drawn towards the grease. But if sufficient water were poured on the glass so as to stand higher than the grease on the edges, and high enough to overcome the repulsion of the grease, the excess of water would flow over the edges of the glass and run away to some lower level. This would take place all round the edges of the glass, showing that the force of gravity is acting at all parts at the same instant of time.

The atoms of which water is composed are free to move in any direction. If a vessel is partly filled with water and then more is added, that already in the vessel would have some of its atoms pushed aside to make room for that added; but the whole body of the water would be

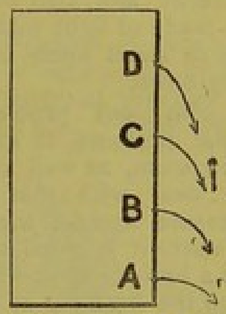


FIG 394

increased in volume and would stand at a higher level in the vessel. But the surface would be horizontal, no part being raised higher than another, excepting at the point of contact between the surface of the water and the sides of the vessel. This part being slightly raised by the action of capillarity. If the vessel were made of porous material water would be found to ooze through in all directions, but with greater speed at the bottom, and sides near the bottom, than at higher places. If the vessel had holes made in it, as shown by Fig. 394, and the height of water in it kept at a constant level, water would run out of the hole A, much faster than any of the others. B would discharge water faster than C; and C, than D. The reason of the water running out of the holes, no matter their size, is because of the attraction of gravitation. Water flows out of A, faster than the other holes because of the weight of the water above pressing downwards. Hence, the greater the depth or head of water, the greater the speed at which it escapes though the openings. And by the same rule, the greater the depth of water the more pressure is exerted against the sides of the vessel which holds it. The shape and plan of the vessel, or cistern, have no bearing on the matter, and it is only the pressure due to head or depth that have to be considered. From these remarks it will be gleaned that the water presses in all directions, and the pressure of water in a cistern is greatest on the bottom and the sides close to the bottom than at other parts, and is reduced gradually as the surface of the water is approached. To make this more clear, we will assume an elementary problem first. Supposing we had an open cistern filled to the brim with water, the cistern being 6 ft. deep. Water presses with a force of 62·5 lbs. on each square foot, and ·434 lbs. on each square inch of surface for each foot of head or depth. If we multiply 62·5 lbs. by 6 ft., we find that a total of 375 lbs. is pressing on each square foot of the cistern bottom. If we further assume that the cistern is 3 ft. by 2 ft., we find the area of the bottom to be 6 ft., which, multiplied by the 375 lbs. gives a total pressure on the bottom only of 2,250 lbs. This being really the actual weight of the water.

We may here pause for an instant to again draw attention to the importance of having good supports to cisterns, and also of having platforms for those made of light material, such as galvanised iron, to stand upon to prevent the bottoms bagging down.

To proceed with our problem, we have already seen that pressure is exerted against the sides of the cistern, as well as the bottom, and we must deal with that as well. In calculating pressure against the sides of any vessel holding water it is usual to take a mean of the depth as a basis to work with. Although water presses on the bottom, as above stated, at the surface the pressure is nothing; so, if we now take the 375 lbs. as pressing on each square foot of the cistern bottom + 0 for that at the water surface and ÷ 2, we get a mean pressure of 187·5 lbs. on each square foot of the sides of the cistern. To find the total pressure inside the cistern we proceed to first find the area of the sides. By collecting the dimensions thus: 3 ft. + 2 ft. + 3 ft. + 2 ft, we find that there are 10 ft. girt inside the cistern, which × 6 ft., the depth, gives a total of 60 square feet, which × 187·5 lbs. gives us 11,250 lbs. as pressing against the sides only. This, added to the pressure on the bottom, shows a total of 13,500 lbs. pressing against the sides and bottom of the cistern. It is here necessary to draw attention to the difference between "weight" and "pressure," as applied to this branch of our subject. "Weight" means a ponderous mass; something heavy; that which weighs down, &c. "Pressure," the force of one body acting on another. In our problem we have 2,250 lbs. "weight" of water exercising a "pressure," which is distributed over the whole inside area of the cistern, of 13,500 lbs. Thus showing that the two terms must not be confounded. We shall have more to say on pressure at a future time. We will now deal with pressure on cistern sides and its results.

Cisterns are frequently made for holding water and no thought whatever given to the importance of properly "staying" them to resist internal pressure. Wooden cisterns, when to be lined with sheet metal, have dovetailed angles; but this kind of joint only resists pressure in one direction. Hence the frequency of finding them broken, or gaping open; and the metallic lining being left without any support, torn or cracked. The centre of the sides also will bulge outwards by the inside pressure of water, and as the cistern empties they will spring back, or nearly so, to their original position. This rocking motion, if I can make myself understood by that term, will cause the metallic lining to crack near the bottom. In the case of a lead lined cistern this crack is generally found on the top edge of the soldering near the bottom. Galvanised iron cisterns will often leak at the rivetting to the bottom or upright angles. Slate cisterns will crack, or the joints start leaking. To prevent these failures occurring, all cisterns should be well braced or stayed together, and the ties should be placed in the positions where they are of the most use. And not only that, but the cisterns should be made of good stout material. Wooden casings for metallic lined

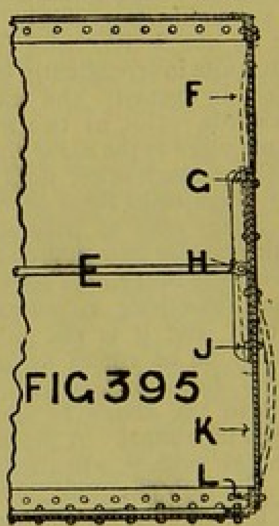


FIG. 395

cisterns should never be less than 1½ in. to 2 in. thick, excepting where they are very small in size. Galvanised iron cisterns of a small size should be made out of not less than ⅛th plate. What may be called a medium size iron cistern should be made of 3-16th plate, and one of 300 or 400 gals. should have not less than ¼ in. thick iron plate sides and bottom, and rivetted to good strong angle irons. A rim round the top should always be fixed to strengthen the edge. Two or three lectures could be devoted to this subject with advantage, but we can only afford time to give a few examples to illustrate a few leading points in "staying" cisterns.

Fig. 395 is a fragment of a side of a wrought-iron cistern with angle irons at top and bottom. The usual practice is to fix a tie across, as shown at E, about halfway between the top and bottom. But the greatest pressure of water is not exerted on the sides at this point. If the cistern is full, and 6 ft. deep, by calculations we find that at F the pressure is $62\frac{1}{2}$ lbs. on each square foot of surface. At G, the pressure is 125 lbs.; at H, $187\frac{1}{2}$ lbs.; at J, 250 lbs.; K is $312\frac{1}{2}$ lbs., and L 375. By simple addition we then find that the pressure above the tie-rod E, is equal to 375 lbs., and below it $937\frac{1}{2}$ lbs. for each square foot of surface. The sides of cisterns so braced are sometimes found to be as shown by dotted lines.

By calculation we find the mean of pressure against the cistern sides is equal to nearly 219 lbs. per square foot, and this is exerted at a distance of 3 ft. 6 in. from the top, or about 6 in. below the position of the rod, as shown in the figure. In practice it is best to fix the rod 2-3rds of the depth down when measured from the top edge, as the cistern is very rarely filled so full as we have assumed.

If two tie-rods are used instead of one, as shown by Fig. 395, they should be fixed 2 ft. 6 in. and 4 ft. 6 in. respectively from the top edge, still assuming the cistern to be 6 ft. deep. For cisterns of other depths the above distances to be varied in proportion. For very deep cisterns it is sometimes necessary to fix three or four tie-rods in the depth, and for those of a large size, on plan, these rods should, in some cases, not exceed 2 to 3 ft. apart unless the materials of which the cisterns are made is strong enough to resist the pressure of the water against them. The pieces of angle, or T-iron to which the ends of the tie rods are bolted or rivetted, should also be

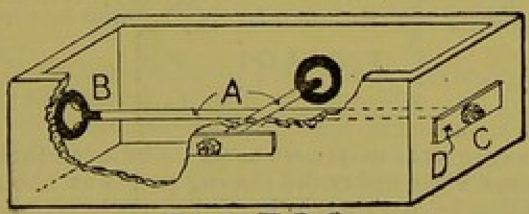


FIG 396

stronger than is usually fixed, and should be well rivetted to the cistern sides to prevent them be-torn asunder. In Fig. 395, this iron is shown with four rivets. In some cisterns only two rivets are used, and they are fixed near the ends some distance away from the tie-rod, where the greatest strain is exerted.

For metal-lined wood cisterns, the tie-rods should pass through pipes, as shown at A, Fig. 396, the ends being soldered to the sides as shown at B, and the iron bolts each having a head at one end. The other end being screwed and made to fit tight by means of a nut, as shown at C. Iron-plates should be fixed outside the cistern, as shown at D, so as to distribute the strain when being screwed up, and also the internal pressure when the cistern is filled with water. The writer some little time ago had to examine a very large lead-lined wood cistern, and by measurement he found that 225 ft. of pipe had been used for the iron-tie rods to pass through the number of soldered joints to the sides being 36. It may be considered to be a mistake to fix tie-rods in a cistern of this size, as workmen step on and bend them down when getting in and out. They are also in the way when working inside the cistern. The old-fashioned method of making a timbered

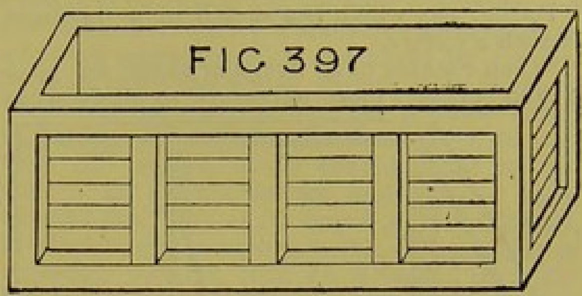


FIG 397

framework lined with boards would be much better. Such cisterns are frequently found in old mansions, and an example of one is shown by Fig. 397.

Fig. 398 is a sketch of an old lead battened cistern. These were made of cast lead plates which were soldered together at the angles when of a large size. When smaller, the front

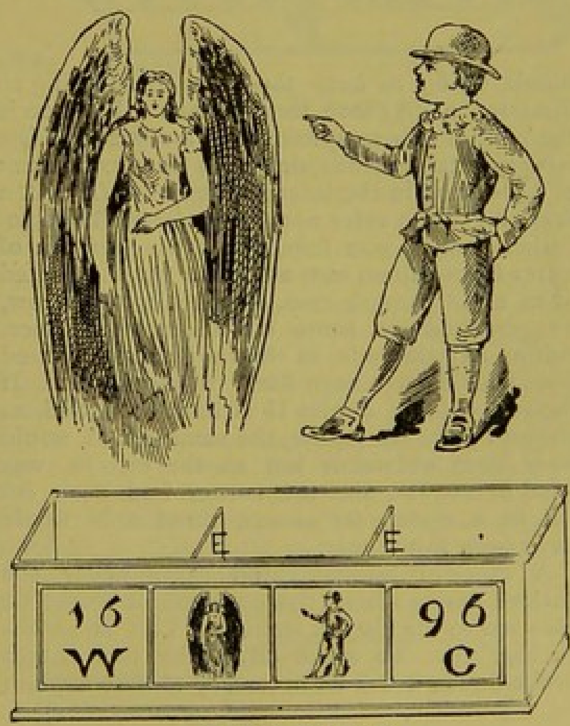


FIG 398

and ends were cast in one piece, generally with raised ornaments on the face. The backs and bottoms were cast plain and soldered on by "wiping" the angles inside. The cisterns were braced together as shown at E E in the figure by means of pieces of cast sheet lead, about $\frac{1}{4}$ in. to $\frac{3}{8}$ in. thick, the ends of which were wiped to the sides. A great many of this kind of cisterns are found in the older parts of London, and, generally speaking, are in very good condition, although some of them are nearly 200 years old.

When cisterns are made of cast iron plates, bolted together, and are of such a size as to require being bonded with ties, it is usual to connect the sides to the bottom, as shown at F F, Fig. 399, which is a sketch of a fragment of such a cistern.

When cisterns of an irregular shape are used it then becomes more necessary to study what

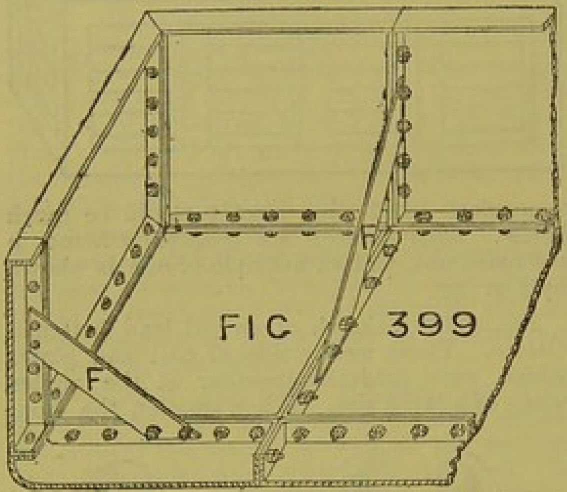


FIG 399

bonds to fix to keep the sides from being so distorted as to cause them to leak. Fig. 400 is the plan of an example of such a cistern. The writer's attention was drawn to this on account of its leaking in the internal angle at G. At a first glance the sides appear to be well tied together, but it was found that the pressure of water forced them out, as shown by the dotted lines, and the angle iron, denoted by the arrow, was cracked for some considerable distance. Additional tie rods, as shown by thick dotted lines should have been fixed to prevent this. If the two outside angles H H had been tied, as shown by the chain line, the same result would have been obtained; but as the cistern was fixed in a tower, and the corner had been cut out as a means for access, these rods would have been in the way.

A case of another kind came under the writer's notice where the omission of proper tie rods led to the cistern leaking. This is shown by Fig. 401. To make clear why this cistern broke down, it will be necessary to first explain that water not only presses downwards and sideways, but also upwards, when confined in any vessel. And the upward pressure is equal to that in other directions, when exerted at the same level. The cistern being made of wood, the upright angles could be dovetailed together. But this mode of joining, as usually practised,

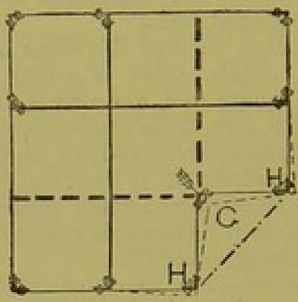


FIG 400

is only useful in one direction, and of no use at all unless the notches are cut a certain way with regard to the grain of the wood. The sloping side of the cistern could not be dovetailed to advantage, with the result that it was simply nailed at the ends, as shown in the figure. Screws would have been much better, but in

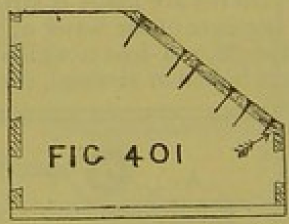


FIG 401

this case nails only were used. The mean pressure of water under the sloping part was about 846 lbs. in all, that is over the whole surface, and the result was the nails were partly drawn out and the boarding forced outwards, thus throwing the whole of the strain on the lead. Another source of weakness arose from the lead lining not being properly supported. When the cistern was empty the lead inside the sloping part bagged down and, on the cistern being again filled, was forced back to its original position, with the result that it cracked in the angle to which the arrow points.

CLEANING OUT CISTERNS.

OPINIONS vary very much on this topic, especially when metal or metallic lined cisterns are under consideration. It is impossible to draw clean water from a dirty cistern, hence the necessity of frequent cleansing. But in the case of lead cisterns it is sometimes argued that when scrubbing them the oxidised surface of the lead is removed, and a frequent repetition of the process will reduce the thickness of the metal. But this does not take place in the manner generally understood. Metallic lead can be scrubbed clean and no harm done, but if it is in a state of corrosion, as we so often find, and which is generally shown by white patches, scrubbing will remove these patches, but the lead is not affected by being cleansed so much as by the action of the water. Where lead is thus affected, the sooner it is cleaned the better, as the chemical action of the water on the parts that are corroded, dissolves some of the lead and takes it up in solution. Water so charged is dangerous to use for drinking. Zinc lined cisterns are affected in a similar manner.

In the case of galvanised iron cisterns the water will eat away, as we generally call it, the zinc coating, which can frequently be seen floating on the surface of the water, and having the appearance of a thin film of milk, which can be skimmed off. Some of this zinc will sink to the bottom, and a great deal become dissolved in the water.

Complaints are frequently made that cisterns leak after the plumbers have cleaned them out, and the unkind charge advanced that the men have done this for the sake of making more work for them to do. In such cases the mischief is done before the plumber is sent for, and the cisterns would have leaked at an early date, and thus necessitated his attention for repairs. In most cases the above charge is unfounded. Wherever the water acts on the metallic lining of cisterns precautions should be taken to prevent this action, but it should never be advanced as an excuse for not having them cleaned out. Better far spend a few shillings, or pounds, as the case may be, in repairing or renewing cisterns, than be poisoned by drinking bad or dirty water. My own cisterns are emptied once a week, and thoroughly scrubbed out once a month.

LINING CISTERNS WITH LEAD.

THIS subject was so fully dealt with in "Plumbing Practice" that it is difficult to say anything new on the matter; but for the sake of those who have not read that work it is proposed to make a few remarks on the proceedings.

In the first place the lead should never be of less substance than 6 lb. for the sides, and 7 lb. for the bottom. Seven pound sides and 8 lb. bottoms are better where the work is to be well done. In some cases 8 lb. and 10 lb. respectively, have been used. The lead should always be cut out from near the centre of the sheet, or at all events, some distance from the outer end, which is sometimes injured by being rolled over rough or gritty substances. Before the sheet is opened out the floor should always be carefully swept and search made for any stray clout nail that may be laying about, or if any nail-heads are standing up out of the floor. Either of these would cut a hole through the lead from the under side and not show sufficiently on the upper surface to be noticed, and thus lead to a lot of trouble after the cistern is lined, by resulting in a leakage. Careful measurements should be taken from the wooden cistern case, so that the lead may be cut out to the exact size and thus avoid any waste of material by being too large, or having to stretch the lead if cut too small. In addition to the dimensions of the inside of the cistern, margins have to be added for the laps at the angles and for turning over the top edge and to lay on the bottom. As an example, assume a cistern measured inside is 4 ft. long × 3ft. broad × 3 ft. deep. Such a cistern would be lined with three pieces of lead, namely, one for the bottom and two for the sides and ends, which would be cut out in pairs so that only two out of four of the upright angles would require to be soldered. The length of the two latter pieces would each = 4 ft. + 3 ft. + 2 in. (for the laps at the angles) or 7 ft. 2 in. long. The width equal to the depth of the cistern, with 2½ in. added for turning on the top edge and laying on the bottom, or 3 ft. 2½ in. in all. The bottom to be cut ⅛ in. less than the size of the cistern. Before cutting out the lead a square should be tried in the angles of the cistern to make sure that it is not "out o' square," or distorted. If all the sides and the bottom are found to be square, or at right angles to each other, the same tool must be used when marking out the lead. If the case is found to be out of shape by carelessness of the carpenter, or designedly so to suit the position it is to be fixed in, then a "bevel" should be used to take the angles properly and then

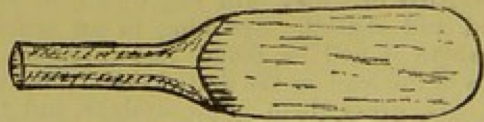


FIG 402

applied to the sheet of lead for marking out, so that the piece may be cut to the proper shape. A strip of wood or a straight lath is best for taking the dimensions of the sides and ends. After marking it out the lead should be carefully cut to the lines. This is sometimes slovenly done, with the result that the plumber gives himself unnecessary trouble by having to trim the edges afterwards. After the pieces of lead are cut out they should be laid on a smooth surface, either on the bench or on the floor, and "flapped" down nice and even. The "flapper," which is usually made out of a remnant of sheet lead with a handle formed as shown by Fig. 402, and having rounded corners, being preferable to using a "dresser," especially when the face of the latter is rough or much worn. Very few plumbers can dress out lead quite smooth without making tool marks, and young men almost invariably bruise it by digging in the heel of the dresser. When this tool is used it should be made of hornbeam in preference to boxwood, and the face should be rounded, both in its length and across the face. Neither should the "setting-in-arris" be so sharp as that on a dresser used for finishing off when lead laying on roofs.

After the lead has been so far prepared, the edges for the angles should be made quite straight, a "steel-faced jack-plane" is best for this purpose, and fresh lines made near the edges for creasing those that are to fit in the angles. As these lines have, of necessity, to be made on the upper face, they should be so measured for distance that the lead will fit its exact position, and not be too large. In other words, an allowance of from ⅛ in. to 3-16 in. must be allowed for the thickness of the lead in the upright angles. Otherwise the piece will fit too tight, and either disjoint the wooden casing or buckle out of shape. All the edges of the lead, excepting those which are to turn on the top of the cistern, should be rasped thin, or what is commonly called to a "feather-edge." From this point there are two methods of pro-

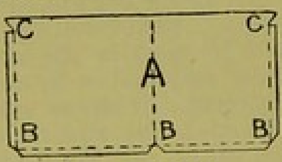
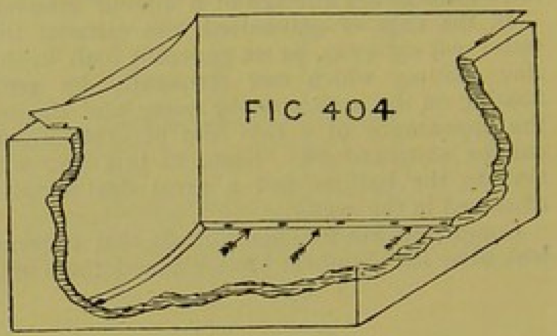


FIG 403

ceeding. A very skilful and neat workman will soil and shave all the parts that are to be joined together with solder, but anyone not so good will make a botch of it, and so spoil the prepared parts that they will require to be again soiled and shaved. Speaking to an ordinary craftsman it will be found best to crease the edges of the lead on the dotted lines, shown by Fig. 403, dress them quite straight, and then fold the piece as shown by the line A. The corners at B B being first cut off so as to meet in mitres when in their position. The corners C C being left for meeting in a similar way when the lead is folded over the top edge of the case. Some plumbers will score the lead on the dotted lines shown in the figure by ploughing a groove with the sharp point of a shave hook. By doing this tne lead is slightly reduced in thickness, and the edges can be folded up without distorting the lead or bruising it. The angle A should be creased and lightly "set in" with a dresser, but not scored on any account. The outside of the angle should then be dressed quite straight, so that it will fit the angle of the deal case, and not require any further setting in, which would perhaps reduce the substance of the lead. The piece, when so far prepared, should be folded slightly, so that it can be easily lifted into the cistern and after-



wards unfolded. The best way for doing this is to place the prepared corner in its position, fold the sides backwards, so that the ends can be pushed into their respective angles, when by pressing back the centre or bellied portions of the sides the lead is at once in its proper position without any dressing or use of tools. Fig. 404 shows one side in its position, and the bellying of the other side ready for pressing back. A mallet and dresser, or a "chasewedge," can now be used, as shown by the arrows, to drive in the return edges on the bottom, after which a few clout nails can be driven in as shown by the dots to hold the lead tight in the angle. The upright angles to be then treated in the same manner. The top edge should then be dressed over, care being taken to keep the arrises nice and straight, but on no account to work them up too sharp.

When folding the lead on the top edge care should also be taken to keep the sides from being pulled up so that the bottom edge is raised from its position. Some plumbers will score the back of the lead sides, on a level with the top edge of the cistern case, so that the lead will fold over easier; but this practice is bad and should not be followed. The other side and end should then be treated in a similar manner to the last, excepting that no nailing should be done in the upright angles. Or if it is found to be necessary to put in one or two to keep the lead from rising when working over the top edge, these nails should be driven in only half-way, so that they can be easily taken out again. Otherwise, the angles could not be properly shaved afterwards.

The bottom next claims our attention. The piece of lead should be cut to about 1-16th larger than the cistern, when measured inside the side linings, and the outside margins rasped down to "feather edges." The lead should be slightly bellied from the underside, either by the flat of the hand or by dropping it onto a sack of shavings. On then placing the piece of lead in the cistern case and pressing down the bellied part the edges will be forced tight against the sides. Great care should be exercised when doing this, as the solder will run through when wiping the angles if any openings are left. A, in Fig. 405, shows a section of the angle when finished. When cisterns of a large size are being lined, and the piece of lead for the bottom is so heavy that it cannot be easily handled; or if, when moving it about, there is a liability of the edges being damaged if prepared beforehand, it is then best to cut the lead about 1 in. too large and curl the edges upwards. The lead being then placed in its position and the edges chased into the angle as shown by the section B in last figure. The surplus to be cut off about ⅛ in. above the bottom, at the point to which the arrow directs.

After all the angles have been properly fitted they should be soiled about 4 in. wide on the upright and 6 in. on the bottom, the margins

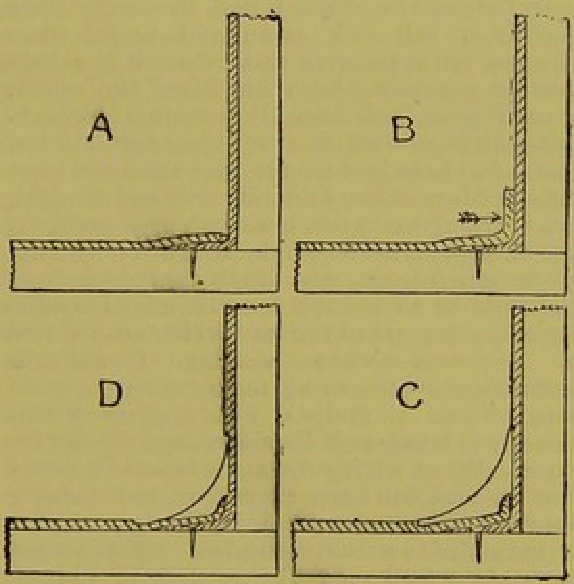


FIG 405

for the soiling being marked with a chalk line. A pair of compasses are often used for scribing a line for soiling to, but the points cut into the lead and for that reason the chalked lines are best. The "soil" or "smudge," as it is sometimes called, should be freshly made. When old it is not so good, and will rub off; in which case the solder will sometimes "tin" to the lead in an awkward manner. For the sake of the uninitiated I may here describe the usual process for making soil.

The ingredients are size or weak glue, lamp-black and chalk. About equal quantities of the two latter being ground up together until there are no lumps of chalk left. A little melted size should then be worked with the mixture until the whole is of the consistency of, and as smooth as, cream. A little water should then be added and the whole warmed up in the soil pot, but on no account should the soil be boiled, as it would destroy the properties of the size. A small-size glue pot, as used by joiners, is best for the purpose. The quantity of the size used generally depends upon the quality. If too much size is used the soil will peel off the lead in flakes when dry, and if too little is used the soil will rub off, and, in addition to its being no protection against the solder tinning to the lead where not wanted, the wiping cloth will get very dirty and thus smear the soldering, making it look black and unsightly. The soil is put on with a fair sized painter's sash tool. One that has been half worn out answers very well for the purpose, but all the paint must have been first washed out of it. Some plumbers will add a teaspoonful of brown sugar or a small quantity of porter or stout to the soil, but this makes it sticky and the solder does not slip over it nicely.

Before applying the soil the lead should be well chalked, to "kill the grease," and rubbed with a piece of clean rag, carpet, or a handful of wood shavings. If the soil is applied to a greasy surface it will not adhere properly. The soil should be dried after it is put on, by means of heated plumbers irons, and the practice of burning wood shavings should, for this purpose, be condemned. Not only because of the smoke, &c., being unpleasant to the plumber, especially in confined situations, but there is some risk of a fire occuring from the sparks that escape.

The shaving is usually done with a shave-hook which is half worn out and just the size to shave the lead angles the necessary width. The point of the hook should not be too sharp, or it will cut too deep into the lead at the edge of the shaving; and make it thin at that part. This rule should be strictly adhered to, as if the solder is wiped too bare at the edges those parts will be very weak. This applies more particularly to the top edges of the bottom soldering. Scores of cisterns are found with the side lead cracked or broken, close to the bottom soldering, after they have been in use for a few years. The reasons for this have been given before, but may be repeated, and the further explanation given that the lead sides are partly suspended from the top and partly supported on the bottom edges, but the centre portion rarely has any fixing at all. When the cistern is full of water, the lead is pushed outwards against the sides, but on being emptied the lead bags inwards. This motion eventually causes the lead to break at the positions referred to, and hence the necessity of not weakening them by reducing the substance of the lead. If a piece of cardboard is creased, and then bent backwards and forwards on the creasing, it will soon break through, and the lead in the positions referred to above is often broken in the same manner. When the lead sides have been supported by means of "soldered dots" to the wooden casing, or where "stay-rods" have been used, for bracing the cistern sides together, and the ends of the rod pipes soldered to the sides, the lead is frequently found to crack round the edges of the dots or soldered joints from the same cause. To prevent the bulging of the lead sides I have practiced as follows with advantage.

Place a piece of stout board upright and edgeways against the cistern side, in the position where it is necessary to support the lead, and firmly fix it there by struts or any other convenient method, but no nails must be used or driven into the cistern lead for this. Nail a strip of sheet lead on the board with the edge of the lead close to the cistern sides. Then soil, shave, and wipe as for an upright angle. The piece of lead being then cut off close to the soldering, and the piece of board removed.

No nails should be driven into the angles of a cistern, as the lead, if properly fitted, will not require any further fixing, and the nail heads will sometimes show through the soldering if wiped too bare. If nails are used they should first be warmed so as to ensure their being free from moisture. Otherwise steam will generate when wiping, and leave "blow-holes" in the soldering.

It is impossible to describe the whole of the operations gone through when wiping the angles of a cistern, and a man could no more learn how to do it from a written description than he could to play a violin by reading a book on music. A few hints is all that can be given on the subject.

In the first place, the solder should be good, and heated until the back of the hand would be scorched if held over a ladleful of it, but on no account should it ever be heated to redness. For putting on the solder a "splash stick" is generally used,, although a great many plumbers use a "pouring stick." This is made out of a dry piece of deal or other soft wood, about 6 in. to 9 in. long, by 1½ wide, and 1 in. thick, with a groove cut in it as Fig. 406. The stick is held in the left hand and the other hand holds a ladle, full of the heated solder, with the spout against the hollow in the centre of the stick. The solder is poured onto the stick, which at the same time is kept in constant motion so as to distribute the solder over the parts to be joined. This should be done quickly, but care should be taken not to pour continually upon any one place, which would, perhaps, melt the lead; nor pour at too great a distance, which would chill the solder. The upright angles of the cistern should be soldered first. As soon as the metal has been splashed or poured on, the plumber should take an iron heated to redness and hold it in the solder, drawing it slowly upwards, the wiping cloth following the iron so as to pull or push the solder upwards as it runs downwards by being heated. As soon as the metal is in such a condition that it will move by pressing the cloth against it, begin wiping from the top downwards, first wiping the part that lays on the top edge and then about a foot in length of the upright portion. This should be done quickly and the cloth held firmly, so that all the superfluous solder is removed and the edges left clean to the soiling. If the first wipe does not do this the cloth to be passed down again, pressing on it a little harder. If, after this, the margins of the solder are ragged and projecting onto the soiled part of the lead, it may be found necessary to heat and push all the solder back again and repeat the operation. If ragged edges are left they look unsightly, unless they are trimmed with a knife afterwards, and this cannot be too strongly condemned owing to the risk of the lead also being cut. After a portion of the angles has been wiped the next to be heated and finished, and so on, until the bottom is reached, when an old, useless, shave-hook should be used to drag away the spare solder which has accumulated. Some men can take longer "wipes" than others, but they, the wipes, should always be done as quickly as possible, and the second portion of the soldering should be done before the last has set.

If the solder is good and the work done quickly it will look clean and bright when finished, but if the man goes about it in a half-hearted way and "loses his heat," the solder, even if good, will look dirty owing to efforts being made to wipe it after it has partially set. Stress has been laid on the importance of leaving the edges of the soldering true and straight, but in trying to do this too much pressure must not be applied to the cloth, which would take off too much solder and leave the edges bare. It should be a fixed rule for all kinds of soldering that the parts of the lead which are reduced in thickness when shaving should be strengthened by leaving them entirely covered with solder. C and D, Fig. 405, show this clearly; C being as it should be, and D the reverse. When wiping the angle it will be found that the lead will keep expanding, and bulging outwards, when a longer time than is necessary is expended on the operation. The bulged parts of the lead should be gently pressed back by means of a small straight piece of wood, but this should be done before wiping. If done afterwards the soldering will crack down the centre and the cistern leak when filled with water. If an effort is made to push the lead by means of the wiping cloth, the lead being very soft when heated, will result in some parts being more prominent than others, when it becomes more difficult to make a true seam, and it becomes impossible to wipe the edges clean; some parts having no solder on them and others too much.

The cloth for cistern wiping should be about 3 in. by 3 in. for bold soldering, but for small cisterns, when shaved about ¾ in. to 1 in. each way, half an inch narrower works very well The cloth should be of a good thickness, so that the heat does not pass through to the hand, and also so that the centre finger only is necessary for pressing it into the angle. By having the cloth a good size the spare solder is pushed away as the wiping is done, and not only are the edges made clean, but there is less risk of the little finger of the wiping hand being burnt by the solder that will often cling to the soiling

To prevent this latter a little touch rubbed on the soiled parts is an advantage.

A common mistake made by young plumbers is to drench their cloths with grease and leave them lying about amongst dust, &c., until they are in such a dirty condition that it is impossible to make their soldering look clean and smart with them. A little grease on the wiping surface is all that is necessary. When working as a journeyman I frequently unfolded my cloths and boiled them in soda and water in an empty solder pot to clean them. When not in use they were always carefully put away in a small size bag, made of carpet, to keep them clean. Amongst other disadvantages of having too much grease are, that it gets almost to boiling point when using, which makes the cloths painful to hold, added to an injurious effect on the muscles in the palm of the hand. With too much grease in it the cloth is rendered very hard and stubborn, so that some time has always to be spent in warming it to make it pliable and bend easily to the shape of the soldering, either on a joint or in an angle. I find it very difficult to make student plumbers understand the folly of not keeping their wiping cloths clean and in workable condition, and also get them out of the slovenly habit of, when making a joint especially, constantly drawing the hot greasy cloth over the seat of their trousers, or some other portion of their dress, until it is so covered with fat that the material of which it is made cannot be seen.

To get back to our cistern wiping; after the upright angles have been done the bottom soldering comes next. With some plumbers it is usual, before commencing this, to put strips of pasted brown paper on the soldering in the upright angles for a few inches above the bottom ends, but an inch or two above the cistern bottom, so that when wiping round the latter there is less difficulty in getting past the corner. To ensure the bottom soldering alloying with the end of that in the angles, which has set and is cold, it is necessary that the heat shall be sufficient to render the whole into a plastic condition, so that after the wiping is done the join can scarcely be seen. Instead of using the pasted paper, which will often come off during the operation of wiping, some men will rub chalk over the angle soldering to prevent any of that on the bottom tinning to it too high up, which sometimes necessitates a considerable portion of it being re-wiped. Pasted paper and chalk both make dirty, unsightly marks on the solder, and for this reason a skilled workman, who takes a pride in his work, will succeed in getting past this portion of the bottom without using either on the upright parts. But it is scarcely safe for a younger man to attempt this, or he will find himself in a fix. A beginner should use the pasted paper until he gets to be very expert with the metal.

A few remarks on using the plumber's iron would, perhaps, here be of advantage. For cistern wiping they should be of a good size, so as to carry as much heat as possible, but not too large, or they will, when being used, scratch the soiling near the edge of the shaving. The solder will often "tin" to these scratched places. The bulbs of the irons should always be kept filed smooth. This is always the younger apprentice's or assistant's work, and

FIG 406

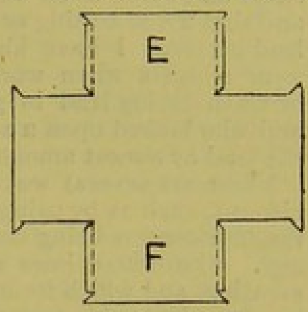


FIG 407

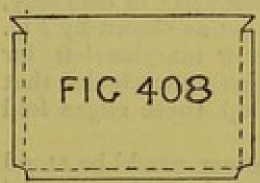


FIG 408

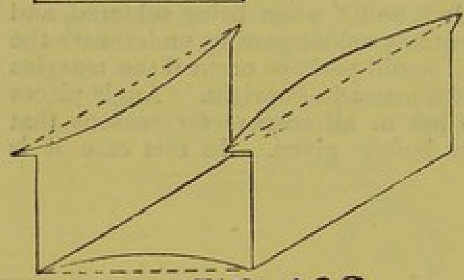


FIG 409

his industry can always be judged by the way he keeps his irons. One who is careless will put the irons in the fire and leave them there, without attention, until they get so heated that the outer surfaces will scale oft leaving indentions like pock-marks. When the surface of the iron is very rough it does not heat the solder so readily as when quite smooth. When the apprentice is found to be very careless in this matter it is a good plan to give him a drilling by refusing to use an iron that is not kept in proper order and insist upon him filing it smooth. He finds this a tiresome job, and leads him to pay more attention to its heating. Irons cost money, and it is a mistake to leave them in the fire until the bulbs are almost burnt away. A plumber can do more wiping in a cistern with one clean iron than with two, having rough surfaces. He can also make smarter looking work. Irons should never be heated above a bright red. If too hot they burn the solder, which will stick to the iron as dross, thus wasting it and making the soldering look dirty. The dross will also mix with the solder when wiping, and under certain conditions lead to a leakage of the cistern.

When a cistern bottom is being wiped, especially in the case of a small sized one, the plumber should move about, if he is inside it, with great care, and avoid all sudden or jerky motions which would, perhaps, crack the soldering before it was thoroughly set. It is also a good plan to kneel on a piece of clean dry board. This saves the knees from being burnt by any spare solder and helps to keep the lead from rising by the expansion, which invariably takes place when soldering. If the workman has nails in his boots, or steel points or brads, which are worse than nails, he should always stand on boards when working inside a cistern and thus avoid cutting or otherwise injuring the lead bottom. I have known men who would wear slippers when working inside a cistern or when laying lead in gutters or on flat roofs, and who looked upon a scratch or tool mark on the lead as almost amounting to a crime.

There are several ways for lining small size cisterns, such as by using one piece of lead only, the four corners being cut out as shown by Fig. 407. The dotted lines show margins left for creasing, and which form the undercloaks, that is, when the lead is folded up these edges fold outside the other side.

Cisterns lined in this manner would be stood on the ends E and F when being soldered, and thus prevent any solder getting underneath the lead, which would perhaps occur if the margins were laid flat instead of upright. Angle pieces should be left at all corners for reasons that have been before given. In this case it is assumed that the cistern can be lined before being fixed.

Another way for lining a small cistern is to cut the bottom and sides out of one piece of lead and the two ends separately. A cistern thus lined should have the ends put in first, they each being cut as Fig. 408, and creased on the dotted lines. The bottom and sides would appear as Fig. 409, when folded ready for dropping into the cistern case, the bellying in the bottom and sides to be pressed down and back after being placed in its position. Cisterns thus lined can have the lead soiled and shaved before placing it in the deal case. But this should not be done if some time is to elapse before the soldering is executed. Neither should any touch be rubbed on the shaved edges until the lead is fixed ready for soldering. No nails should be driven into any of the angles, and those in the top edge should be of copper in preference to iron.

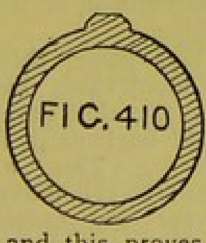
In these few remarks we have dealt with most of the leading points with regard to lining cisterns, and I do not think it necessary to proceed any further with this branch of our subject. Rising mains and service pipes will next have our attention.

RISING MAINS AND SERVICE PIPES.

WE will deal with rising pipes first and assume that the water is supplied from a main in connection with a waterworks or reservoir. In country mansions we sometimes find several branch pipes, from a main running round the houses, supplying the cisterns in their various positions, but in town houses it is usual to fix only one pipe. In London, within the writer's recollection, for large houses two mains were fixed, one being called the "high pressure" and the other the "low pressure." The latter supplying the basement and ground floor cisterns and the former all those above the ground floor level. But this practice is now abandoned by most, if not all, of the companies who supply the water, owing to improvements they have made in their pumping arrangements. The sizes of the house mains used to be, in lofty houses, 1½ in. or 2 in. for high service, and 1 in. or 1¼ in. for low service, but in later years these sizes have been considerably reduced. Other improvements that have been made in some parts, and in progress in others, of London, is the substitution of a "constant" for an "intermittent" supply. In the former case the cisterns fill again immediately any water is drawn out, and in the latter they are filled up once each day, the water being turned on in the main for a short time for that purpose. For ordinary sized houses, with a constant supply, ½ in. and ¾ in. pipes are now generally used, but in some cases, where the houses are very lofty, and the top cisterns are nearly level with the reservoir, or source of supply, it is advisable to use pipes of a larger size. It is found in practice that at certain times of the day so much water is being used that the lower cistern ball valves are nearly always running; this so reduces the pressure in the main that the water will not rise to the higher levels. When little or no water is being used, during the night time for instance, and the lower ball valves are closed, the pres- is often found to be sufficient to fill the upper cisterns, but the pipe should be of a good size to ensure their filling as quickly as possible in case the pressure should be reduced by any cause, such as when a plug is opened to supply a fire engine.

The advantages of a constant supply are that the cisterns need not be of a large size; that fresh water is always available in preference to that which has been stored until it had become so stagnant as to be unfit for using; and in some cases where cisterns may be said to be unnecessary the water being drawn directly from the street main. In an earlier lecture reasons were given for having a cistern or cisterns in all cases, owing to the liabity of a breakdown, or the water being turned off at the street main for any repairs that may be necessary to the pipes or fittings.

Lead pipes are generally used for rising mains. Most of the water companies insist upon this, but iron and galvanised iron are sometimes used. Where the water does not attack the lead to any great extent lead is the best material for the purpose. More water will pass through a lead pipe than through either of the other kinds in a given time, assuming that all other conditions are equal. This is owing to its smoothness inside and, when properly fixed, the absence of any sharp elbows or bends or arrises at the joints. An iron pipe will so rust inside that the water way is considerably reduced. The roughness of the rusted inside surface will also retard the velocity of the water, the friction being so great as to reduce the quantity of water delivered by perhaps 50 per cent. when compared with a new pipe, or one of lead. Iron pipes, protected by galvanising, are always rough inside, and the zinc coating only lasts for a time. Lead has also the advantage that it can easily be fixed and will resist the action of moisture on the outside when buried in the ground, whereas iron will rust, unless protected by being covered with pitch or other suitable material. Lead services when laid underground should never have any lime near them, which will reduce them to a carbonic di-oxide of lead. Old mortar will be found quite as destructive as lime. Ordinary earth does not act on lead, and pipes laid in yellow clay have been found nearly as good as new, as seen on the outside, after having been buried perhaps a hundred years or more. The writer, a few years ago, took up some hundreds of yards of 4 in., 5 in., and 6 in. lead main that had been in use quite the above time. Some portions, which had been enveloped in clay, were found to be in very good condition, but other portions were very much corroded, especially where found near old buried walls and foundations of buildings which had disappeared years ago in an historical part of London. Fig. 410 is a a seciion of this old pipe. The seam was

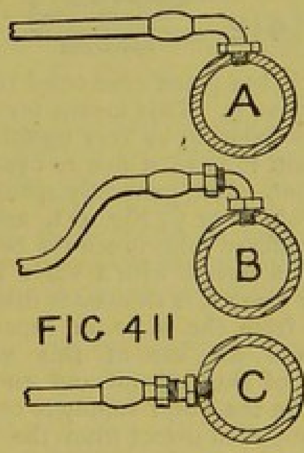


"ladle burnt," and this proves to us that the ordinary way of burning up pump barrels, as still practiced in some parts of the country, has been handed down to us from our forefathers, and that in some things we have not made much progress in the trade of plumbing.

We will now follow the service from the street to the cisterns, and begin at the connection with the street main pipe. This pipe is now almost invariably made of cast iron, in some cases coated with what is commonly known as Dr. Angus Smith's solution to keep it from rusting. Some water companies coat these pipes inside with a wash made of freshly slaked lime before laying them, but others use them as they come from the foundry. Such pipes rust inside to a considerable extent. Some of the rust will at times pass from the main into the house branches, and this is a frequent cause of the "stop" and "ball valves" leaking. Reference was made, in an earlier lecture to iron rust being found in cistern bottoms, and the corrosive action that follows with the metals of which the cisterns are made.

There are various methods for connecting the branches to the main service. Some of these, such as by "Coberg's," "driving ferrules," &c., although common enough some years ago are now obsolete, so we need not waste any space in describing them. Neither need we stay to describe all the modern fittings used. Those that are in most constant use will be sufficient for our purpose.

A, Fig. 411, is what is known as an "elbow-screw ferrule," but this kind is never used, ex-



cepting for very cheap work. The objection to it is the disadvantage of having to make the soldered joint after the ferrule has been fixed, which must be done owing to the difficulty of screwing it into the iron main after it has been soldered to the lead pipe. Some plumbers will solder a short piece of lead pipe to the ferrule, but as this necessitates two joints being made, instead of one, time and material are both wasted. More time is also taken in making the connection to the main and one of the joints has of necessity to be made in the trench in which the pipe is laid. B, in the figure, is an "elbow-screw ferrule with union." This can be soldered onto the end of a coil of pipe in the workshop and afterwards taken to its position and unrolled in the trench which has been prepared for it. One half of the ferrule having been fixed to the iron main and the union, which has been soldered on the end of the lead pipe, having been screwed on to it, the job is completed so far as making the connection goes. C is a "straight screwed ferrule with union." This is generally used when the iron main is under a road and is not very deep beneath the surface. When this ferrule is used the lead pipe should be laid zig-zag for a short distance to avoid any strain on the connection, which would be the case if the pipe were laid perfectly straight. This ferrule has also an advantage in that, the lead pipe can, generally speaking, be laid with a fall to the iron main, so that all water will drain out when the main is shut off. In nearly all cases with the elbow ferrule, the pipe is bent down, as shown at B in the figure, so that it is impossible for all the water to drain out.

Fig. 412 is a ferrule for joining a lead service pipe to an iron main without any soldering. A brass cap and lining is slipped over he end of the lead pipe, which is then opened by means of a "tan-pin." This is then screwed onto the

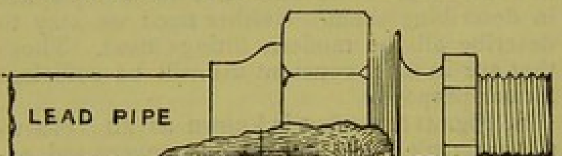


FIG 412

ferrule which has been connected to the main ready to receive it. This means for connecting is sometimes found to be very useful where it is not convenient to have a fire to heat solder for making a joint. But, generally speaking, I prefer the ferrule B or C, Fig. 411, and consider the wiped soldered joint much the best.

Fig. 413 is a ferrule with a valve attached to it. In some cases it is desired to disconnect the service pipe from the main, or repairs may be necessary and the use of this valve saves the trouble of shutting off and emptying the main. Where the water supply is constant and houses are supplied direct from the main, it is very inconvenient for the water to a whole street or district to be cut off during the time a service pipe is being repaired. In such cases this valve is of great advantage. The valve is protected by means of a cast iron cover, as shown by dotted lines.

If any bends are made in a service they should always be laid horizontally. When they are made up and down air will get into the higher parts, the pipe will then be what is called "air bound," and, under certain conditions, no water at all will pass through. For the same reason the bottom of the pipe trench should always be carefully trimmed so that there are no bumps or hollows. When services are laid beneath newly made roads, over which there is a great deal of traffic, the pipes will frequently break through from the vibration that takes place. The fractures will nearly always be found where the pipe enters the building. It was a long time before the writer could account for this, and the first examples that came under his notice he attributed to the presence of some dross in the lead, of which the pipe was made. But when he found the same thing occur at exactly the same position in nearly every house on the side of a London square he came to the conclusion that the evil resulted from the lead service pipe being built in the cellar wall. This held a portion of the pipe quite rigid, but that beyond and under the street was in a constant state of quivering caused by the traffic over it. This was doubtless the cause of the pipe breaking asunder. The fractured ends were at right angles to the pipe, and were as clean as if they had been cut with a fine toothed saw. The above conclusion was fortified by the fact that, in a few cases, the bricklayer had not made good the holes in the walls through which the pipes passed, and in these cases there were no fractures in the pipes. This experience tends to show that, under the conditions stated, the service pipe under the street should not have any portion fixed too tightly, and neither should it be laid perfectly straight. It being an advantage to have bends or a little "slack," as it is

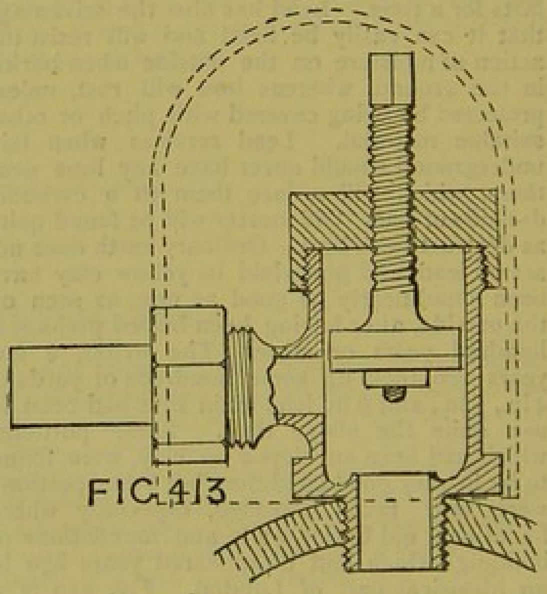


FIG. 413

sometimes called, to allow for any movement, or it may be a settlement, of the ground which surrounds the pipe.

Where the pipe passes through an outside wall, in a great many cases this is the wall of the vault under the side pavement, a piece of drain pipe should be built in for the lead pipe to pass through. This will, if properly arranged, prevent the evil above referred to, and will also prevent any contact between the mortar in the wall and the lead pipe, which would set up a corrosive action.

In most cases it will be found necessary to puddle with clay the annular space between the pipes to prevent any rain water which would filter though the ground into the pipe trench and, following the course it took, run through the hole in the wall into the vault or building.

All pipes laid outside a house should be so far beneath the surface that frost will not penetrate to them. Two feet six inches is generally considered the necessary depth, but pipes should never be less than 2 ft. deep if in hard, and 3 ft. in soft, ground. I am given to understand that in some parts of America it is necessary to have water pipes 5 ft. to be beyond the reach of the severe frosts that take place there. With some water companies or corporations it is the rule to fix a stop cock in the pavement, or other suitable position outside the house. A cock box being fixed over for giving access for shutting off the cock, a long socket or Tee-key being used for that purpose. To prevent the earth falling in and smothering up the cock a small brick chamber is sometimes built. When this is done the bottom of the chamber, and a course or two of the brickwork above the bottom, should be laid dry, that is, without any mortar or cement. This will allow any water, from rain or other cause, that may get into the chamber to soak away into the ground. The omission of this precaution will sometimes render the stop cock useless, as, during a frost, this water will freeze, when it will be found almost impossible to thaw it, and lead to the necessity of taking up the pavement and digging down to the cock for thawing it prior to closing it. Sometimes the brick eyes round the stop cocks are packed with dung or stable litter to prevent frost reaching them. Dung may be good, but for obvious reasons hay or straw commends itself as being more suitable from a sanitary point of view.

The cock in the street is generally under the control of the waterworks official, but it is always advisable to have a second one inside the house easily accessible by the occupiers. This cock should be fixed as near the point of entry as possible, so that the whole of the pipe inside the house is controlled by it. In some houses a branch from the main is taken to a cistern in the vault under the pavement, and in most cases this branch is at such a low level that all water in the main can be drained out of it. Where this is not the case it is advisable to fix a small bib cock or valve, especially for emptying the house main when the stop cock is

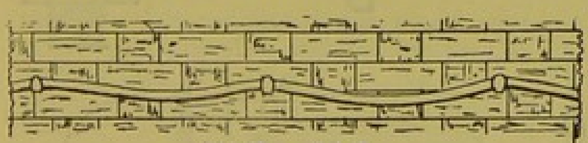


FIG 414

closed. Where pipes are so exposed that the water in them is liable to be frozen it is useless to shut off the stop cock unless the whole of the water can be drawn off. For this reason the emptying cock is of quite as much importance as the stop cock. The omission of the former cock often gives the plumber extra trouble when necessary to make any repairs to the main service pipe, he having to make a hole with a nail or bradawl, and catch the escaping water in a pail, to empty the pipe before he can make the repairs.

The service pipe from the cocks should be laid with an inclination, so that all the water can be drained out of it, and if the pipe has to cross an area or open space it should be encased and packed with some non-conducting material to prevent injury or being frozen. Horizontal service pipes are usually fixed on "wall" or "pipe" hooks. The wall hooks are best for this purpose, as the narrow stems of the pipe hooks cut into the lead. Neither of these fixings can be considered as quite satisfactory, as the pipe will sag down between them, as shown by Fig. 414, when fixed horizontally. The better plan is to fix a wooden fillet on the wall and lay the pipe on it, as shown by Fig. 415. A section is also given showing the fillet hollowed on the top to prevent the pipe slipping off.

When wall hooks are used for fixing vertical service pipes they have to be driven in so tight as to bruise the pipe, and thus contract its

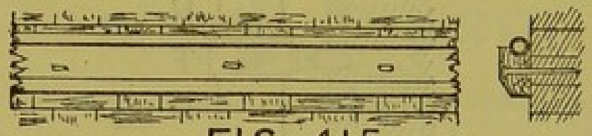


FIG 415

waterway. Another evil sometimes crops up by the sharp edge of the head of the wall hook cutting into the pipe, or slicing off a piece, as shown at D, Fig. 416. Some first class plumbers will solder tacks or lugs on to the pipe and drive pipe nails through them into the wall. Others will solder lead flanges or collars

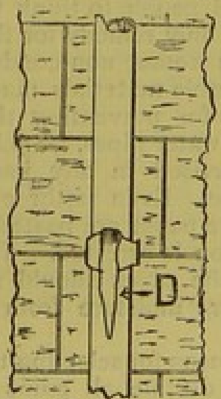


FIG 416

on to the pipes and drive in special made hooks beneath and close to the flanges. Both these methods are good, as the pipes are not injured in any way. Some architects have all vertical service pipes fixed as shown by Fig. 417. It will be noticed that the pipe is fixed clear of the wall, so that it is accessible all round. The bracket E is cut and pinned into the wall, and the clip F is in two halves, which are held together by the bolts G. H is a narrow lead flange soldered onto the pipe to prevent it slipping down. By some this may be considered rather expensive, but those who are far seeing will appreciate its value and anticipate a saving in any future cost for repairs or renewals.

The positions of service pipes should always be well considered. The noise made by water running through pipes is a frequent cause of complaint. This noise is not generated so much in the pipes themselves as in the stop and ball cocks. This we shall refer to again presently. But in whatever part of the service the sound has its origin the pipe acts as a kind of telephone, so that for this reason no pipes should ever be fixed in or near living or sleeping rooms, or other places where the sound is objectionable.

Amongst other reasons for not fixing pipes in the above named places are, that under certain conditions of the atmosphere a great deal of moisture will condense on the services and run

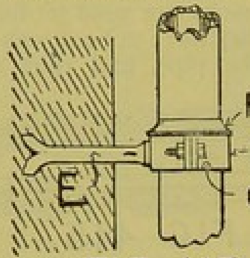


FIG 417

down the walls or drip onto the floors. A great many people call this "sweating," and are under the impression that the pipes are so porous that the water is oozing through them. Cases have occurred where the plumber has been sent for to repair the pipes when the above action has lead people to think that they were leaking. The only remedy for this is to encase the pipe with some non-conducting matter. There are suitable materials made for this purpose and also for preventing the radiation of heat from hot water pipes. Such materials can be found advertised in any journal connected with the trade. Even if three or four thicknesses of brown paper are pasted onto the pipes the above action is arrested. But whether encased or not, the pipes should not be fixed in any place where moisture from them would be a nuisance.

A further reason for selecting the positions for pipes, is that, despite all pains and care that may be taken with them, there is always a liability of a breakdown. Even a hole the size of a pin in a pipe will allow sufficient water to escape to do a great deal of damage to furniture, ceilings, and other parts of a house.

To prevent the condensation referred to above, the pipes are sometimes embedded in the walls, or perhaps, fixed on the brickwork and then covered with the plastering. This should never be done as there is always a risk of some one, who did not know of the presence of the pipes, driving a nail into them. The writer knew of a case where a row of nails, for hanging pictures on, were driven through a leaden service pipe so embedded in a wall. Other examples come to memory but a great many readers doubtless have had similar experiences so we need not refer to anymore.

The evil effects of exposing water pipes to the action of frost have already been referred to, and it is assumed that any thinking reader will know, from what has been said, what precautions to take to prevent the pipes being injured, or the water supply interrupted by such action which can always be anticipated.

We can now go back over our subject and deal with the strength of the pipes used for rising mains to cisterns, also with a few examples of ball and stop cocks, &c.

On referring back to previous lectures, I find that the thickness and weights of lead pipes, and the pressure at which lead and lead encased tin pipes burst, have been fully dealt with. A good deal was also said on wiped joints to lead pipes, but a few additional remarks on this subject can be made with advantage. One of the first points to be dealt with refers to the joints between the pipes and pieces of brasswork. The latter are generally made so short that the joints cannot be properly made, by reason of the thickest part not being where the most strength is wanted. Fig. 418, which is shown partly in section and partly in elevation, will explain this.

Assuming A to be a joint on a union to an elbow screw ferrule for connecting to a water main, owing to the shortness of the brass lining,

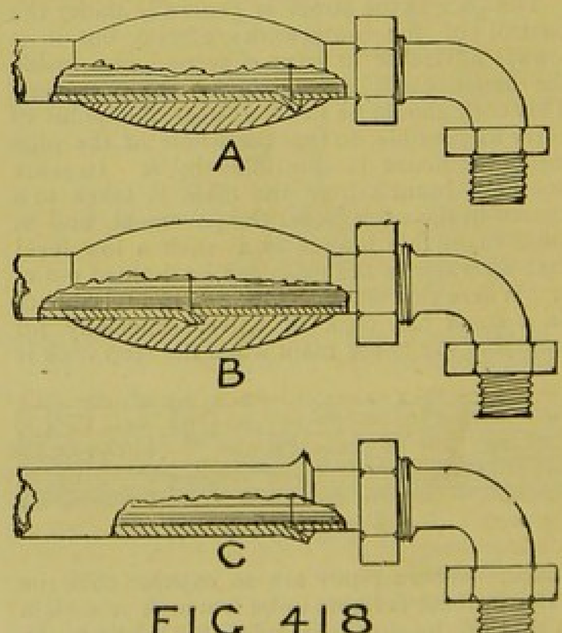


FIG 418

scarcely any solder is over the part that sockets into the lead pipe. If the brass lining had been made its proper length, the solder would then have extended onto it to the same distance as onto the lead, thus bringing the thickest part of the joint over the place where the strength is most needed. This is illustrated by the sketch B, in the same figure, which is also partly in section. Joints made as shown by A, have sometimes broken asunder by the strain brought to bear when screwing up the unions. The sketch C is a blowpipe, or copper bit joint, which is here shown for comparing with the wiped joints, and to illustrate the difference between the two kinds. The same remarks apply to joints on stop-cocks. The only fixings for those fittings are the joints, so that when opening or shutting the cocks, they are liable to become disjointed if the soldering is not strongly done.

We will go further in our comparison of joints, and consider wiped branch joints with those made with a copper bit, onto the bosses of bib-cocks. D, in Fig. 419, shows a properly-wiped joint, and the lead pipe, which is made thinner at the sides when the opening is being made, strengthened by the covering of solder. E, in the same figure, is a copper-bit joint. These illustrations speak more plainly than words as to the merits and demerits of each kind of joint; and there cannot be two opinions as to which is best or strongest. There are some so-called plumbers, who prefer the copper-bit joint, but it is because they are such poor wretched trades-

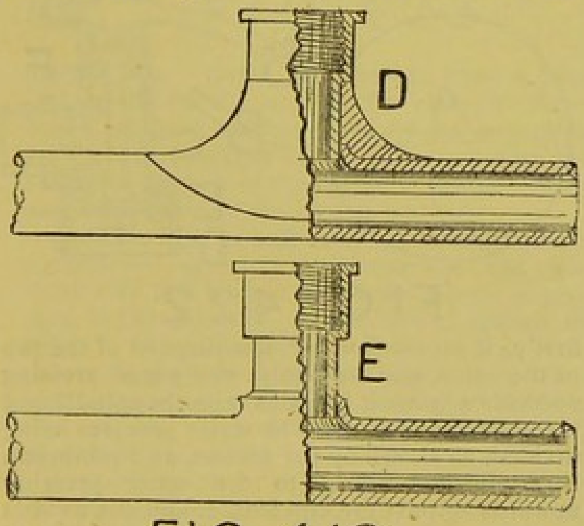


FIG 419

men that they cannot make a wiped ioint, and mask their ignorance and unskilfulness by protesting that the others are the best. The writer meets with many such people in his travels. Now we are on branch joints, it will be well to explain how necessany it is to be careful when making the hole in the side of a lead pipe preparatory to making a branch joint. This is frequently carelessly done, and some of the mistakes are illustrated by Fig. 420, in which F is a longitudinal, and G a cross section of a piece of pipe after it has been opened. The "bolt," see Fig. 41, in an earlier lecture, should be so bent that the end can be placed inside the pipe and the lead worked up as shown at *a a*, sketch H, instead of being driven sideway as at *b b*, sketch F. The bent bolt, if it is rough, should be made quite smooth at the end and held in a proper manner when opening the sides of the hole, otherwise the inside of the pipe will be bruised or indented, as shown at *c c*, in section G. To make the hole quite round the "tan-pin," Fig. 35, is generally used, and if care is not taken the point will bruise the bottom side of the pipe, as shown at *d* in sections G and F, and the top side of the pipe driven inwards, as shown at *e*, in section F. The velocity of water running through pipes is retarded by any roughness or projections inside, and also by any sudden bends or turns. For this reason the hole for branching any bib or draw-off valve should always be opened out as much as possible so that the boss can be kept some dis-

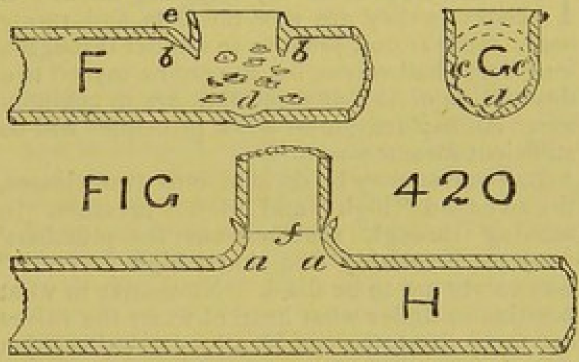


FIG 420

tance back, as shown at *f*, section H. The water in passing through would then have to turn a less sudden corner than it would if the hole had been opened as shown by section F.

When a leaden pipe is branched into another of the same material, the plumber can make his branches as nearly as possible follow the lines of bends. Fig. 421 explains this. The dotted lines show the shape of the pipes inside the soldering. To prepare the pipes for this kind of joint, the piece for the branch should have its end bent. If in doing this the throat of the bend should buckle, or contract, a little the bolt should be used to work it out again. The end of the pipe should then be sawn off at the right angle and, if the piece of work is "set out" on the bench with a few chalk lines, this is easily

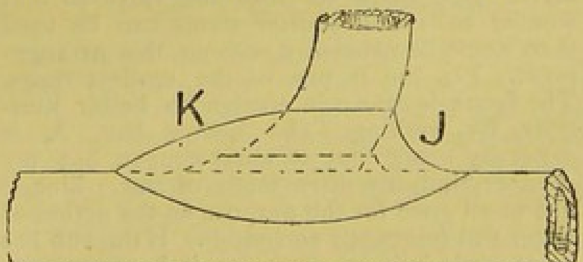


FIG 421

done. The hole could then be marked in the proper position, and of the right size, on the other piece of pipe and the joint prepared and made as in the ordinary manner. The only oint of importance to remember when making a joint of this kind, is to wipe all the solder off that is possible in the acute angle at J and leave a good body, or thickness, on at K. In practice the opposite is usually done, so that when finished the joint looks as if the branch was at right angles to the main, and the part at K has little or no solder on it, thus leaving that the weakest part of the joint.

We can now pass on to brasswork used by plumbers and, to make our subject continuous, deal with "ball," "stop," and "bib" valves only at this stage. Other kinds of brasswork will be dealt with at a future time.

BALL VALVES.

I DO not propose to say anything about ball cocks as they are now obsolete and rarely used. Neither do I propose to wander through a long list of ball valves, but to confine myself to a description of two or three that are in common use. An explanation of a few principles will be sufficient for our purpose.

Ball valves may be divided into two classes, the so-called "high" and "low" pressure. In reading through specifications for plumbers' work we invariably find that "high pressure" ball valves are to be fixed. No matter in what position or under what head of water the valves are to be fixed, the specifications describe them all to be as stated above. This is a thoughtless act, for the reason that high-pressure valves, generally speaking, will not allow so much water to pass through as those for low pressures. This will be further explained presently. A high-pressure valve is nearly always necessary for fixing in cisterns placed in the lower parts of houses; but for those cisterns fixed at the top of a lofty building, which may be almost on a level with the source from which the water comes, the ball-valve should be "full bore" or what is commonly called low-pressure.

A great many of the H.P. ball-valves are made on what is known as the "equilibrium" principle. The construction of these valves is such that the pressure of the water in the service-pipe helps to close the valve so that smaller balls and shorter stems can be used than would be necessary without this arrangement. Fig. 422 is one of the earliest types. The figure is drawn in section to better illustrate its working. The hollow ball, A, is generally made out of sheet-copper, but the cheaper kinds are often made of zinc. Zinc is not at all good for the purpose as the action of water will frequently corrode it. If the ball has holes made in it by corrosion it becomes useless, owing to water getting into it and destroying its buoyancy. If the balls are made of an alloy instead of pure copper, the same results sometimes occur as with zinc. All balls are generally made in two halves, similar to hemispheres, these being soldered together with fine solder. The solder is often eaten away by the voltaic action which sets up between the metals. The use of this float, or ball, is to raise the end of the "stem" or shank, B, which acting as a lever, pulls up the spindle C and closes the valve D against the seating E, and prevents any water passing out.

At F, in the figure, a cup leather is fixed on the spindle. This cup leather has a double use,

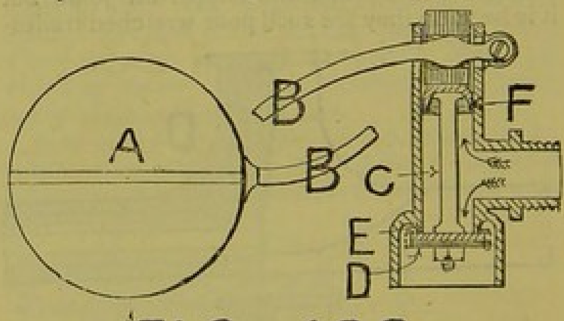


FIG 422

firstly, it prevents water spurting out of the top of the valve, and secondly, the water pressing upwards against it helps to raise the spindle and thus close the valve. The water pressure being divided, as shown by the arrows, an equilibrium is established owing to the water pressing upwards against the cup leather and downwards on the valve over the outlet. If the upper portion of the valve was made larger than the lower one the upward pressure would be exerted on a larger surface, so that the ball valve would remain closed. Differential valves are made on this principle, and used to reduce an excessive pressure of water in the pipes. In the case of the ball valve, but for its special form of construction, the mechanical power, as represented by the stem of the ball which acts as a lever, would have to be very much increased, either by adding to the length of the stem or making the ball or float much larger.

It is not at all a good plan to construct a ball valve so as to establish a perfect equilibrium, especially when the spindle of the valve is not tightly pinned or keyed to the ball stem. If this works loosely in the slot cut in the upper portion of the spindle, the valve being acted upon by the water pressing in opposite directions is alternately closed and opened. When this is done quickly, which is often the case, especially when the cistern is nearly full, a chattering or humming noise is made. The service pipe acts as a kind of telephone, and this noise is heard at all places wherever the pipe is fixed.

Another reason why ball valves hum, or sing, as it is sometimes called, is because of the india-rubber valve D having loose or ragged edges, and the valves not properly fitting over the outlet. If the valve does not seat properly, so that one edge is closed before the other, the water escaping out of the slightly opened side will cause the india-rubber edge to vibrate much in the same manner as the tongue of a note in a

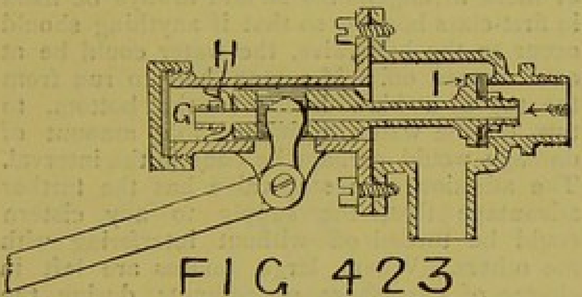


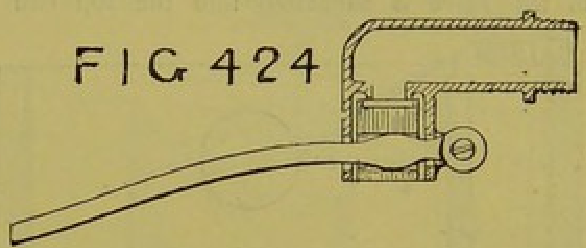
FIG 423

harmonium. Some ball valves have a brass ring fitted over the edge of the valve, as shown by dotted lines, so that there are no free edges for the water to play upon. This ring also prevents the friction of the escaping water tearing away the edges of the rubber washer.

Another kind of ball valve constructed on the equilibrium principle is shown by Fig. 423. With this description the water exerts a pressure, in the direction of the arrow, against the valve I. The spindle is hollow, so that water passes through and fills the small chamber G, and presses against a cup leather H, fitted on the spindle, thus forcing the valve I back against the incoming water. If these valves are not carefully made they sing very much, but when properly constructed they are very good.

Both the valves that have been described are considered as "high pressure," but are really "low pressure," and have full waterways through them. Some manufacturers make Fig. 423 with a very small waterway through the valve, that is, a 1 in. valve has only about ¼ in. hole through for the water to escape. The ball and stem being equal in size to those used for the larger size valves. These valves withstand a very great pressure, but should never be used for low pressure, owing to the contracted waterway which retards the flow of water.

Fig. 424, which is shown without the ball, is another kind of ball valve which is recommended by some water companies, and which will resist a very great water pressure. In this case, too, it is the smallness of the orifice over which the valve fits that makes it so good for very high pressures. Another thing in favour of this kind of valve is that there is little or no friction in the moving parts, and it is very rarely found that they "hang up," that is, stick so fast that the weight of the ball is not sufficient to open them. With some kinds of valves this evil is constantly occurring and using oil or grease for lubricating adds to the evil, owing to the formation of verdigris on the brasswork. The valve shown by Fig. 424 is a very good one, but it unfortunately happens that it is often

FIG 424


made in an inferior manner, and there are thousands sold which can only be called rubbish and so bring the class into disrepute.

Another kind of high pressure ball valve is worked by means of compound levers, Fig. 425 being an example of the class. The sketch shows the action, and by using one lever, worked by the rise and fall of the ball, to raise a second lever, it is easily understood the enormous pressure that this valve will resist. In spite of this the writer knows a place where the water is pumped into the mains at a distance of about two miles from the town, where at each stroke of the pump a drop or two of water is forced through the valve after the cistern is filled and the valve closed. This kind is not so suitable, owing to its short action, for very low water pressures as others that have larger waterways through them, but for very high pressures, and

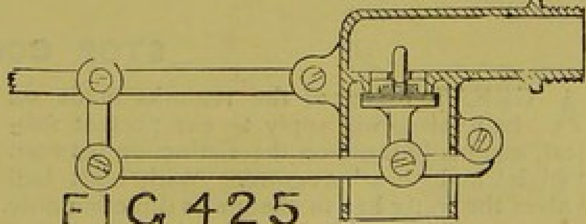


FIG 425

because of the freedom from friction of the working parts, these valves are very serviceable.

A compound action ball valve is also made with a primary lever working a secondary lever with a "cam" on the end. The cam presses against the spindle of the valve and forces it onto its seating.

There are hundred of other descriptions of ball valves, but the greater number are made on some of the lines that have been described, so we need not dwell longer on this part of our subject.

Mention has been made of the noise of water passing through ball valves, and also of that made when the cisterns are filling. The former is generally beyond the plumber's control, but the latter can be prevented by fixing a "silence" or "hush" pipe on the nozzle of the ball cock to convey the water to the bottom of the cistern instead of allowing it to fall from the top on to that already in the cistern. This pipe is shown at J, Fig. 426. A piece of lead pipe a size larger than the service is generally used, the bottom end being perforated, or slits cut in as shown in the figure, and a flange turned for resting on the cistern bottom. The nozzle of the valve is socketted into the top end

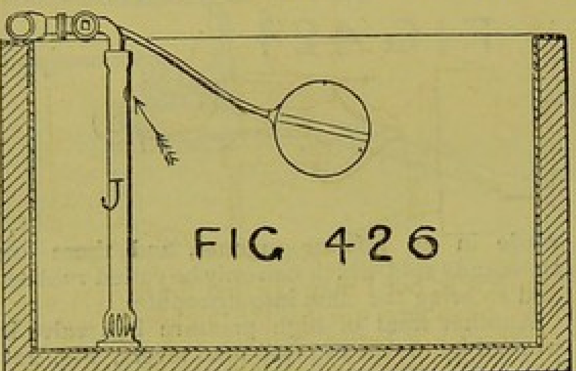


FIG 426

of the pipe. Some plumbers solder the pipe on to the nozzle with a copper bit, but when this is done there is some difficulty when repairing the ball-valve. Some makers have unions screwed onto the nozzles for attaching the silence-pipe. As a matter of fact, these pipes should never be made to fit too tight, or if they are so fixed, a hole should be made as shown by the arrow; otherwise, the water would be syphoned back into the main whenever it was shut off. The hole is made by means of a good-size bradawl, it being held at the angle shown by the arrow. This prevents any water that escapes from the hole spurting against the cistern-side or splashing over the top edge, which would be the case if the hole was made straight through the side of the pipe or in an upright direction. It is difficult to attach silence-pipes to the ball-valves shown by Figs. 424 and 425.

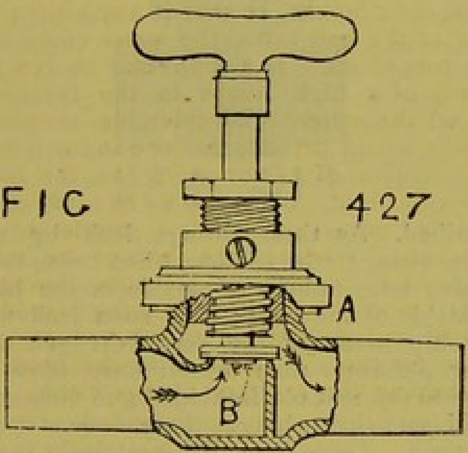
Some first-class plumbers fix a stop-valve to each ball-valve, the ends of the stop being screwed to fit the threads of the ball-valve and boss respectively. Some manufacturers make a "combined stop and ball-valve." One of these arrangements should always be fixed in first-class houses, so that if anything should occur to the ball-valve, the water could be at once turned off. If a man had to run from the top of a high house to the bottom, to turn off the water, a considerable amount of damage would perhaps be done in the interval. The addition of a stop-valve has the further advantage that, the supply to any cistern could be turned off without interfering with the others. Where large houses are left in charge of caretakers or servants, during the winter months, all the cisterns could be emptied and thrown out of use, excepting one or two for the use of those in the house and for keeping the sanitary fittings clean.

STOP COCKS OR VALVES.

A GREAT many of the remarks made on ball valves will apply to our present subject, especially those on the distinction between "high" and "low" pressure. With most ball valves the water has to change its direction only once, see Figs. 422 to 425, but with the so-called H.P. stop valves it is different, and the water, when passing through the valve, has to change its direction as many as four times. Fig. 427, which is a section of a very common description of valve, explains this. The arrows denote the direction of the water current. On looking at the figure it will be noticed that when the water reaches the centre of the valve it has to pass upwards, turn horizontally for a short distance, then downwards, and again at right angles before finally passing out of the valve. The friction of the water as it passes these turnings is very considerable, and so retards the velocity that not nearly so much escapes as would be the case if the waterway had not been so tortuous. The evils of these valves are frequently aggravated by fixing them of a smaller size than the pipes. This is often done as an economy, and the fact of fixing a pipe of any size, and then throttling the water way, as described, by means of a smaller size stop valve, and that having a contracted water way, shows want of thought. Some plumbers, when this description of valve is used, will fix them of a larger size than the service pipe. The water travelling through the larger valve at a lesser velocity than through the smaller one, reduces the amount of friction and allows more water to pass. If an economy has to be practised why not reduce the size of the pipe as well as that of the valve?

And then, again, this kind of valve, by reason of its shape, cannot have the inside trimmed or bored when being made, or the roughnesses left from the sand core, used when casting, removed. Hundreds of valves are found to have a water way only the size of a pea, and sometimes less than that, at the point A in the figure. The valve, B, or "jumper," as it is sometimes called, is generally left loose, as, if fixed on to the spindle, it would turn round with it, when being opened or closed by the screw, and thus soon become cut through or worn out. When loose the valve is opened by the pressure of water against it, but the back pressure on the opposite side will keep it closed, that is, the valve can be shut to keep the water from the street main passing up and into the cistern, but if the street main is shut down the water will be retained in the service pipe and will not become emptied back into the main, owing to the valve closing by the back pressure. For this reason most of the best makers "key" or "pin" the valve on to the spindle, so that the valve can be opened or shut by turning the spindle. In some cases where these valves have been fixed

FIG 427

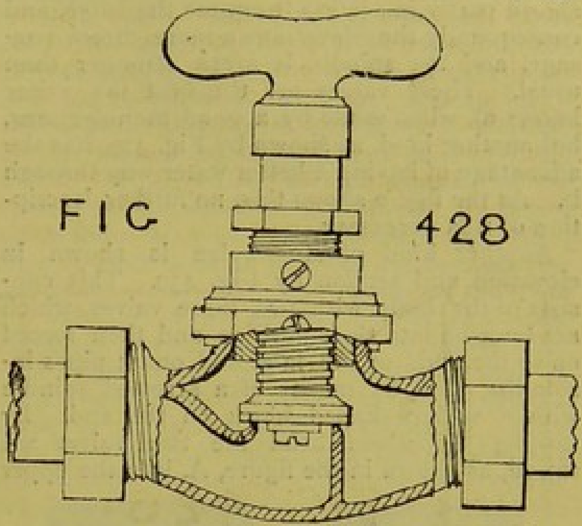


horizontally on the down pipes from cisterns and under low pressures, air has accumulated inside them to such an extent as to prevent any water passing through. The writer has met with such cases and had to fix vent pipes to allow the pent up air to escape.

Fig. 427 represents the principles on which nearly all H.P. valves are made, and when properly constructed they do resist very great water pressures, it is true, but this kind cannot be considered as being perfect in all details, and there is plenty of room for improvement being made in them.

As a passing remark I may here say that numbers of people will make slight variations in other people's designs, these not being always for the better, and will then put something on the market as being original inventions. At the same time, in the endeavour to make money by underselling other people, they manufacture an inferior article, and so it arises that the market is flooded with rubbish that, when fixed, become a permanent tax on householders for repairs, besides often bringing the original article into disrepute. These remarks apply particularly to some kinds of plumber's brasswork, and to none more than stop valves. To further illustrate this, it may be added that some makers will charge 10s. 6d. for a valve that others will sell for 3s. 6d. Now, one of these people must make an excessive profit, or the other one sells an inferior article. I leave the reader to judge

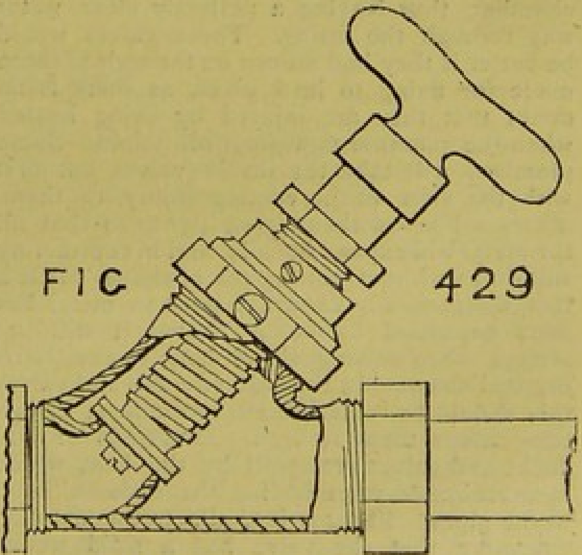
FIG 428



which it is, but I may say that the most respectable plumbers will fix the higher priced, and consequently better, article, and so keep up their reputation for doing their work well. Some of the London water companies have very strict regulations as to the kind of stop valve to be used in connection with their supply, not only as to the kind of materials to be used in their manufacture, but also the substance of the metal, thickness of spindle, weight of the complete fitting, and also stipulate that screwed unions shall be attached to the ends, so that the valve can be easily changed or renewed as occasion requires. This also prevents injury to the indiarubber, leather, or fibre seating of the valve by the heat of the solder when making the joints.

Fig. 428 illustrates one of these valves. The

FIG 429



unions on the ends are of a good length, so that they can be properly soldered to a lead pipe. The body of the valve is enlarged and thus allows the water to pass through with less friction than in the other valve referred to. The valve seating is low down in the body, which is shown partly in section to expose the valve, and consequently the water has a more direct passage, and the spindle is much stronger than usual. These valves are the best the writer knows of, when made by a good manufacturer, but another kind, as shown by Fig. 429, has the advantage of having a better water way through it. As the figure shows this, no further description of it is necessary.

Another kind of stop valve is shown in elevation and section by Fig. 430. This consists of the body with two loose valves, which are lowered into their position and then forced on to the ends of the inlet and outlet pipes inside the valve, by means of a screwed spindle with a wedge shaped block on the end. By turning the wheel head the two valves are raised, as shown in the figure, A, into the upper

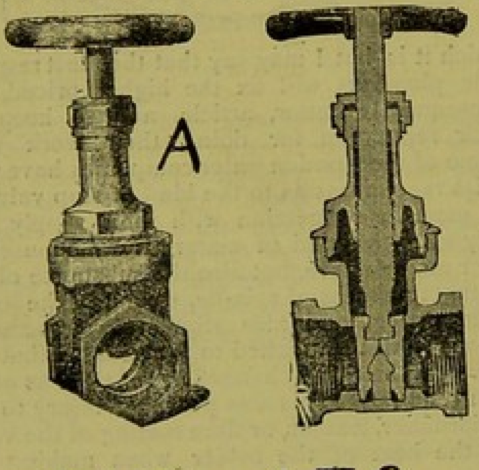


FIG 430

chamber, thus leaving a perfectly clear water way through the fitting. These valves would be better if they had unions on the ends of those made for fixing to lead pipes, as there is no doubt that they are injured by being heated when the plumber is wiping his joints. Some plumbers will take the inside valves out first with the view of preventing injury to them, others will screw them down tight, so that all the metal will expand equally, and in contracting will do so without getting out of shape. It is a fact, not generally known, that when metal has been expanded by being heated it will not always, when cooling, shrink back to exactly its original shape. In the case of cocks and valves this should be remembered, as the least distortion causes them to leak. Hundreds of stop cocks and valves are spoilt by the heat, which is unavoidable. when having the ends soldered to the pipes. Fig. 431 is similar to the last one, excepting that the valve has a solid wedge instead of the loose faces.

In addition to stop-valves, "stop cocks" are sometimes used. These are divided into a large number of descriptions, such as "full way," "square way," "round way," "shell pattern," "gland," "rivet bottom," "screw bottom," "crutch key," "square head," "lever handle," "bow key," &c., and are used not only as stop-cocks on main and service-pipes, but also for filling and emptying baths, washbasins, &c. They are all in such common use that it would not help a reader much if they were all

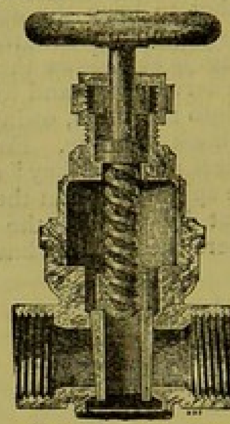


FIG 431

described. As these fittings leak by much usage, owing to the friction, when being turned, wearing away either the outside of the hey or the inside of the body; they soon leak unless they are made of the very best gun metal. Older plumbers than myself have often been heard to say that old-fashioned gun metal cocks would last twice as long as those made at the present time. There is not the least doubt that the present rage for cheap work has driven the old gun metal cocks out of the market and helped to foster the trade in cheap-made brass valves. I was rather interested in reading in a New York Trade Journal an advertisement of a company who "are prepared to make cocks of the very best steam metal, carefully ground by hand, of extra weight, and so proportioned as to secure the maximum of durability and guarantee them against leakage for ten years, in that city." The well known respectability of the firm referred to disarms all or any suspicion of this being an empty boast. Looking nearer home, I may say that I know two or three country master plumbers who send to one of the oldest manufacturers in the City of London for gun metal cocks, swear by them, and will have no other kind or anybody else's make. To repeat the remark of one man, "I can buy cheaper but not so good anywhere else, and I don't care for the valves so much used nowadays."

We may now leave the description of stop-valves and dwell for a short time on their position. In the first place, as this fitting is sometimes wanted to be used in emergency it should never be hidden away out-o'-sight, but should be placed in a conspicuous position, where it can readily be seen. But as there is always a liability of the pipe between the cistern, or main service-pipe, and stop-valve breaking down, it follows, as a matter of course, that it should always be fixed as close to the cistern, or main, as convenient, and thus control the whole, or as much as possible of the service-pipe. The writer, in his examinations of houses, often finds stop-cocks and valves in positions either impossible or difficult to get at without a great deal of trouble, so that in some cases they are almost useless. Even when the position is satisfactory the valves are so often neglected that they become rigidly fixed and difficult to turn, thus detracting from their usefulness. To every stop-valve a tablet should be fixed, describing with what pipes or fittings it is in connection. Neglect of this often leads to unnecessary trouble. This applies more particularly to down-pipes from cisterns. Amongst other cases, the writer knew of a house which was not properly fitted with stop-valves, in which two pictures, valued at over a thousand pounds sterling each, a grand piano, which cost about £200, besides a decorated ceiling, carpets, and furniture, were much damaged owing to a broken pipe allowing the water to escape. The servants could not stop the water, and about two hours had to be spent in getting a plumber. The proper fitting and arrangement of stop-cocks cannot be too strongly insisted upon. There is scarcely a mansion or any other house, fitted with water-cisterns and pipes, that has not at some time or other suffered damage which would have been either prevented or minimised if the stop-valves had been properly arranged and kept in order. It may, perhaps, be urged that in large buildings, too many stop-valves would lead to confusion; but this would not be so if they were all labelled as to their use. The writer, in some large mansions, has fixed stop-cocks, or valves, to every branch service to a fitting, even to the W.C.'s, draw-off or bib-cocks to sinks, and ball-valves to cisterns. By this means any single ball or draw-off cock, or W.C. can be repaired without shutting off the water from the whole of the others. In cases where there is an excessive pressure of water, the stop-cock is found to be of further use for throttling, or regulating the supply by reducing the velocity of the escape; but as one cock would not answer for the whole, it follows that each fitting must have a separate one. A simple illustration of this necessity is frequently found in connection with wash-basins. How often do we find on opening a basin-valve, the water comes in with such velocity as to splash over the basin onto the person's dress? In the case of a range of basins supplied from one service-pipe, if a stop-cock was used to reduce the velocity to suit a single basin, we should only get a dribble of water into the others, supposing that two or three were being used at the same time. It is true the plumber will often "pea" his basin-valves, that is, insert metal discs with small holes through them in the union connections to the pipes, or with his hammer bruise or flatten the service-pipes; but both these methods are only makeshifts, and not nearly so good as fixing stop-valves which can be partly closed to the required degree.

BIB COCKS AND VALVES.

FOR ordinary use there is nothing better than a good, well made, gun metal cock, what is the so-called shield or shell pattern being the best. Such an one is shown by Fig. 432. Cocks of this kind, which are sometimes called "engineer's pattern," have the keys longer than ordinary ones, and the water way through the body is a long narrow slit instead of having a round, or oval-shaped hole. When properly made the water has a clear course through the cock nearly, if not quite, equal to the water-way of the pipe to which it is connected, assuming them both to be of the same nominal size, but is changed in form when passing through the key. This adds a little to the friction, but not to any great extent so as to seriously retard the escape of the water. The "shut off" of these cocks is much greater than with those of ordinary form, and consequently they will resist a greater water pressure without leaking. Fig. 433 is drawn to illustrate this, A being a longitudinal cross section of the key and barrel of a shell pattern cock, and B that of an ordinary one. C is a longitudinal vertical section of the same kind of cock, which has a hollow key. Opinions are divided as to whether the key should be hollow, as shown, or solid. The hollow key has the advantage that the substance of the cock can be made equal in all parts, and will expand equally in every direction; this being of importance when used for hot water. But a drawback to this is that when used for cold water, and the cock is in an exposed situation, the small quantity of water retained in the hollow key will, on becoming frozen, expand sufficiently to break it across as shown by dotted line at C, and push out the sides of the barrel as shown by the arrows at B. Every winter the writer has experiences of cocks being "frosted," as it is called, in which the above evils are found to occur. The same evils obtain with valves as with cocks, but the results are different with valves, the top is generally forced off and the screws broken.

Another point is that with some kinds of cocks, and with certain descriptions of water, those that have a moderate amount of usage will last longer without leaking than those that are seldom used. This may appear paradoxical,

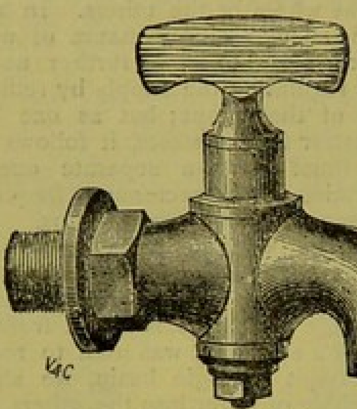


FIG 432

but arises from the corrosion that takes place on the parts of the metal exposed to the action of the water. These parts being shown on sketch B by the arrows inside the barrel, and by D D on the outside of the key. These parts becoming rusted, so to speak, on turning

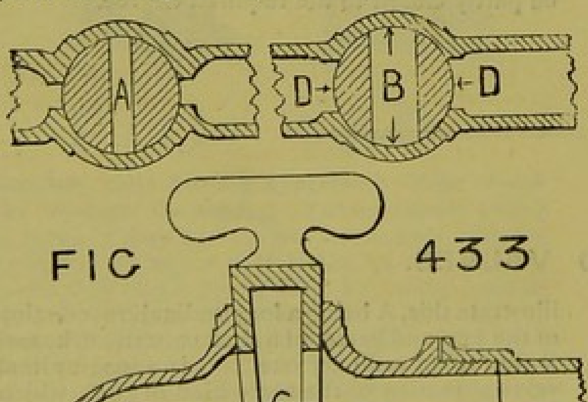


FIG 433

the key the roughened surfaces grind against each other and wear each other away, the detached matter acting in the same manner as grit, and thus helping to scratch the surfaces in contact. This can easily be found by taking out a key and looking at it, and also inside the barrel. When the cocks have a fair amount of usage the constant turning prevents the corrosive action, to a certain extent, and the key wears away equally its whole length. No doubt many readers have noticed that cocks frequently have the keys so worn that they project through the bottom of the barrel so that the bottom screws are loose, and, if they have been leaking, by simply pressing down the key the leakage has been stopped, thus showing that the metals have mutually worn each other to a smooth surface.

It has been suggested that the keys and barrels of cocks should be made of different metals, and it may safely be assumed that the experiment has been tried and found not to be a success, otherwise we should find such cocks placed upon the market. For very cheap work, cast iron cocks with brass keys are sometimes found, but those the writer has met with, although acting fairly well, were not sufficiently successful to justify him in speaking well of them for good work.

For hot water, gun metal cocks are found to answer much better than a great many of the valves that are made, and for steam, the cocks are nearly always preferred. For either of these latter uses lever-handled cocks are the best, as there is sometimes more difficulty in turning them than those used for cold water.

FIG 434

As the heat would travel to the levers, they should be made of some material that would not conduct the heat to the hand. As the lever must be made of metal, the handle part is usually covered with ebony, horn, or some other material. The lever should always be fastened on to the cock by means of a pin or screw to prevent its falling off. If hot water was being drawn from a cock, and the lever fell into the vessel of hot water, damage might be done before the cock could be closed.

In some gentlemen's houses the bad practice of enclosing the sinks is followed. The practice is bad, inasmuch as whenever the lids are opened a puff of sickly smelling air escapes. But with sinks so fitted, it is necessary to have "horizontal" bib cocks, so that they can be kept as near the top edge as possible. Such cocks are shown by Fig. 434. When used for hot and cold water they are fixed in pairs, one being right and the other left handed. Another kind of bib is known as a "gland cock.' Fig. 435 is an illustration of one. This is intended for fixing to a range boiler, but when used for soldering to a lead pipe a screw boss is substituted for the extra long screw and back nut. This kind of cock is considered to be superior to the one shown by Fig. 434, but this is only to a degree. It will be noticed that instead of having a screw at the bottom to keep the key tight, a collar is fastened with screws to the top edge of the barrel for the same purpose. The advantage is that if the key becomes so loose as to allow water to leak out, it can only escape at one end, that is, the top—the bottom of the barrel being solid. When used as a stop cock and fixed in a recess, or other difficult position, the key can be tightened from the front by turning the screws at each end of the gland. The top end of the inside of the barrel of the cock is recessed for a short distance down; this is packed with hemp, cotton, asbestos, or other suitable material, and a neck on the gland pushes or presses the packing down on to a shoulder left near the top end of the key, thus keeping it from working out, and also preventing any water escaping. When the cock is much used, or constantly being turned, the latter use of the gland is questionable, excepting when the packing is continually being seen to.

With a view to making cocks last longer, especially when used for hot water, various expedients have been tried. Amongst the rest is to have sinkings inside and lengthways with the barrel in which the key turns. The sinkings being filled with asbestos so tightly packed that the key presses against it. These cocks have a good reputation, and are easier to turn than some other kinds of cock.

There are a great many other details in connection with bib cocks that could be dealt with, but it is doubtful if any really good purpose would be served by dealing with them, so we will now make a few remarks on bib valves. Fig. 436 is an illustration of one that is very much used. Although this is a London made valve I find the same kind, slightly varied in

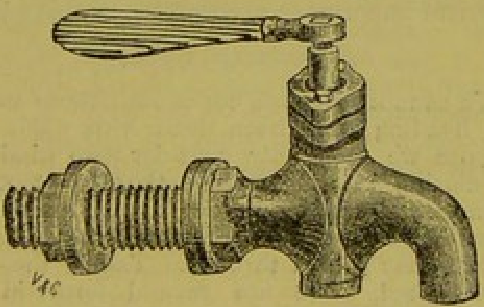


FIG 435

form, in use in nearly all parts of the country. The internal works are very similar to Fig. 427 in last lecture. This is a neat looking valve, and when nickel plated, fitted with a milled head, or with spoke knobs, is frequently used for wash basins. The remarks made on Fig. 427 will also apply to this valve, both with regard to the water-way and the working parts. When used for cold water, the valve washer or jumper is generally made of leather, but for hot water, vulcanite ebonite, woodite, and other preparations of indiarubber are used, as the leather, with very hot water, is totally destroyed. So-called asbestos and fibre washers are also used by some makers of valves. Other makers have gun metal ground-in valves instead of using washers, and a patent has been applied for, for using a soft metal jumper that will adjust itself to the seating of the valve, and be affected by neither hot nor cold water. The writer can only add that if this turns out a success the inventor will make a fortune in a very short time. There is not the least doubt that a good hot water valve is one of the wants of the age. Not only has the variation in temperature of the water to be considered, but also the grit from the boiler; rust, in some cases, from the pipes; servants screwing the valve so tight as to cut or injure the materials; the materials "growing" together when the valve is left closed for some time, and torn or broken when the valve is again opened; natural decay or corrosion of the

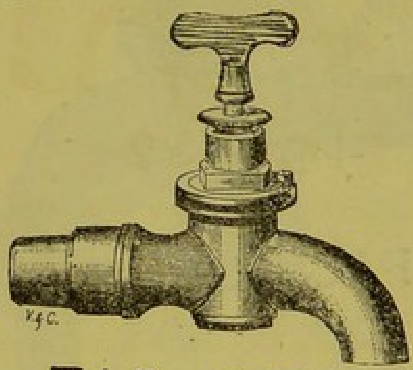


FIG 436

materials and other matters, which are well known to most thoroughly practical men, tend to injure the valve.

One of the advantages of valves is the ease with which new washers can be fitted, but in country places a plumber is not always at hand to do it.

Another advantage is that with a slow closing valve in distinction to one with a quick thread, by which the valve can be closed suddenly, there is very little, in some cases none, "water hammer" or noise in the pipes caused by the sudden stoppage of the water.

The valve can also be opened slowly when necessary to draw water into a jug or glass, and thus run less risk of breaking the vessel.

Bib cocks and valves are sometimes fitted with unions on the nozzles for attaching hose pipes or flexible tubes for using in stable and court-yards, gardens, and other places where the pressure in the pipes is sufficient to throw the water to a considerable distance. Similar fittings are also useful as fire hydrants, but as it is probable that a chapter will be devoted to this important branch of our subject at a future time we will not dwell upon it now.

We may here make a few remarks to the uninitiated on securing the end of a hose pipe onto the union of a cock. Assuming it is to be fixed in a stable yard and used for washing carriages, there is often a considerable strain brought to bear on the joining when dragging the hose about. Sometimes the hose will be pulled off the union or broken off close to it. Fig. 437 illustrates a cock with a union attached to it. The "cap" A has horns on opposite sides for screwing the union tight, these being preferable to a cap with octagonal or hexagonal faces, and which requires a spanner for screwing it tightly onto the nozzle of the cock, whereas the other can be done by the hand. The lining B should be fluted as shown in the figure, but should not have any sharp arrises

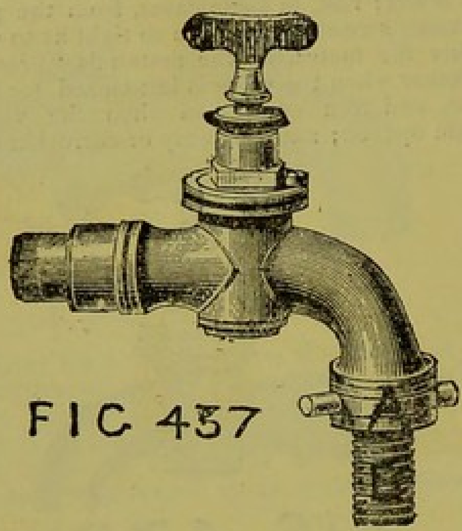


FIG 437

which would, perhaps, cut the hose pipe. If the bore of the hose pipe is large enough, a thimble of leather can be put on the brass lining before slipping on the end of the hose pipe. If the hose is made of vulcanised indiarubber or woven canvas, a thin piece of leather is sometimes wrapped round and outside the joint before binding, to prevent the wire cutting into the material. The easiest way to bind the joint is to first fasten one end of the wire, which should be made of copper, to something fixed rigid, lay the other end of the wire lengthways on the joint, and then holding the part to be joined horizontally between the hands, slowly turn it round towards you, keeping the wire strained as tight as convenient. After about eight to twelve turns have been made, by means of a pair of plyers, twist the wire ends together as shown by sketch C, Fig. 438. This wants doing as neatly and quickly as possible and while the binding wire is still strained tight, and thus prevent it unwinding or getting slack on the joint. Cut off the spare wire and tap the twisted ends down by means of the flat part of the plyers. Some plumbers will do the binding in a way similar to a whip maker's joint, which, when finished, appears as shown by sketch D in the same figure. In this case the two ends of the wire are laid in opposite directions on the joint, the wire fixed in a screw vice for holding when binding, and after sufficient has been wound on the joint the slack is pulled through and cut off. This is a troublesome way, although easilg

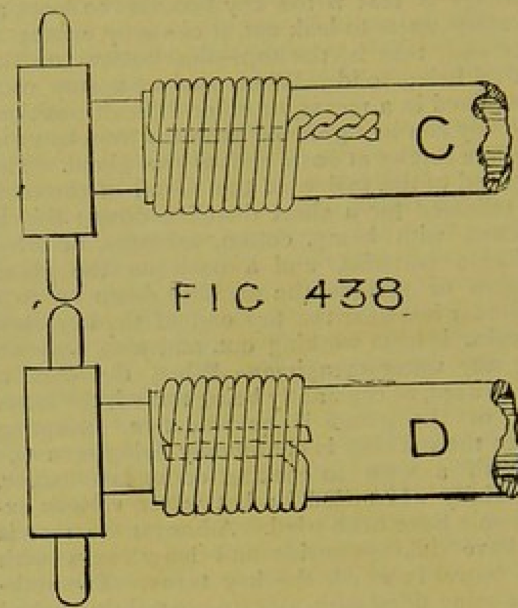


FIG 438

done when string or cord is used instead of wire. Another way to get the same result as the last is to do the binding as first described, but with a loose piece of wire, or a hard piece of wood, laid lengthways by the side of the end of the underlap. This wire or wood being pulled out after sufficient binding had been done, and the loose end of the binding wire pushed through the small space, the slack pulled through and cut off at the end or near the centre of the binding. This method can be varied, and other ways of wiring adopted, but the subject is not of sufficient importance to dwell longer upon it

Self-closing Cocks.

We cannot leave bib cocks until those under this heading have been dealt with. For our purpose we need only consider two kinds of self-closing cocks, namely, those that close themselves immediately they are released, and those that close after a certain or given quantity of water has passed through. Taking the first kind named, there are several forms in the market, but they are very nearly all alike, only two principles entering into their construction One kind closes *with* the water pressure, and the other kind *against* the pressure. An example of the latter is shown at Fig. 439. The drawing speaks for itself, so far as the working parts of the valve is concerned. This valve will be referred to again presently from another point of view. The valve is opened by means of a lever, or a cam, and is closed by means of a spring when the handle is released. Valves of this kind are sometimes found to be useful where the water supply is limited. Ordinary cocks can be left open and water run to waste, but with those latterly described this cannot be, unless they are tampered with. With sinks having plugged waste pipes and no overflows, damage will frequently occur through bib cocks being left running, but with self-closing cocks the handles or levers must be held until sufficient water has been drawn. A modification of this kind of valve is useful for fixing to a wash-hand basin, but if used for filling a bath the person's patience would be exhausted long before the bath was filled. Fig. 440 is an illustration of a bib valve which closes after a given quantity of water has passed through. Cocks

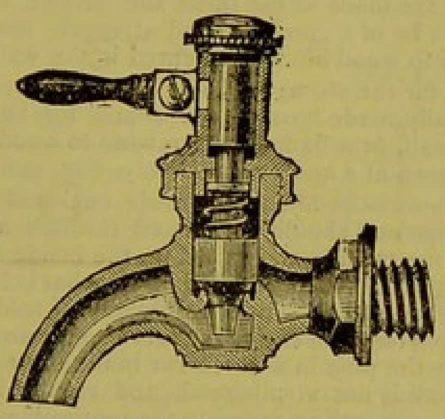


FIG 439

of this kind can be made to run from half to almost any number of gallons that may be necessary. The action of this valve is very simple, and not nearly so complex as is generally imagined by those who use it. On looking at the figure, which represents the valve in section, the centre piece, C, which is the valve, is nicely fitted inside the cup, E E. The valve piece is not fixed to the cup, but is so accurately fitted that it can slide inside. When at rest the valve covers the water way, D, and is kept there by the pressure behind it, that is, the valve closes with the water. To open the valve, the key is turned in the ordinary way, this raises the cup and creates a partial vacuum on the top of the valve. That is raised also, thus allowing the water to flow through to the nozzle or outlet. An arrangement is made for water to enter the cup above the "falling valve," as it is termed, which breaks the vacuum and allows the valve to descend slowly. As the water enters the cup, slowly or fast, so the valve descends, and by regulating the speed

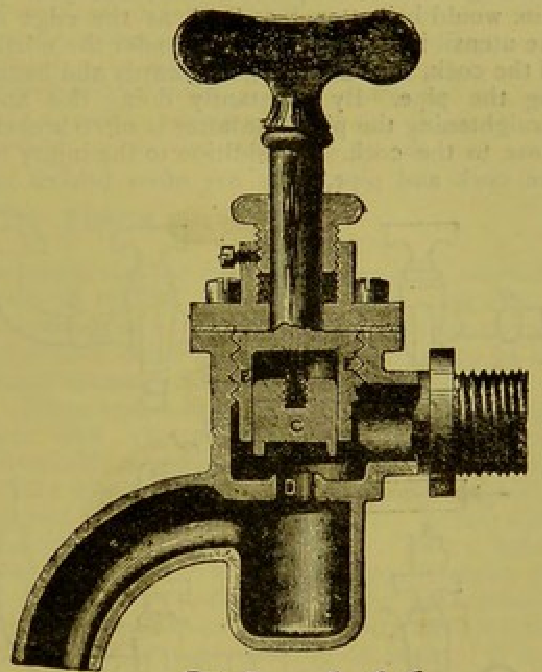


FIG 440

at which the valve falls more or less water is allowed to pass through.

This cock is found to be useful in public places where children or mischievous persons would leave an ordinary cock open and allow water to run to waste. A modification is used for flushing urinal basins, and in another form for W.C.'s. In some of its forms, it meets certain water company's, or coporation's requirements, and is used under conditions where a stipulated quantity of water is allowed for certain purposes.

FIXING BIB COCKS.

I THINK it necessary to refer to this subject, as, generally speaking, not one plumber in twenty ever thinks it worth considering. I may go further, and say that not one bib-cock in a hundred is fixed at all. A branch joint is made between the boss of the cock and the service-pipe, the latter being of lead is hooked against the wall, but before many days have elapsed after fixing, the pipe is found to be bent and loose and the cock not in the same position that the plumber left it, owing to want of proper fixing or the hooks being too far from the cock.

The first point to consider is at what height should a bib-cock be fixed? Before replying, we must first know for what purpose the cock is to be used. No matter what the primary pur-

NOTE.—Fig. 440 is reproduced from a drawing of Messrs. Tylor & Sons, the Patentees of the Valve.

pose may be, a cock is nearly always used at some time or other for drawing water into a pail, consequently the height of the pail should govern the height at which the cock should be fixed. Small house pails and cans are about 9 in. to 10 in. high. Others, such as slop pails and stable buckets, are from 12 in. to 15 in. high. Cocks should always be fixed at least 2 in. higher than the pails or cans, but 3 in. or 4 in. would be better, inasmuch as the edge of the utensil is frequently caught under the nozzle of the cock, thus knocking it upwards and bending the pipe. By constantly doing this and straightening the pipe, the latter is often broken close to the cock. In addition to the injury to the cock and pipe, jugs are often broken by

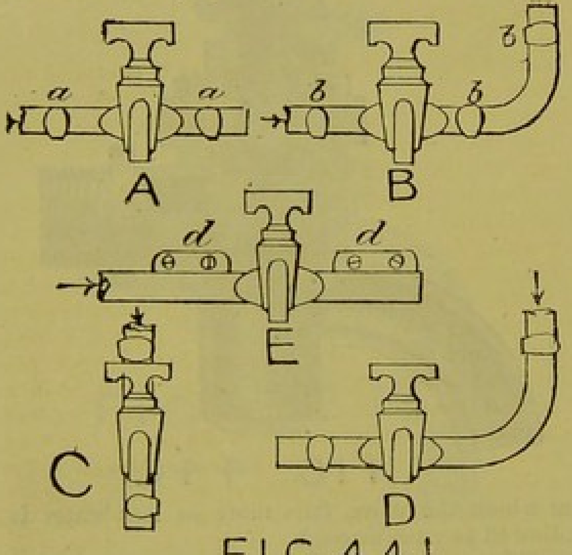


FIG 441

catching under the nozzle of the cock, and this occurs more frequently when the latter is fixed too low down.

The second point is to fix the cock firmly. A, Fig. 441, shows the usual way, *a a*, being ordinary wall hooks driven into the wall. But these do not grip the pipe unless they are driven in so tightly as to bruise it. By frequent use the cock is knocked upwards, as above stated, and then pushed down again until the evil pre-stated, occurs. B, in the same figure, shows the end of the pipe bent upwards and fixed by the hooks *b b*. This adds much to the strength of the fixing, but is not entirely satisfactory, especially when thin or light lead is used. C shows the cock fixed on a vertical pipe; this fixing is not any better than that shown at A, as the cock can be easily bent sideways, and this often occurs when the cock or valve is hard to turn. The cock, as shown at D, is an improvement on the latter. No matter how the problem is varied, wall hooks cannot be accepted as being anything but makeshift fixings, for the reason that, in addition to supporting the weight of pipe and cock, they have to resist any movement of the cock by knocks or turning the handle.

A much stronger fixing is shown at E. This consists of a pair of "Face" tacks soldered onto the pipe, as shown at *d d*. The soldering being done on the front of the tack instead of behind, as in the ordinary way. Counter-sunk

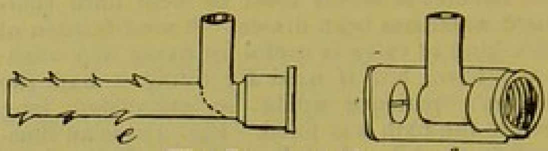


FIG 442

holes are made in the tacks and screws, which should be of a good size and strength, used for fixing to wood blocks cemented in the wall.

By far the strongest fixing for a bib-cock is a specially made boss with a shank for building in a wall, or a flange for screwing to woodwork, as shown at *e* and *f* respectively, Fig. 442.

When cocks are fixed inside enclosed sinks the pipe end should be passed through a hole from the outside and tafted on the inside of the sink, the boss then soldered on by what is known as a flange joint. The slovenly way of soldering the boss onto the end of the service pipe and then laying the pipe in a notch cut in the top edge of the sink is not at all good, and results in the woodwork rotting owing to the continual wetting it gets. By such an arrangement the enclosure and floor beneath the sink are rendered into a chronic state of being mouldy and damp. Hundreds of sinks are found to be thus, and smells proceeding from them.

To fix cocks to sinks that have high backs, whether made of stoneware, fireclay, lead, or copper-lined deal, it is a good plan to first

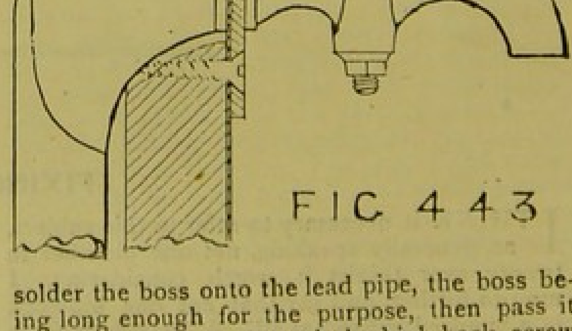


FIG 443

solder the boss onto the lead pipe, the boss being long enough for the purpose, then pass it through a hole cut through the high back, screw a brass disc onto the shank of the cock and then fix the cock in the ordinary way. The service-pipe to be out of sight behind the high back of the sink. The whole arrangement is shown in section by Fig. 443. The brass flange being fixed as shown at G, and fastened with screws to the back of the sink. With stoneware or fireclay sinks holes would have to be drilled, and lead dowels run in for the screws to fasten to. The brass flanges are sometimes called "face plates," and are engraved, to show what kind of water can be drawn from the cock, such as "Hot," "Cold," "Rain," &c. These face plates also hide any irregularity or space between the cock and the sink if the hole is cut too large or improperly.

WATER HAMMER IN PIPES.

I DO not here purpose to go into the whole science of hydro-mechanics, but to deal only with the subject of our heading so far as it is necessary for the plumber to know certain principles to apply practically in his work when occasion requires.

If it were possible to have a tube with sealed ends, a small quantity of water in it, but all the air exhausted, the tube being placed upright and then quickly reversed, the water would fall to the lower end and make a noise which has been compared to that of a hammer when used. Water falling in a vacuum meets with no resistance, as it would when falling through air, until it comes into contact with a solid body sufficiently rigid to check its forward movement, and the noise proceeds from the point or space of impact between the water and resisting body. When water is flowing through a pipe and is suddenly checked, the same noise is made as in the tube without air inside it. The noise proceeds from the knocking of the water against the end of the pipe or whatever is placed as a barrier to stop the flow. The noise is heard at every part of the pipe throughout its length, but not always at the same instant of time. In the case of a long length of service-pipe the noises appear to repeat very quickly, so that the water hammer then is known as "chattering."

Length of pipe has a great deal to do with the noise, that is, the longer the pipe the greater the noise. Position of pipes appears to have very little effect, although the noises made by horizontal pipes with a low water-pressure are sometimes louder than those from vertical pipes supplied from a higher head. A pipe from a cistern fixed a few feet above a floor can be fixed beneath the floor and connected to a cock over a sink a considerable distance away, and water hammer is still found to occur, although the noise is muffled to a certain extent. When inspecting houses the writer frequently makes use of this noise to enable him to trace the runs of the service-pipes, and also to distinguish them from each other.

Another point worth mentioning is that when the service pipe and cock are of the same nominal size the noise is greater than when the pipe is largest. This is owing to the water travelling at a lower rate of speed in the larger pipe and, consequently, is not checked in the same manner as with the smaller pipe.

When common bib-cocks, as shown by Figs. 432 and 435 are used, the noise almost invariably occurs owing to the sudden stoppage of the flow of water when the cock is quickly turned. The noise is very rarely heard when valves as Fig. 436, are used. These valves close very slowly, and thus gradually check the flow of water instead of doing so suddenly. Hence these valves are frequently used instead of cocks to prevent noises in the pipes. It may be here mentioned that this kind of valve has a *slow* thread on the spindle; so that it cannot be closed suddenly. There are several makers who have valves with *quick* threads. These are generally known as "half-turn," "quarter-turn," &c. Such valves can be closed as quickly as ordinary cocks and thus produce water hammer, but the noise is not so great with valves owing to the seatings being made of indiarubber, or other material which is not so hard and rigid as the key of a cock. These valves will not resist such a great water pressure as those with the slow threaded spindles, hence their suitability for low pressure only. Even in the latter case when two valves have been used on the same service-pipe, the rebound of water caused by the sudden closing of one valve has forced the other one partially open. In such cases it is usual to screw the stuffing box so tight as to grip the spindle and trust to the friction to keep it from turning.

It is claimed that no water hammer is heard when the valve shown by Fig. 439 is used. This is termed a "non-concussive valve." A close examination of the working parts will show that the valve itself slides past the inlet portion of the waterway, and in so doing, gradually cuts off the water current. This may be ingenious, but it is doubtful if the principle adopted can be trusted to entirely stop all water hammer in the pipe to which it is attached.

We have now dealt with the causes of noises and alluded to two mechanical means for stopping them, namely, the slowly closing valves and those with the valves sliding past the inlets. These two methods are those mostly practised, but they cannot be accepted as being entirely satisfactory ; and neither would it be wise to entirely trust to them. Not only is the sound of water hammer objectionable, but the force engendered is frequently sufficient to burst the pipes or break any delicately made parts of valves or fittings in connection with them.

The simplest way for explaining the amount of force expended on the insides of pipes, by water hammer, is to first refer to the method in mechanics by which work the effect of force is measured. What is known as a "foot pound" is generally accepted as the unit of measurement. In our case, this would mean the amount of force represented by one pound falling from a height of 1 ft. in a given time, this being known as "one foot pound." Ten pounds falling from a height of 1 ft. would be called ten foot pounds, and one pound falling a vertical distance of 10 ft. would also be called ten foot pounds, and so on for other weights and heights. To apply this rule to our question we can assume that a pipe is filled with water from a cistern or reservoir 10 ft. above the lowest end. We know that the pressure of water, under ordinary conditions, in any vessel, is equal to ·4335 lbs. per square inch of surface for each foot of head. From a cistern, the surface of the water in which is 10 ft. above it, the pressure on the end of the pipe would be 4·335 lbs. on each square inch of surface. But this is simply "dead weight" of water, and we should have to multiply it by the distance the water has fallen to find the momentum and from that the bursting force expended inside the pipe when the momentum is checked. Those who know the action of a hydraulic ram will better understand this when they are reminded that with a head of 1 ft., sufficient power is exerted to force a portion of the same water to a height of 8 ft. to 10 ft. above the machine, and with a height of 10 ft. of driving head water can be raised 80 ft. to 100 ft. One ram in the market is advertised that it will raise water thirty times higher than the fall or head of water above it. The successful working of a ram depends amongst other things, on the suddenness with which the momentum of the water is checked. This causes violent water hammer, which is not only heard at the ram but also at the extremity of the drive-pipe in the reservoir, which may be 100 yards away. But for the air vessel on the ram the noise caused by water hammer would be heard at the end of the delivery-pipe, even if in a house a mile away from the ram. This noise is a frequent cause of complaint and invariably takes place when the air has been exhausted and the air vessel has become water-logged or filled with water. The action of a ram will be explained at a future time; it has only been referred to here to more clearly explain the root of our subject. With a knowledge of the causes we can now proceed to deal with the remedies. Slowly closing valves for this have already been referred to, and also valves with elastic seatings. Before dealing with the next remedy it will be necessary to refer to atmospheric air.

Atmospheric air always occupies a certain amount of space, and this space depends, amongst other things, on the position of it with regard to the earth's surface, that is, the air near the earth occupies less space than an equal amount would at any height above. Air near the earth is compressed by that above it, this pressure being generally accepted as being 15 lbs. (more exactly 14·7 lbs.) on each square inch of surface. This pressure is exerted not only downwards, but upwards and sideways, at the same level to the same extent. This is sometimes called a pressure of one atmosphere. Not only can air be compressed, but by mechanism it can be made to return to the same density at the earth's surface as it has some considerable distance above it. If a quantity of air was enclosed in a tube made as Fig. 444, the two ends being left open, the atmosphere would press downwards, as shown by the arrows, equally, and the air inside the tube would be of the same density as that outside. If a tightly fitting piston was pushed down one of the legs the air would still occupy the same amount of space, only that a portion of it would be pushed out of the tube. But if we were to first seal up the open end of the tube, and make it air tight, then push down the piston in the other leg, the contained air would be compressed and occupy a lesser space. The amount of this space would depend upon the amount of power expended on the piston. That is, if a pressure equal to 15 lbs. on a square inch of surface was applied to the

FIG 444

end of the piston the air inside the tube would be made to occupy about half the space it did, and would then be considered as being under two atmospheres of pressure. If the piston was held down by means of a weight, immediately the latter was removed, the piston would be forced upwards. This would arise from the expansive force of air in returning to its ordinary bulk. Air can be made less dense and to occupy a larger space than it generally does by simply enclosing a portion of it and removing all external pressure. To make this clear, we will assume an indiarubber bag filled with a small quantity of air. If this were placed in the glass receiver of an air pump, and the air then pumped out of the receiver, the indiarubber bag would be found to grow larger and larger as the air inside became expanded through no longer being subjected to external pressure from the atmosphere. Unless the bag was a very strong one it would keep on expanding until it burst by the internal pressure of the air. If, instead of going to this extreme, air was let into the receiver, the indiarubber bag would at once return to its original size and condition. Thus showing that the air above us is an elastic fluid, which can be compressed into a lesser space or expanded so as to fill a larger one. To do either of these, a certain amount of force is necessary, but immediately the force is removed the air will return to its ordinary condition.

These properties of air are made use of by engineers in a great many forms, and, amongst the rest, to prevent water hammer in pipes, &c. Bib valves have been made with hollow spindles, the hollow being filled with air, which is pent up and cannot escape. On closing the valve suddenly the water knocks against the air in the spindle; this acts as a pad or cushion to deaden the noise, and also to gradually check the velocity of the water. It is doubtful if this valve is a thorough success, the amount of confined air being so very small.

Any flexible kind of ball filled with air and placed, and kept, in the proper position inside a service pipe will act as a buffer for water to knock against. The ball is not recommended, owing to the material of which it is made being liable to corrosion, so that after a time it would be useless. Spring buffers have been suggested for use, but all machinery is bound to break down sooner or later, and neither can any really good substitute be found for air.

Referring again to Fig. 444, and assuming that the end *a* is airtight, and *b* is continued to a cistern some distance above, filled with water, the air in *a* would be compressed in the same manner as when the piston was used. If a bib cock was branched in as shown by the dart at *c*, and this cock was opened, the water that was in the leg *a* would immediately fall to a lower level and, in some cases, disappear, if seen in a glass tube, but on closing the cock suddenly the water would again appear in the tube, but at a higher level than before. This shows that the impetus of the water was sufficiently powerful to compress the air in the tube beyond the density caused by the dead weight of the water when not in motion. So soon as the air has been compressed sufficiently to overcome the water that has been forced into the tube, a reaction takes place and the air pushes the water out of the tube again. Sometimes this is done so violently, and the water has such an impetus given to it, that it will flow back up the pipe again, eventually returning. On watching an air vessel made of glass it will be found that the surface of the water will not stand steady for some little time after it has been put in motion in the manner described, thus showing that the weight of the water and the resistance offered by the compressed air must be in a state of equilibrium before the motion as seen in an air vessel is arrested. If the whole of the air was exhausted out of the tube *a*, the above action would not take place, and we should then again have water hammer.

If a tiny hole, say the size of a pin, was made in the end of the tube at *a*, a small jet of water would play up as a fountain, but by opening and shutting the bib cock at *c* this jet would fall and rise in height as the cock was opened and shut. Water hammer would still be heard, but if instead of the small hole a larger one was made, the noise would be overcome. This leads away to another part of our problem, but we will leave it for the time being and confine ourselves to our present subject.

Experience has taught us the value of chambers containing air as buffers, or cushions, for slowly arresting the flow of water in pipes and preventing sudden shocks. To be thoroughly efficient the air vessel should be placed as near the cock as possible, and in such a position that the column of water is directed onto the body of air. B, Fig. 441 shows the end of the pipe turned upwards. The illustration was used to draw attention to a means for strengthening the fixing of a service pipe with a cock attached, but a further use is that the pent up air in the turned up end acts as an air vessel. For this latter use the small piece of pipe is much too small, and contains too little air to be of any real value. This could be obviated by making the turned up piece of pipe much longer, so as to contain more air. A further reason for enlarging the pipe is because after a time a great deal of the air will become absorbed by the water. A small quantity will also escape each time the cock is opened. This may be explained by saying that owing to the friction of the water in the pipe some air will escape from the nozzle of the cock, when suddenly opened, before the entire column of water is put in motion. The interval of time for this may be only a fraction of a second, but great events often occur in that length of time. A small size pipe does not make such a good air vessel as one of a larger size. For a ¾ in. pipe a 2 in. air vessel acts very well. The cross sectional area of a 2 in. pipe is equal to a little over seven times that of a ¾ in. pipe, hence the larger amount of air surface for the water to knock against.

Fig. 445 illustrates a few different methods of fixing air vessels, A being the one last referred to. The chamber is shown as fixed to a wall with face tacks and screws or nails. The darts in all cases denote the direction of the wate

The adjoining sketch B is another method, the dotted lines show the service-pipe continued inside the pipe nearly to the bottom. But for this, all air would escape up the service-pipe, and there would be nothing to prevent water-hammer. The sketch C shows a globular, or balloon-shaped air-vessel, branched into the top side of the service-pipe; and F shows a common way for treating a vertical service-pipe.

Very often the pipe is treated as shown at D, but this is not nearly so good as the others. The writer once saw the end E soldered into the service-pipe, and the plumber was under the impression that the water would run round

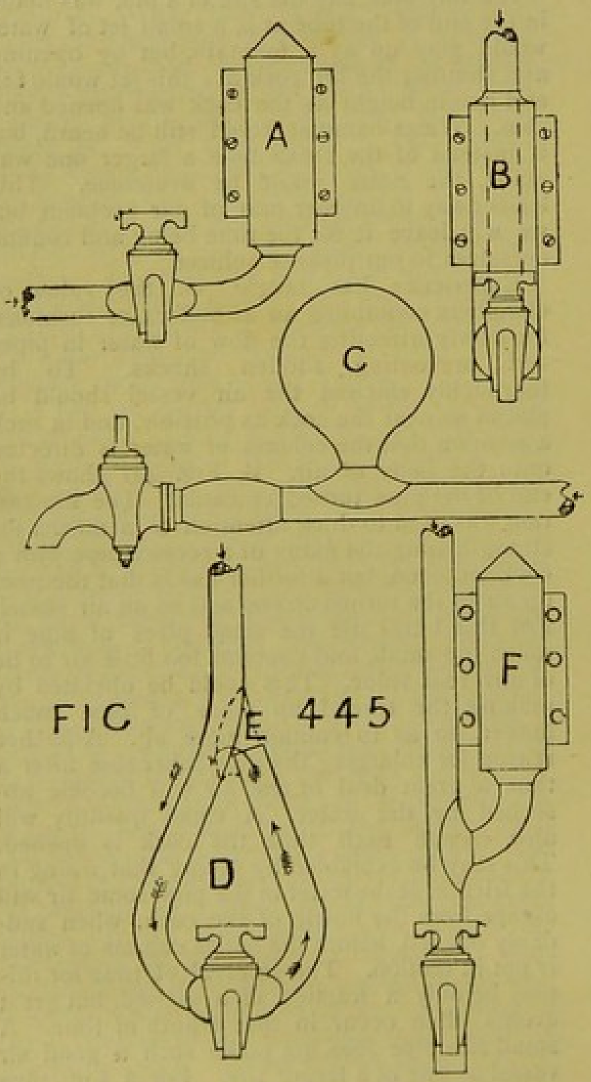


FIG 445

the pipe as shown by the arrows. Of course, this was a mistake, and some trouble was necessary to disprove the use of the pipe as arranged. When plumbers make air vessels out of lead pipe they should always be very careful to properly seal the ends. It is a good plan to first close the end, by bossing, and then solder it over with fine solder, using a copper-bit for the purpose. When the end is "wiped" over, and common plumber's solder used, the air will frequently escape owing to the porosity of the solder, more especially when it is coarse or wiped too cold. The other extreme of wiping the end when the pipe is too hot, should be avoided. Wiped joints and ends will often be found to "sweat," as it is called, when the solder used is too hot or the joint wiped two or three times in quick succession, so that eventually the pipe becomes so heated that after the joint has been made the heat of the pipe is sufficient to keep the tin in the solder melted, so that it will run to the lower part, thus leaving the lead in what may be called a spongy condition. The small cellules, left by the separation of the tin,

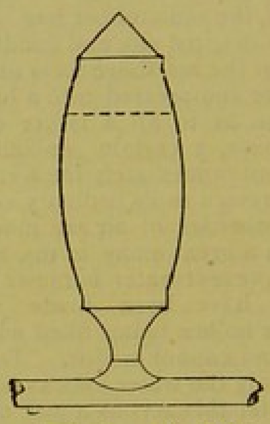
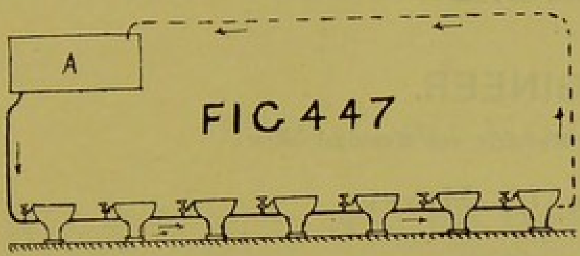


FIG 446

will allow air or water to ooze through. If the air escapes by any means out of an air vessel it then becomes useless. Another point to remember is that an air vessel should always be made of stout material, and, if of lead, the lead should be of a good thickness. It is sometimes thought that the vessel is to hold air only, and light lead is good enough for the purpose. I have seen a vessel 3 in. in diameter swell out in the centre, as shown by Fig. 446. As the sides bulge outwards the lead is reduced in substance. This bulging would continue until the vessel burst. True, air only is in the vessel before using it, but when in use the air is compressed, according to the head of water, into a smaller space, in some cases, probably to the dotted line shown in the figure. The pressure of water in the vessel may be only about 10 lbs. on the square inch, but this is sometimes raised considerably, and may be from 100 to 200 lbs. per square inch when the flow of water in the pipes is suddenly checked. A 3 in. pipe made of lead 1-5th of an inch in thickness will only resist a pressure of about 300 lbs. on the square inch, so you will see the necessity of making air vessels very strong.

From what has been stated you will understand that air vessels are the right things to use to prevent water-hammer, but I must now go further and explain that under certain conditions they will aggravate matters and increase the noises in water-pipes—made when opening and shutting cocks. To make this clear, I cannot do better than give a few examples of where this has been the case.

Fig. 447 represents a row of W.C.'s, each one being flushed by means of a branch from an 1½in. lead service-pipe, and a valve and regulator on an iron frame, screwed to the floor. These are omitted in the drawing. The cistern A was about 10 ft. above the floor. The closets were fixed in a large institution and were in constant use. No matter how carefully the valve regulators were adjusted, one or other of them would frequently get out of order and

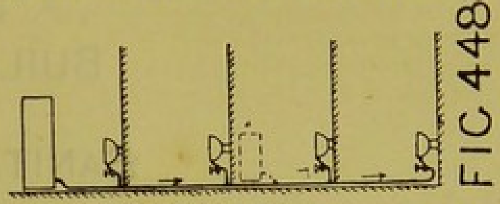


close so quickly as to start water-hammer in the pipes. All the valves would then commence chattering. Air vessels were tried as a remedy, but no matter where they were fixed in the service-pipe or what their size, the noises were much worse than before the air vessels were used. As a last resource the main service-pipe was continued, as shown by dotted line, back to the cistern and turned over the top edge. This acted as a relief-pipe, and the force of the water was spent in pushing the water out of the top end of the pipe instead of on the valve seatings.

A second case is shown by Fig. 448. Here four valve W.C.'s, with valves and regulators for flushing, were fixed on different floors. After using one of the W.C.'s the service-valves of one of the others would chatter. On adding an additional weight to the lever of that one another would become troublesome, on weighting that a third one would commence to hum, and so on until so many weights had been added to the valve-levers as to make them so heavy that it became quite a labour to raise the W.C. handles. Air vessels were tried, but the evils were made worse instead of better. Finally it was decided to put an additional cistern, as shown by dotted lines, to supply the two lower W.C.'s, and this was found to answer the purpose of curing the noises in the pipes.

A third case was in a palace, where a valve W.C. and a bath were fixed side by side and supplied from the same service-pipe. Whenever the valve to the bath was opened and shut, that on the W.C. would commence to hum, and the lever to vibrate up and down. The way this was cured may, when compared with previous examples, seem paradoxical. The supply-valve to the bath was opened by means of a lever with a knob and chain. On attaching a bellows regulator to the lever so that the valve could not close suddenly, the noises were entirely cured. An air vessel in this case, too, had been found useless.

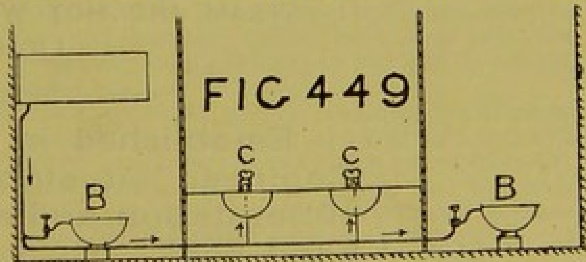
One more illustration is shown by Fig. 449. In this case the pipe from a cistern flushed two valve W.C.'s, B B, and also supplied two wash-basins, C C, which had "cam-action" valves to them. These valves closed by means of springs inside them. On using either of the basin-valves, those to the W.C. would commence to hum, and *vice versa*. On fixing an air vessel,



the sounds were converted from a hum into a chatter—if the reader can understand the difference in those terms. After a great many experiments had been tried, it was finally decided to fix a separate pipe for the wash-basins, and this was found to be a success.

The writer has had experiences where a long row of wash-basins has been supplied from the same service-pipe, by means of, so-called, self-closing-valves, where one of them has had a very weak spring to it, and that one has started humming when any of the others has been used. When this occurs, an air vessel has rarely been found to be of any use, but rather otherwise. The valves made on the principle illustrated by Fig. 439, have been found fairly successful when fixed under these condition.

Air vessels should always be fixed when water hammer takes place with bib-cocks; but



when the noise partakes more of the nature of chattering or humming, as is the case with spring, and other kinds of self-closing-valves, the air vessels have not always been found to be a success. It is difficult to summarise what has been said so as to apply to all or any cases of water-hammer that may turn up in practice, because no two cases are exactly similar. The least variation in any detail will sometimes so alter matters that a remedy in one case would not be so in another. After what has been said the reader will doubtless know which remedy to apply when called upon to deal with a problem similar to any that have been described. We shall deal with drop-valves in cisterns and the noises they sometimes make, when we enter on the subject of service-boxes.

APPENDIX.

PUBLIC HEALTH (LONDON) ACT, 1891.

BE it enacted by the Queen's most Excellent Majesty, by and with the advice and consent of the Lords Spiritual and Temporal, and Commons, in this present Parliament assembled, and by the authority of the same, as follows:—

1. *Sanitary authority to inspect district for detection of nuisances.*—It shall be the duty of every sanitary authority to cause to be made from time to time inspection of their district, with a view to ascertain what nuisances exist calling for abatement under the powers of this Act, and to enforce the provisions of this Act for the purpose of abating the same, and otherwise to put in force the powers vested in them relating to public health and local government, so as to secure the proper sanitary condition of all premises within their district.

NUISANCES (GENERAL.)

2. *What nuisances may be abated summarily.*—(1.) For the purposes of this Act,—

(*a.*) Any premises in such a state as to be a nuisance or injurious or dangerous to health;

(*b.*) Any pool, ditch, gutter, watercourse, cistern, watercloset, earth closet, privy, urinal, cesspool, drain, dung-pit, or ashpit so foul or in such a state as to be a nuisance or injurious or dangerous to health;

(*c.*) Any animal kept in such place or manner as to be a nuisance or injurious or dangerous to health;

(*d.*) Any accumulation or deposit which is a nuisance or injurious or dangerous to health;

(*e.*) Any house or part of a house so overcrowded as to be injurious or dangerous to the health of the inmates, whether or not members of the same family;

(*f.*) Any such absence from premises of water fittings as is a nuisance by virtue of section thirty-three of the Metropolis Water Act, 1871, set out in the First Schedule to this Act; and

(*g.*) Any factory, workshop, or workplace which is not a factory subject to the provisions of the Factory and Workshop Act, 1878, 34 & 35 Vict. c. 113, and 41 & 42 Vict. c. 16, relating to cleanliness, ventilation, and overcrowding, and

(i.) is not kept in a cleanly state and free from effluvia arising from any drain, privy, earth closet, watercloset, urinal, or other nuisance, or

(ii.) is not ventilated in such a manner as to render harmless as far as practicable any gases, vapours, dust, or other impurities generated in the course of the work carried on therein that are a nuisance or injurious or dangerous to health, or

(iii.) is so overcrowded while work is carried on as to be injurious or dangerous to the health of those employed therein,

shall be nuisances liable to be dealt with summarily under this Act.

(2.) Provided that—

(i.) Any accumulation or deposit necessary for the effectual carrying on of any business or manufacture shall not be punishable as a nuisance under this section, if it is proved to the satisfaction of the court that the accumulation or deposit has not been kept longer than is necessary for the purposes of the business or manufacture, and that the best available means have been taken for preventing injury thereby to the public health; and

(ii.) In considering whether any dwelling-house or part of a dwelling-house which is used also as a factory, workshop, or workplace, or whether any factory, workshop, or workplace used also as a dwelling-house, is a nuisance by reason of overcrowding, the court shall have regard to the circumstance of such other user.

3. *Information of nuisances to sanitary authority.*—Information of a nuisance liable to be dealt with summarily under this Act in the district of a sanitary authority may be given to that authority by any person, and it shall be the duty of every officer of that authority and of every relieving officer, in accordance with the regulations of the authority having control over him, to give that information; and it shall be the duty of the said authority to make the said regulations, and also the duty of the sanitary authority to give such directions to their officers as will secure the existence of the nuisance being immediately brought to the notice of any person who may be required to abate it, and the officer shall do so by serving a written intimation.

4. *Notice requiring abatement of nuisance.*—(1.) On the receipt of any information respecting the existence of a nuisance liable to be dealt with summarily under this Act the sanitary authority shall, if satisfied of the existence of a nuisance, serve a notice on the person by whose act, default, or sufferance the nuisance arises or continues, or, if such person cannot be found, on the occupier or owner of the premises on which the nuisance arises, requiring him to abate the same within the time specified in the notice, and to execute such works and do such things as may be necessary for that purpose, and, if the sanitary authority think it desirable (but not otherwise) specifying any works to be executed.

(2.) The sanitary authority may also by the same or another notice served on such occupier, owner, or person require him to do what is necessary for preventing the recurrence of the nuisance, and, if they think it desirable, specify any works to be executed for that purpose, and may serve that notice notwithstanding that the nuisance may for the time have been abated, if the sanitary authority consider that it is likely to recur on the same premises.

(3.) Provided that—

(*a*.) where the nuisance arises from any want or defect of a structural character, or where the premises are unoccupied, the notice shall be served on the owner:

(*b*.) where the person causing the nuisance cannot be found, and it is clear that the nuisance does not arise or continue by the act, default, or sufferance of the occupier or owner of the premises, the sanitary authority may themselves abate the same and may do what is necessary to prevent the recurrence thereof:

(*c*.) where the medical officer of health certifies to the sanitary authority that any house or part of a house in their district is so overcrowded as to be injurious or dangerous to the health of the inmates, whether or not members of the same family, the sanitary authority shall take proceedings under this section for the abatement of such nuisance:

(*d*.) where the nuisance is such absence of water-fittings as is declared a nuisance by section thirty-three of the Metropolis Water Act, 1871 (set out in the First Schedule to this Act), 34 & 35 Vict. c. 113, such absence shall be deemed to render the premises unfit for human habitation, unless and until the contrary is shown to the satisfaction of the court.

(4.) Where a notice has been served on a person under this section, and either—

(*a*.) the nuisance arose from the wilful act or default of the said person; or

(*b*.) such person makes default in complying with any of the requisitions of the notice within the time specified,

he shall be liable to a fine not exceeding ten pounds for each offence, whether any such nuisance order as in this Act mentioned is or is not made upon him.

5. *On non-compliance with notice, order to be made.*—(1.) If either—

(*a*.) the person on whom a notice to abate a nuisance has been served as aforesaid makes default in complying with any of the requisitions thereof within the time specified; or

(*b*.) the nuisance, although abated since the service of the notice, is, in the opinion of the sanitary authority likely to recur on the same premises,

the sanitary authority shall make a complaint, and the petty sessional court hearing the complaint may make on such person a summary order (in this Act referred to as a nuisance order).

(2.) A nuisance order may be an abatement order, a prohibition order, or a closing order, or a combination of such orders.

(3.) An abatement order may require a person to comply with all or any of the requisitions of the notice, or otherwise to abate the nuisance within a time specified in the order.

(4.) A prohibition order may prohibit the recurrence of a nuisance.

(5.) An abatement order or prohibition order shall, if the person on whom the order is made so requires, or the court considers it desirable, specify the works to be executed by such person for the purpose of abating or preventing the recurrence of the nuisance.

(6.) A closing order may prohibit a dwelling-house from being used for human habitation.

(7.) A closing order shall only be made where it is proved to the satisfaction of the court that by reason of a nuisance a dwelling-house is unfit for human habitation, and if such proof is given the court shall make a closing order, and may impose a fine not exceeding twenty pounds.

(8.) A petty sessional court, when satisfied that the dwelling-house has been rendered fit for human habitation, may declare that it is so satisfied and cancel the closing order.

(9.) If a person fails to comply with the provisions of a nuisance order with respect to the abatement of a nuisance he shall, unless he satisfies the court that he has used all due diligence to carry out such order, be liable to a fine not exceeding twenty shillings a day during his default; and if a person knowingly and wilfully acts contrary to a prohibition or closing order he shall be liable to a fine not exceeding forty shillings a day during such contrary action; moreover the sanitary authority may enter the premises to which a nuisance order relates, and abate or remove the nuisance, and do whatever may be necessary in execution of such order.

6. *Provision as to appeal against order.*—(1.) Where a person appeals to the court of quarter sessions against a nuisance order, no liability to a fine shall arise, nor, save as in this section mentioned, shall any proceedings be taken or work done under such order until after the determination or abandonment of such appeal.

(2) There shall be no appeal to quarter sessions against a nuisance order, unless it is or includes a prohibition or closing order, or requires the execution of structural works.

(3.) Where a nuisance order is made and a person does not comply with it and appeals against it to the court of quarter sessions, and such appeal is dismissed or is abandoned, the appellant shall be liable to a fine not exceeding twenty shillings a day during the non-compliance with the order, unless he satisfies the court before whom proceedings are taken for imposing a fine that there was substantial ground for the appeal, and that the appeal was not brought merely for the purpose of delay, and where the appeal is heard by the court of quarter sessions, that court may, on dismissing the appeal, impose the fine as if the court were a petty sessional court.

(4) Where a nuisance order is made on any person and appealed against, and the court which made the order is of opinion that the continuance of the nuisance will be injurious or dangerous to health, and that the immediate abatement thereof will not cause any injury which cannot be compensated by damages, the court may authorise the sanitary authority immediately

to abate the nuisance; but the sanitary authority, if they do so, and the appeal is successful, shall pay the cost of such abatement and the damages (if any) sustained by the said person by reason of such abatement; but, if the appeal is dismissed or abandoned, the sanitary authority may recover the cost of the abatement in a summary manner from the said person.

7. *Provision in case of two convictions for overcrowding.*—Where two convictions for offences relating to the overcrowding of a house or part of a house in any district have taken place within a period of three months (whether the persons convicted were or were not the same), a petty sessional court may, on the application of the sanitary authority, order the house to be closed for such period as the court may deem necessary.

8. *In certain cases order may be addressed to sanitary authority.*—Whenever it appears to the satisfaction of the petty sessional court that the person by whose act, default, or sufferance, a nuisance liable to be dealt with summarily under this Act arises or the owner or occupier of the premises is not known or cannot be found, then the nuisance order may be addressed to, and if so addressed shall be executed by, the sanitary authority.

9. *Power to sell manure, &c.*—Any matter or thing removed by the sanitary authority in abating, or doing what is necessary to prevent the recurrence of, a nuisance liable to be dealt with summarily under this Act may be sold by public auction or, if the authority think the circumstances of the case require it, may be sold otherwise, or be disposed of without sale; and the money arising from the sale may be retained by the sanitary authority, and applied in payment of the expenses incurred by them with reference to such nuisance, and the surplus (if any) shall be paid, on demand, to the owner of such matter or thing.

10. *Power of entry.*—The sanitary authority shall have a right to enter from time to time any premises—

(*a*) for the purpose of examining as to the existence thereon of any nuisance liable to be dealt with summarily under this Act, at any hour by day, or in the case of a nuisance arising in respect of any business, then at any hour when that business is in progress or is usually carried on, and

(*b*) where under this Act a nuisance has been ascertained to exist, or a nuisance order has been made, then at any such hour as aforesaid, until the nuisance is abated, or the works ordered to be done are completed, or the closing order is cancelled, as the case may be, and

(*c*) where a nuisance order has not been complied with, or has been infringed, at all reasonable hours, including all hours during which business therein is in progress or is usually carried on, for the purpose of executing the order.

11. *Costs of execution of provisions relating to nuisances.*—(1.) All reasonable costs and expenses incurred in serving notice, making a complaint, or obtaining a nuisance order, or in carrying the order into effect, shall be deemed to be money paid for the use and at the request of the person on whom the order is made; or if the order is made on the sanitary authority, or, if no order is made, but the nuisance is proved to have existed when the notice was served or the complaint made, then of the person by whose act, default or sufferance, the nuisance was caused; and in case of nuisances caused by the act or default of the owner of premises, such costs and expenses may be recovered from any person who is for the time being owner of such premises.

(2.) Such costs and expenses, and any fines incurred in relation to any such nuisance, may be recovered in a summary manner or in the county court or High Court, and the court shall have power to divide costs, expenses, and fines between persons by whose acts, defaults, or sufferance a nuisance is caused, as to it may seem just.

12. *Power of individual to complain to justice of nuisance.*—(1.) Complaint of the existence of a nuisance liable to be dealt with summarily under this Act on any premises within the district of any sanitary authority may be made by any person, and thereupon the like proceedings shall be had with the like incidents and consequences as to making of orders, fines for disobedience of orders, appeal, and otherwise, as in the case of a like complaint by the sanitary authority.

(2.) Provided that the court may, if it thinks fit,—

(*a*.) adjourn the hearing or further hearing of the complaint for the purpose of having an examination of the premises where the nuisance is alleged to exist, and may authorise the entry into such premises of any constable or other person for that purpose; and

(*b*.) authorise any constable or other person to do all necessary acts for executing an order made on a complaint under this section, and to recover the expenses from the person on whom the order is made in a summary manner.

(3.) Any constable or other person authorised under this section shall have the like powers, and be subject to the like restrictions as if he were an officer of the sanitary authority authorised under the foregoing provisions of this Act to enter any premises and do any acts thereon.

13. *Proceedings in High Court for abatement of nuisances.*—The sanitary authority may, if in their opinion summary proceedings would afford an inadequate remedy, cause any proceedings to be taken against any person in the High Court to enforce the abatement or prohibition of any nuisance liable to be dealt with summarily under this Act, or for the recovery of any fines from, or for the punishment of, any persons offending against the provisions of this Act relating to such nuisances, and may pay as expenses of the execution of this Act their expenses of and incident to all such proceedings.

14. *Power to proceed where cause of nuisance arises without district.*—(1.) Where a nuisance liable to be dealt with summarily under this Act appears to be wholly or partially caused by some act, default, or sufferance committed or taking place without the district the inhabitants of which are affected by the nuisance, the sanitary authority for that district may take or cause to be taken against any person in respect of such act, default, or sufferance any proceedings in relation to nuisances by this Act authorised, with the same incidents and consequences as if such act, default, or sufferance were committed or took place wholly within their district; so, however, that summary proceedings shall in no case be taken otherwise than before a court having jurisdiction in the district where the act, default, or sufferance is alleged to be committed or take place.

(2.) Section one hundred and eight of the Public Health Act, 1875, 38 & 39 Vict. c. 55, set out in the First Schedule to this Act, shall continue to extend to London, with the substitution of a sanitary authority, under this Act for any nuisance authority mentioned in the said section, and any reference in that section to a nuisance in the metropolis shall include a nuisance within the meaning of this Act.

15. *Penalty for injuring closet, &c., so as to cause a nuisance.*—If a person causes any drain, watercloset, earth closet, privy, or ashpit to be a nuisance or injurious or dangerous to health by wilfully destroying or damaging the same, or any water-supply, apparatus, pipe, or work connected therewith, or by otherwise wilfully stopping up, or wilfully interfering with, or improperly using the same, or any such water-supply, apparatus, pipe, or work, he shall be liable to a fine not exceeding five pounds.

PENALTIES IN RESPECT OF PARTICULAR NUISANCES.

16. *Byelaws by sanitary authority and county council as to cleansing streets and prevention of nuisances.*—(1.) Every sanitary authority shall make byelaws—

(*a.*) for the prevention of nuisances arising from any snow, ice, salt, dust, ashes, rubbish, offal, carrion, fish, or filth, or other matter or thing in any street; and

(*b.*) for preventing nuisances arising from any offensive matter running out of any manufactory, brewery, slaughter-house, knacker's yard, butcher's or fishmonger's shop, or dunghill, into any uncovered place, whether or not surrounded by a wall or fence; and

(*c.*) for the prevention of the keeping of animals on any premises in such place or manner as to be a nuisance or injurious or dangerous to health; and

(*d.*) as to the paving of yards and open spaces in connexion with dwelling-houses.

(2.) The county council shall make bye-laws—

(*a.*) for prescribing the times for the removal or carriage by road or water of any fœcal or offensive or noxious matter or liquid in or through London, and providing that the carriage or vessel used therefor shall be properly constructed and covered so as to prevent the escape of any such matter or liquid, and as to prevent any nuisance arising therefrom; and

(*b.*) as to the closing and filling up of cesspools and privies, and as to the removal and disposal of refuse, and as to the duties of the occupier of any premises in connexion with house refuse, so as to facilitate the removal of it by the scavengers of the sanitary authority.

(3.) It shall be the duty of every sanitary authority to observe and enforce any byelaws made under this section.

(4.) Except as otherwise provided by the byelaws, a constable may arrest without warrant and take before a justice any person whom he finds committing an offence against such byelaws and who refuses to give his true name and address.

(5.) Provided that the byelaws shall not make it an offence to lay sand or other material in any street in time of frost to prevent accidents, or litter or other matter to prevent the freezing of water in pipes, or in case of sickness to prevent noise, if the same is laid, and when the occasion ceases duly removed, in accordance with the byelaws.

17. *Penalty for keeping swine in unfit place.*—(1.) A person shall not—

(*a.*) feed or keep any swine in any locality, premises, or place which is unfit for the keeping of swine, or in which the feeding or keeping of swine may create a nuisance or be injurious to health, or

(*b.*) permit any swine to stray or go about in any street or public place.

(2.) If any person acts in contravention of this section he shall be liable to a fine not exceeding forty shillings, and to forfeit the swine, and to a further fine not exceeding ten shillings for every day during which he continues such offence after notice from the sanitary authority to discontinue the same.

(3.) Any swine found straying or going about in any street or public place may be seized and removed by any constable.

(4.) Any premises within forty yards of any street or public place shall be deemed for the purposes of this section to be a place unfit for keeping swine.

18. *Power to prohibit keeping of animals in unfit place.*—Where it is proved to the satisfaction of a petty sessional court that any locality, premises, or place are or is unfit for the keeping of any animal, the court may by summary order prohibit the using thereof for that purpose for the future.

OFFENSIVE TRADES.

19. *Prohibition and regulation of establishing anew certain offensive businesses, and byelaws as to offensive businesses.*—(1.) If any person—

(*a.*) establishes anew the following businesses, or any of them; that is to say, the business of blood boiler, bone boiler, manure manufacturer, soap boiler, tallow melter, or knacker; or

(*b.*) establishes anew, without the sanction of the county council, the following businesses, or any of them; that is to say, the business of fellmonger, tripe boiler, slaughterer of cattle or horses, or any other business which the county council may declare by order confirmed by the Local Government Board and published in the London Gazette to be an offensive business,

he shall be liable to a fine not exceeding fifty pounds in respect of the establishment thereof, and any person carrying on the same when established shall be liable to a fine not exceeding fifty pounds for every day during which he so carries on the same:

(2) Provided that this enactment shall not render any person liable to a fine for establishing anew with the sanction of the county council, or carrying on, the business of soap boiler, if and as long as that business is a business in which tallow or any animal fat or oil other than olein is not used by admixture with alkali for the production of soap.

(3.) The county council shall give their sanction by order, but, at least fourteen days before making any such order, shall make public the application for it, by serving on the sanitary authority within whose district the premises on which the business is proposed to be established are situate, and by advertising, notice of the application and of the time and place at which they will be willing to hear all persons objecting to the order, and by causing a copy of the notice to be affixed in a conspicuous part of the said premises; and they shall consider any objections made at that time and place, and shall grant or withhold their sanction as they think expedient.

(4.) The county council may make byelaws for regulating the conduct of any businesses specified in this section, which are for the time being lawfully carried on in London, and the structure of the premises on which any such business is being carried on, and the mode in which the said application is to be made.

(5.) Any such byelaw may empower a petty sessional court by summary order to deprive any person, either temporarily or permanently, of the right of carrying on any business to which such byelaw relates, as a punishment for breaking the same, and any person disobeying such order shall be liable to a fine not exceeding fifty pounds for every day during which such disobedience continues.

(6.) Any sanitary authority or person aggrieved by any proposed byelaw under this section, or by any proposed alteration or repeal of a byelaw, may forward notice of his objection to the Local Government Board, who shall consider the same.

(7.) There shall be charged for an order of the county council under this section, and carried to the county fund, such fee not exceeding forty shillings as the county council may fix.

(8.) For the purposes of this section a business shall be deemed to be established anew not only if it is established newly, but also if it is removed from any one set of premises to any other premises, or if it is renewed on the same set of premises after having been discontinued for a period of nine months or upwards, or if any premises on which it is for the time being carried on are enlarged without the sanction of the county council; but a business shall not be deemed to be established anew on any premises by reason only that the ownership of such premises is wholly or partially changed, or that the building in which it is established having been wholly or partially pulled down or burnt down has been reconstructed without any extension of its area.

(9.) Nothing in this section shall render an order of the county council necessary to authorise the slaughter of cattle at the Metropolitan Cattle Market, or at the cattle market at Deptford, or shall authorise the making of byelaws affecting either of those markets or the slaughter-houses erected thereat either before or after the commencement of this Act.

(10.) In the application of this section to the City of London, the commissioners of sewers shall be substituted for the county council, and the consolidated rate for the county fund.

20. *Licensing of cow-houses and slaughter-houses.*—(1.) A person carrying on the business of a slaughterer of cattle or horses, knacker, or dairyman, shall not use any premises in London (outside the City of London) as a slaughter-house, or knacker's yard, or a cow-house or place for the keeping of cows, without a licence from the county council, and if he does he shall for each offence be liable to a fine not exceeding five pounds, and the fact that cattle have been taken into unlicensed premises shall be primâ facie evidence that an offence under this section has been committed.

(2.) A licence under this section shall expire on such day in every year as the county council fix, and when a licence is first granted shall expire on the day so fixed which secondly occurs after the grant of the licence, and a fee not exceeding five shillings to be carried to the county fund may be charged for the licence.

(3.) Not less than fourteen days before a licence for any premises is granted or renewed under this section, notice of the intention to apply for it shall be served on the sanitary authority of the district in which the premises are situate, and that sanitary authority, if they think fit, may show cause against the grant or renewal of the licence.

(4.) An objection shall not be entertained to the renewal of a licence under this section, unless seven days previous notice of the objection has been served on the applicant, save that, on an objection being made of which notice has not been given, the county council may, if they think it just so to do, direct notice thereof to be served on the applicant, and adjourn the question of the renewal to a future day, and require the attendance of the applicant on that day, and then hear the case, and consider the objection, as if the said notice had been duly given.

(5.) Where a committee of the county council determine to refuse, or to recommend the county council to refuse, the renewal of any licence under this section, the county council shall, on written application made within seven days after such determination is made known to the applicant, hear the applicant against such refusal.

(6). For the purposes of this section a licence shall be deemed to be renewed where a further licence is granted in immediate succession to a prior licence for the same premises.

(7.) The sanitary authority shall have a right to enter any slaughter-house or knacker's yard at any hour by day or at any hour when business is in progress or is usually carried on therein, for the purpose of examining whether there is any contravention therein of this Act or of any byelaw made thereunder.

(8.) Nothing in this section shall extend to slaughter-houses erected before or after the commencement of this Act in the Metropolitan Cattle Market under the authority of the Metropolitan Market Act, 1851, or the Metropolitan Market Act, 1857.

21. *Duty of sanitary authority to complain to justice of nuisance arising from offensive trade.*—(1.) Where any manufactory, building, or premises used for any trade, business, process, or manufacture, causing effluvia, is certified to the sanitary authority by their medical officer of health, or by any two legally qualified medical practitioners, or by any ten inhabitants of the district of such authority, to be a nuisance or injurious or dangerous to the health of any of the inhabitants of the district, such authority shall make a complaint, and if it appears to the petty sessional court hearing the complaint that the trade, business, process, or manufacture carried on by the person complained of is a nuisance, or causes any effluvia which is a nuisance or injurious or dangerous to the health of any of the inhabitants of the district, then, unless it is shown that such person has used the best practicable means for abating the nuisance, or preventing or counteracting the effluvia, the person so offending (being the owner or occupier of the premises, or being a foreman or other person employed by such owner or occupier) shall be liable to a fine not exceeding fifty pounds.

(2.) Provided that the court may suspend its final determination on condition that the person complained of undertakes to adopt, within a reasonable time, such means as the court may deem practicable, and order to be carried into effect, for abating the nuisance, or mitigating or preventing the injurious effects of the effluvia.

(3.) The sanitary authority may, if they think fit, on such certificate as is in this section mentioned, cause to be taken any proceedings in the High Court against any person in respect of the matters alleged in such certificate.

(4.) The sanitary authority may take proceedings under this section in respect of a manufactory, building, or premises situate without their district, so, however, that the summary proceedings shall be had before a court having jurisdiction in the district where the manufactory, building, or premises are situate.

(5.) Section one hundred and fifteen of the Public Health Act, 1875, 38 & 39 Vict. c. 55 (set out in the First Schedule to this Act), shall continue to extend to London, with the substitution of a sanitary authority under this Act for a nuisance authority mentioned in the said section, and any reference in that section to a nuisance in the metropolis or to any building, manufactory, or place in the metropolis which is injurious to health, shall include any nuisance within the meaning of this Act, and any manufactory, building, or place which is dangerous to health.

22. *Provision as to nuisance created by sanitary authority in dealing with refuse.*—(1.) The removal of house refuse and street refuse by a sanitary authority when collected or deposited by that authority shall be deemed to be a business carried on by that authority within the meaning of the last preceding section, and a complaint or proceedings under that section in relation to any such business may be made or taken by the county council in like manner as if the council were a sanitary authority.

(2.) Any premises used by a sanitary authority for the treatment or disposal of any street refuse or house refuse, as distinct from the removal thereof, which are a nuisance or injurious or dangerous to health, shall be a nuisance liable to be dealt with summarily under this Act, and for the purpose of the application thereto of the provisions of this Act relating to such nuisances the county council shall be deemed to be a sanitary authority.

Smoke Consumption.

23. *Furnaces and steam vessels to consume their own smoke.*—(1.) Every furnace employed in the working of engines by steam, and every furnace employed in any public bath or washhouse, or in any mill, factory, printing house, dyehouse, iron foundry, glasshouse, distillery, brewhouse, sugar refinery, bakehouse, gasworks, waterworks, or other buildings used for the purpose of trade or manufacture (although a steam engine be not used or employed therein), shall be constructed so as to consume or burn the smoke arising from such furnace.

(2.) If any person being the owner or occupier of the premises, or being a foreman or other person employed by such owner or occupier—

- (*a*) uses any such furnace which is not constructed so as to consume or burn the smoke arising therefrom; or
- (*b*) so negligently uses any such furnace as that the smoke arising therefrom is not effectually consumed or burnt; or
- (*c*) carries on any trade or business which occasions any noxious or offensive effluvia, or otherwise annoys the neighbourhood or inhabitants, without using the best practicable means for preventing or counteracting such effluvia or other annoyance;

such person shall be liable to a fine not exceeding five pounds, and on a second conviction to a fine of ten pounds, and on each subsequent conviction to a fine double the amount of the fine imposed on the last preceding conviction.

(3.) Every steam engine and furnace used in the working of any steam vessel on the River Thames, either above London Bridge, or plying to and fro between London Bridge and any place on the River Thames westward of the Nore light, shall be constructed so as to consume or burn the smoke arising from such engine and furnace; and if any such steam engine or furnace is not so constructed, or being so constructed is wilfully or negligently used so that the smoke arising therefrom is not effectually consumed or burnt, the owner or master of such vessel shall be liable to a fine not exceeding five pounds, and on a second conviction to a fine of ten pounds, and on every subsequent conviction to a fine of double the amount of the fine imposed on the last preceding conviction.

(4.) Provided that in this section the words "consume or burn the smoke" shall not be held in all cases to mean "consume or burn all the smoke," and the court hearing an information against a person may remit the fine if of opinion that such person has so constructed his furnace as to consume or burn, as far as possible, all the smoke arising from such furnace, and has carefully attended to the same, and consumed or burned, as far as possible, the smoke arising from such furnace.

(5.) It shall be the duty of every sanitary authority to enforce the provisions of this section, and an information shall not be laid for the recovery of any fine under this section except under the direction of a sanitary authority.

(6.) The provisions of this Act with respect to the admission of the sanitary authority into any premises for any purposes in relation to nuisances, and with respect to the giving of information of a nuisance, shall apply in like manner as if they were herein re-enacted, and in terms made applicable to this section.

(7.) This section shall extend to the port of London, and as respects the port shall be enforced by the port sanitary authority.

(8.) Nothing in this section shall alter or repeal any of the provisions of the City of London Sewers Act, 1851 (14 & 15 Vict. c. 75), or of the Whitechapel Improvement Act, 1853 (16 & 17 Vict. c. cxli.).

24. *Summary proceedings for abatement of nuisance caused by smoke.*—

- (*a*.) Any fireplace or furnace which does not, as far as practicable, consume the smoke arising from the combustible used therein, and which is used for working engines by steam, or in any mill, factory, dyehouse, brewery, bakehouse, or gaswork, or in any manufacturing or trade process whatsoever; and
- (*b*.) Any chimney (not being the chimney of a private dwelling-house) sending forth black smoke in such quantity as to be a nuisance;

shall be nuisances liable to be dealt with summarily under this Act, and the provisions of this Act relating to those nuisances shall apply accordingly:

Provided that the court, hearing a complaint against a person in respect of a nuisance arising from a fireplace or furnace which does not consume the smoke arising from the combustible used in such fireplace or furnace, shall hold that no nuisance is created, and dismiss the complaint, if satisfied that such fireplace or furnace is constructed in such manner as to consume as far as practicable, having regard to the nature of the manufacture or trade, all smoke arising therefrom, and that such fireplace or furnace has been carefully attended to by the person having charge thereof.

Workshops and Bakehouses.

25. *Limewashing and washing of workshops.*—(1.) Where, on the certificate of a medical officer of health or sanitary inspector, it appears to any sanitary authority that the limewashing, cleansing, or purifying of any workshop (other than a bakehouse), or of any part thereof, is necessary for the health of the persons employed therein, the sanitary authority shall serve notice in writing on the owner or occupier of the workshop to limewash, cleanse, or purify the workshop or part as the case requires, within the time specified in the notice; and, if the person on whom notice is so served fails to comply therewith, he shall be liable to a fine not exceeding five pounds, and to a further fine not exceeding ten shillings for every day during which he continues to make default after conviction; and the sanitary authority may, if they think fit, cause the workshop or part to be limewashed, cleansed, or purified, and may recover in a summary manner the expenses incurred by them in so doing from the person on whom the notice was served.

(2.) This section shall apply to any factory which is not subject to the provisions of the Factory and Workshop Act, 1878 (41 & 42 Vict. c. 16), and the Acts amending the same, and to any workplace, in like manner as it applies to a workshop.

26. *Enactments respecting bakehouses.*—(1.) Sections thirty-four, thirty-five, and eighty-one of the Factory and Workshop Act, 1878 (41 & 42 Vict. c. 16), and sections fifteen and sixteen of the Factory and Workshop Act Amendment Act, 1883 (46 & 47 Vict. c. 53), (which relate to cleanliness, ventilation, and other sanitary conditions), shall, as respects every bakehouse which is a workshop, be enforced by the sanitary authority of the district in which the bakehouse is situate, and they shall be the local authority within the meaning of those sections.

(2.) For the purposes of this section, the provisions of this Act with respect to the admission of the sanitary authority and their officers into any premises for any purpose in relation to nuisances shall apply in like manner as if they were herein re-enacted and in terms made applicable to this section; and every person refusing or failing to allow the sanitary authority or their officer to enter any premises in pursuance of those provisions for the purposes of this section shall be subject to a fine.

27. *Notice to factory inspector respecting child or woman in workshop.*—If any child, young person, or woman is employed in a workshop, and the medical officer of the sanitary authority becomes aware thereof, he shall forthwith give written notice thereof to the factory inspector for the district.

Dairies.

28. *Orders and regulations for dairies.*—(1.) The Local Government Board may make such general or special orders as they think fit for the following purposes, or any of them, that is to say,—

(*a.*) for the registration with the county council of all persons carrying on the trade of dairymen;

(*b.*) for the inspection of cattle in dairies, and for prescribing and regulating the lighting, ventilation, cleansing, drainage, and water supply of dairies in the occupation of persons carrying on the trade of dairymen;

(*c.*) for securing the cleanliness of milk-vessels used for containing milk for sale by such persons;

(*d.*) for prescribing precautions to be taken for protecting milk against infection or contamination;

(*e.*) for authorising the county council to make byelaws for the purposes aforesaid, or any of them.

(2.) The county council for the purpose of enforcing the said orders and any byelaws made thereunder shall have the same right to be admitted to any premises as a sanitary authority have under this Act for the purpose of examining as to the existence of a nuisance liable to be dealt with summarily, and the provisions of this Act shall apply accordingly as if they were herein re-enacted and in terms made applicable to this section, and in particular with the substitution of the county council for the sanitary authority.

(3.) The Local Government Board may by any such order impose the like fines for offences against orders made under this section as may be imposed for offences against the byelaws of a sanitary authority under this Act.

(4.) In the application of this section to the City of London, the mayor, commonalty, and citizens of the city acting by the council shall be substituted for the county council, and their expenses in the execution of this section shall be paid out of the consolidated rate.

Removal of Refuse.

29. *Duty of sanitary authority to clean streets.*—(1.) It shall be the duty of every sanitary authority to keep the streets of their district, which are repairable by the inhabitants at large, including the footways, properly swept and cleansed so far as is reasonably practicable, and to collect and remove from the said streets, so far as is reasonably practicable, all street refuse.

(2.) If any such street in the district of any sanitary authority, including the footway, is not properly swept and cleansed, or the street refuse is not collected and removed from any such street, so far as is reasonably practicable, as required by this section, the sanitary authority shall be liable to a fine not exceeding twenty pounds.

(3.) So much of any Act as requires the occupier or owner of any premises in London to cause the footways and watercourses adjoining the premises to be swept and cleansed is hereby repealed.

30. *Removal of house refuse.*—(1.) It shall be the duty of every sanitary authority—

(*a.*) to secure the due removal at proper periods of house refuse from premises, and the due cleansing out and emptying at proper periods of ashpits, and of earth-closets, privies, and cesspools (if any), in their district, and the giving of sufficient notice of the times appointed for such removal, cleansing out, and emptying, and

(*b.*) where the house refuse is not removed from any premises in the district at the ordinary period, or any ashpit, earth-closet, privy, or cesspool in or under any building in the district is not cleansed out or emptied at the ordinary period, and the occupier of the premises serves on the authority a written notice requiring the removal of such refuse, or the cleansing out and emptying of the ashpit, earth-closet, privy, or cesspool, as the case may be, to comply with such notice within forty-eight hours after that service, exclusive of Sundays and public holidays.

(2.) If a sanitary authority fail without reasonable cause to comply with this section, they shall be liable to a fine not exceeding twenty pounds.

(3.) If any person in the employ of the sanitary authority, or of any contractor with the sanitary authority, demands from an occupier or his servant any fee or gratuity for removing any house refuse from any premises, he shall be liable to a fine not exceeding twenty shillings.

31. *Sanitary authority to appoint scavengers.*—Every sanitary authority shall employ a sufficient number of scavengers, or contract with any scavengers, whether a company or individuals, for the execution of the duties of the sanitary authority under this Act with respect to the sweeping and cleansing of the several streets within their district, and the collection and removal of street refuse and house refuse, and the cleansing out and emptying of ashpits, earth-closets, privies, and cesspools.

32. *Disposal of refuse.*—All street refuse and house refuse collected by or on behalf of a sanitary authority shall be the property of that authority, and the authority shall have full power to sell and dispose of the same for the purposes of this Act as they may think proper, and the person purchasing the same shall have full power to take, carry away, and dispose of the same for his own use, and the money arising from the sale thereof shall be applied toward defraying the expenses of the execution of this Act.

33. *Owners, &c. to pay for removal of refuse of trades.*—(1.) If the sanitary authority are required by the owner or occupier of any premises to remove any trade refuse, that authority shall do so, and the owner or occupier shall pay to that authority a reasonable sum for such removal, and such sum, in case of dispute, shall be settled by the order of a petty sessional court.

(2.) If any dispute or difference of opinion arises between the owner or occupier and the sanitary authority as to what is to be considered as trade refuse, a petty sessional court, on complaint made by either party, may by order determine whether the subject matter of dispute is or is not trade refuse, and the decision of that court shall be final.

34. *Provision on neglect of scavengers to remove dust.*—(1.) If the sanitary authority, or any persons employed by them, neglect for the space of seven days to remove all such house refuse as they are required by or in pursuance of this Act to remove, then an occupier of premises (after twenty-four hours' notice given by him to the sanitary authority requiring them to remove the same), may without prejudice to any other proceeding under this Act give away or sell his house refuse; and any person who in pursuance of such gift or sale removes the said house refuse shall not be liable to any fine for so doing.

(2.) Save as aforesaid, if any person other than the sanitary authority or their contractors or servants receives, carries away, or collects any house refuse or street refuse from any premises or street, such person shall be liable to a fine not exceeding five pounds.

35. *Removal of filth on requisition of sanitary inspector.*—(1.) Where it appears to a sanitary inspector that any accumulation of any obnoxious matter, whether manure, dung, soil, filth, or other matter, ought to be removed, and it is not the duty of the sanitary authority to remove the same, he shall serve notice on the owner thereof, or on the occupier of the premises on which it exists, requiring him to remove the same, and if the notice is not complied with within forty-eight hours from the service thereof, exclusive of Sundays and public holidays, the matter referred to shall be the property of the sanitary authority, and be removed and disposed of by them, and the proceeds (if any) of such disposal shall be applied in payment of the expenses incurred with reference to the matter removed, and the surplus (if any) shall be paid on demand to the former owner of the matter.

(2.) The expenses of such removal and disposal, so far as not covered by such proceeds, may be recovered by the sanitary authority in a summary manner from the former owner of the matter removed, or from the occupier, or, where there is no occupier, the owner, of the premises.

36. *Removal of refuse from stables, cowhouses, &c.*—(1.) The sanitary authority, if they think fit, may employ a sufficient number of scavengers, or contract with any scavengers, whether a company or individuals, for collecting and removing the manure and other refuse matter from any stables and cowhouses within their district, the occupiers of which signify their consent in writing to such removal; provided that—

(*a*) such consent shall not be withdrawn or revoked without one month's previous notice to the sanitary authority, and

(*b*) no person shall be hereby relieved from any fine to which he may be subject for placing dung or manure upon any footways or carriageways, or for having any accumulation or deposit of manure or other refuse matter so as to be a nuisance or injurious or dangerous to health.

(2.) Notice may be given by a sanitary authority (by public announcement in the district or otherwise) requiring the periodical removal of manure or other refuse matter from stables, cowhouses, or other premises; and, where any such notice has been given, if any person to whom the manure or other refuse matter belongs fails to comply with the notice, he shall be liable without further notice to a fine not exceeding twenty shillings for each day during which such non-compliance continues.

Regulations as to Waterclosets, &c.

37. *Obligation to provide waterclosets, &c.*—(1.) It shall not be lawful newly to erect any house or to rebuild any house pulled down to or below the ground floor without a sufficient ashpit furnished with proper doors and coverings, and one or more proper and sufficient waterclosets according as circumstances may require, furnished with suitable water supply and water supply apparatus, and with suitable trapped soilpan and other suitable works and arrangements, so far as may be necessary to ensure the efficient operation thereof.

(2.) If any person offends against the foregoing enactment of this section, he shall be liable to a fine not exceeding twenty pounds.

(3.) If at any time it appears to the sanitary authority that any house, whether built before or after the commencement of this Act, is without such ashpit or waterclosets as aforesaid, the sanitary authority shall cause notice to be served on the owner or occupier of the house, requiring him forthwith, or within such reasonable time as is specified in the notice, to provide the same in accordance with the directions in the notice; and, if the notice is not complied with, the said owner or occupier shall be liable to a fine not exceeding five pounds, and a further fine not exceeding forty shillings for each day during which the offence continues; or the sanitary authority, if they think fit, in lieu of proceeding for a fine, may enter on the premises and execute such works as the case may require, and may recover the expenses incurred by them in so doing from the owner of the house.

(4.) Provided that—

(*a*.) where sewerage or water supply sufficient for a watercloset is not reasonably available, this section shall be complied with by the provision of a privy or earth-closet; and

(*b*.) where a watercloset has before the commencement of this Act been and is used in common by the inmates of two or more houses, and in the opinion of the sanitary authority may continue to be properly so used, they need not require a watercloset to be provided for each house.

(5.) Any person who thinks himself aggrieved by any notice or act of a sanitary authority under this section may appeal to the county council, whose decision shall be final.

38. *Sanitary conveniences for manufactories, &c.*—(1.) Every factory, workshop, and workplace, whether erected before or after the passing of this Act, shall be provided with sufficient and suitable accommodation in the way of sanitary conveniences, regard being had to the number of persons employed in or in attendance at such building, and also where persons of both sexes are, or are intended to be, employed, or in attendance, with proper separate accommodation for persons of each sex.

(2.) Where it appears to a sanitary authority that this section is not complied with in the case of any factory, workshop, or workplace, the sanitary authority shall, by notice served on the owner or occupier of such factory, workshop, or workplace, require him to make the alterations and additions necessary to secure such compliance, and if the person served with such notice fails to comply therewith he shall be liable to a fine not exceeding twenty pounds, and to a fine not exceeding forty shillings for every day after conviction during which the non-compliance continues.

39. *Byelaws as to waterclosets, &c.*—(1.) The county council shall make byelaws with respect to waterclosets, earth-closets, privies, ashpits, cesspools, and receptacles for dung, and the proper accessories thereof in connexion with buildings, whether constructed before or after the passing of this Act.

(2.) Every sanitary authority shall make byelaws with respect to the keeping of waterclosets supplied with sufficient water for their effective action.

(3.) It shall be the duty of every sanitary authority to observe and enforce the byelaws under this section; and any directions given by the sanitary authority under this Act shall be in accordance with the said byelaws, and so far as they are not so in accordance shall be void.

40. *Power for sanitary authority to authorise examination of waterclosets, &c.*—(1.) The sanitary authority may examine any of the following works, that is to say, any watercloset, earth closet, privy, ashpit, or cesspool, and any water supply, sink, trap, siphon, pipe, or other works or apparatus connected therewith, upon any premises within their district, and for that purpose, or for the purpose of ascertaining the course of a drain, may at all reasonable times by day, after twenty-four hours' notice has been served on the occupier of the premises, or if they are unoccupied on the owner, or in case of emergency without notice, enter on any premises, and cause the ground to be opened in any place they think fit, doing as little damage as may be.

(2.) If any such work as aforesaid is found on examination to be in accordance with this Act and the byelaws of the county council and sanitary authority and directions of the sanitary authority given in any notice under this Act, and in proper order and condition, the sanitary authority shall cause the same to be reinstated and made good as soon as may be, and shall defray the expenses of examination, reinstating, and making good the same, and pay full compensation for all damages or injuries done or occasioned by the examination; but if on examination any such work is found not to be in proper order or condition, or not to have been made or provided by any person according to the said byelaws and directions, or to be contrary to this Act, the reasonable expenses of the examination shall be repaid to the sanitary authority by the person offending, and may be recovered by that authority in a summary manner.

41. *Penalty on persons improperly making or altering waterclosets, &c.*—(1.) In any of the following cases—

(*a*.) if, on such examination as in the preceding section mentioned, any such work as therein mentioned is found not to have been made or provided by any person according to the byelaws of the county council and sanitary authority, and the directions of the sanitary authority given in any notice under this Act, or to be contrary to this Act, or

(*b*.) if a person, without the consent of the sanitary authority, constructs or rebuilds any watercloset, earth closet, privy, ashpit, or cesspool which has been ordered by them either not to be made, or to be demolished, or

(*c*.) if a person discontinues any water supply without lawful authority, or

(*d*) if a person destroys any sink, trap, siphon, pipe, or any connected works or apparatus as aforesaid either without lawful authority or so that the destruction creates a nuisance or is injurious or dangerous to health,

every person so offending shall be liable to a fine not exceeding ten pounds; and if he does not, within fourteen days after notice is served on him by the sanitary authority, or within any further time allowed by that authority or appearing to a petty sessional court necessary for the execution of the works, cause such watercloset, earth closet, privy, ashpit, or cesspool to be altered or reinstated in conformity with the said byelaws and directions, or, as the case may be, to be demolished, or such water supply to be renewed, or such sink, trap, siphon, pipe or other connected works or apparatus to be restored, such person shall be liable to a fine not exceeding twenty shillings for each day during which the offence continues; or the sanitary authority, if they think fit, in lieu of proceeding for a fine, may enter on the premises and cause the work to be done, and the expenses thereof shall be paid by the person who has so offended.

(2.) If, on such examination as aforesaid, any watercloset, earth closet, privy, ashpit, or cesspool, or any water supply, sink, trap, siphon, pipe, or any of the connected works or apparatus as aforesaid, appears to be in bad order and condition, or to require cleansing, alteration or amendment, or to be filled up, the sanitary authority shall cause notice to be served on the owner or occupier of the premises, upon or in respect of which the inspection was made, requiring him forthwith, or within a reasonable time specified in the notice, to do what is necessary to place the work in proper order and condition; and if such notice is not complied with, the said owner or occupier shall be liable to a fine not exceeding five pounds, and to a further fine not exceeding forty shillings for each day during which the offence continues; or the sanitary authority, if they think fit, in lieu of proceeding for a fine, may enter on the premises and execute the works, and the expenses incurred by them in so doing shall be paid to them by the owner or occupier of the premises.

(3.) Any person who thinks himself aggrieved by any notice or act of a sanitary authority under this section in relation to any watercloset, earth-closet, privy, ashpit, or cesspool, may appeal to the county council, whose decision shall be final.

42. *Improper construction or repair of watercloset or drain.*—If a watercloset or drain is so constructed or repaired as to be a nuisance or injurious or dangerous to health, the person who undertook or executed such construction or repair shall, unless he shows that such construction or repair was not due to any wilful act, neglect, or default, be liable to a fine not exceeding twenty pounds:

Provided that where a person is charged with an offence under this section he shall be entitled, upon information duly laid by him, to have any other person, being his agent, servant, or workman, whom he charges as the actual offender, brought before the court at the time appointed for hearing the charge, and if he proves to the satisfaction of the court that he had used due diligence to prevent the commission of the offence, and that the said other person committed the offence without his knowledge, consent, or connivance, he shall be exempt from any fine, and the said other person may be summarily convicted of the offence.

43. *Sanitary authority to cause offensive ditches, drains, &c. to be cleansed or covered.*—(1.) Every sanitary authority—

(*a*.) shall drain, cleanse, cover, or fill up, or cause to be drained, cleansed, covered, or filled up, all ponds, pools, open ditches, drains, and places containing or used for the collection of any drainage, filth, water, matter, or thing of an offensive nature, or likely to be prejudicial to health, which may be situate in their district; and

(*b*.) shall cause notice to be served on the person causing any such nuisance, or on the owner or occupier of any premises whereon the same exists, requiring him, within the time specified in such notice, to drain, cleanse, cover, or fill up such pond, pool, ditch, drain, or place, or to construct a proper drain for the discharge of such filth, water, matter, or thing, or to execute such other works as the case may require.

(2.) If the person on whom such notice is served fails to comply therewith, he shall be liable to a fine not exceeding five pounds, and a further fine not exceeding forty shillings for each day during which the offence continues; or the sanitary authority, if they think fit, in lieu of proceeding for a fine, may enter on the premises and execute such works as may be necessary for the abatement of the nuisance, and may recover the expenses thereby incurred from the owner of the premises: Provided that—

(*a*.) the sanitary authority, where they think it reasonable, may defray all or any portion of the said expenses, as expenses of sewerage are to be defrayed by that authority; and

(*b*.) where any work which a sanitary authority does or requires to be done in pursuance of this section interferes with or prejudicially affects any ancient mill, or any right connected therewith, or other right to the use of water, the sanitary authority shall make full compensation to all persons sustaining damage thereby, in manner provided by the Metropolis Management Act, 1855, or if they think fit, may purchase such mill, or any such right connected therewith, or other right to the use of water; and the provisions of the said Act with respect to purchases by the sanitary authority shall be applicable to every such purchase as aforesaid.

(3.) Any person who thinks himself aggrieved by any notice or act of a sanitary authority under this section in relation to the construction, covering, filling up, or other alteration of any drain may appeal to the county council, whose decision shall be final.

44. *Power to sanitary authority to provide public conveniences.*—(1.) Every sanitary authority may provide and maintain public lavatories and ashpits and public sanitary conveniences other than privies, in situations where they deem the same to be required, and may supply such lavatories and sanitary conveniences with water, and may defray the expense of providing such lavatories, ashpits, and sanitary conveniences, and of any damage occasioned to any person by the erection or construction thereof, and the expense of keeping the same in good order, as if they were expenses of sewerage.

(2.) For the purpose of such provision the subsoil of any road, exclusive of the footway adjoining any building or the curtilage of a building, shall be vested in the sanitary authority.

45. *Regulations as to public sanitary conveniences.*—(1.) Where a sanitary authority provide and maintain any public lavatories, ashpits, or sanitary conveniences, such authority may—

(*a*.) make regulations with respect to the management thereof, and byelaws as to the decent conduct of persons using the same; and

(*b*.) let the same for any term not exceeding three years at such rent and subject to such conditions as they may think fit; and

(*c*.) charge such fees for the use of any lavatories or waterclosets provided by them as they may think proper.

(2.) No public lavatory, ashpit, or sanitary convenience shall be erected in or accessible from any street without the consent in writing of the sanitary authority, who may give their consent upon such terms as to the use thereof or the removal thereof at any time, if required by the sanitary authority, as they may think fit.

(3.) If any person erects a lavatory, ashpit, or sanitary convenience in contravention of this section, and after notice to that effect served by the sanitary authority does not remove the same, he shall be liable to a fine not exceeding five pounds, and to a fine not exceeding twenty shillings for every day during which the offence continues after a conviction for the offence.

(4.) Nothing in this section shall extend to any lavatory or sanitary convenience now or hereafter erected by any railway company within their railway station yard or the approaches thereto.

46. *Sanitary conveniences used in common.*—The following provisions shall have effect with respect to any sanitary convenience used in common by the occupiers of two or more separate dwelling-houses, or by other persons:—

(1.) If any person injures or improperly fouls any such sanitary convenience, or anything used in connexion therewith, he shall for each offence be liable to a fine not exceeding ten shillings;

(2.) If any such sanitary convenience or the approaches thereto, or the walls, floors, seats, or fittings thereof, is or are in the opinion of the sanitary authority or of their sanitary inspector or medical officer of health in such a state as to be a nuisance or annoyance to any inhabitant of the district for want of the proper cleansing thereof, such of the persons having the use thereof in common as may be in default, or, in the absence of proof satisfactory to the court as to which of the persons having the use thereof in common is in default, each of those persons shall be liable to a fine not exceeding ten shillings, and to a fine not exceeding five shillings for every day during which the offence continues after a conviction for the offence.

Unsound Food.

47. *Inspection and destruction of unsound meat, &c.*—(1.) Any medical officer of health or sanitary inspector may at all reasonable times enter any premises and inspect and examine

(*a.*) any animal intended for the food of man which is exposed for sale, or deposited in any place for the purpose of sale, or of preparation for sale, and

(*b.*) any article, whether solid or liquid, intended for the food of man, and sold or exposed for sale or deposited in any place for the purpose of sale or of preparation for sale,

the proof that the same was not exposed or deposited for any such purpose, or was not intended for the food of man, resting with the person charged; and if any such animal or article appears to such medical officer or inspector to be diseased, or unsound, or unwholesome, or unfit for the food of man, he may seize and carry away the same himself or by an assistant, in order to have the same dealt with by a justice.

(2.) If it appears to a justice that any animal or article which has been seized or is liable to be seized under this section is diseased, or unsound, or unwholesome, or unfit for the food of man, he shall condemn the same, and order it to be destroyed or so disposed of as to prevent it from being exposed for sale or used for the food of man; and the person to whom the same belongs or did belong at the time of sale or exposure of sale, or deposit for the purpose of sale or of preparation for sale, or in whose possession or on whose premises the same was found, shall be liable on summary conviction to a fine not exceeding fifty pounds for every animal, or article, or if the article consists of fruit, vegetables, corn, bread, or flour, for every parcel thereof so condemned, or, at the discretion of the court, without the infliction of a fine, to imprisonment for a term of not more than six months with or without hard labour.

(3.) Where it is shown that any article liable to be seized under this section, and found in the possession of any person was purchased by him from another person for the food of man, and when so purchased was in such a condition as to be liable to be seized and condemned under this section, the person who so sold the same shall be liable to the fine and imprisonment above mentioned, unless he proves that at the time he sold the said article he did not know, and had no reason to believe, that it was in such condition.

(4.) Where a person convicted of an offence under this section has been within twelve months previously convicted of an offence under this section, the court may, if it thinks fit, and finds that he knowingly and wilfully committed both such offences, order that a notice of the facts be affixed, in such form and manner, and for such period not exceeding twenty-one days, as the court may order, to any premises occupied by that person, and that the person do pay the costs of such affixing; and if any person obstructs the affixing of such notice, or removes, defaces, or conceals the notice while affixed during the said period, he shall for each offence be liable to a fine not exceeding five pounds.

(5.) If the occupier of a licensed slaughter-house is convicted of an offence under this section, the court convicting him may cancel the licence for such slaughter-house.

(6.) If any person obstructs an officer in the performance of his duty under any warrant for entry into any premises granted by a justice in pursuance of this Act for the purposes of this section, he shall, if the court is satisfied that he obstructed with intent to prevent the discovery of an offence against this section, or has within twelve months previously been convicted of such obstruction, be liable to imprisonment for any term not exceeding one month in lieu of any fine authorised by this Act for such obstruction.

(7.) A justice may act in adjudicating on an offender under this section, whether he has or has not acted in ordering the animal or article to be destroyed or disposed of.

(8.) Where a person has in his possession any article which is unsound or unwholesome or unfit for the food of man, he may, by written notice to the sanitary authority, specifying such article, and containing a sufficient identification of it, request its removal, and the sanitary authority shall cause it to be removed as if it were trade refuse.

Provisions as to Water.

48. *Provisions as to house without proper water supply.*—(1.) An occupied house without a proper and sufficient supply of water shall be a nuisance liable to be dealt with summarily under this Act, and, if it is a dwelling-house, shall be deemed unfit for human habitation.

(2.) A house which after the commencement of this Act is newly erected, or is pulled down to or below the ground floor and rebuilt, shall not be occupied as a dwelling-house until the sanitary authority have certified that it has a proper and sufficient supply of water, either from a water company or by some other means.

(3.) If the sanitary authority refuse such certificate, or fail to give it within one month after written request for the same from the owner of the house, the owner of the house may apply to a petty sessional court, and that court, after hearing or giving the sanitary authority an opportunity to be heard, may, if they think the certificate ought to have been granted, make an order authorising the occupation of the house; but, unless such order is made, an owner who occupies or permits to be occupied the house as a dwelling-house without such certificate shall be liable to a fine not exceeding ten pounds, and to a fine not exceeding twenty shillings for every day during which it is so occupied until a proper and sufficient supply of water is provided; but the imposition of such fine shall be without prejudice to any proceedings for obtaining a closing order.

49. *Notice to sanitary authority of water supply being cut off.*—(1.) Where a water company may lawfully cut off the water supply to any inhabited dwelling-house and cease to supply such dwelling-house with water for non-payment of water rate or other cause, the company shall in every case, within twenty-four hours after exercising the said right, give notice thereof in writing to the sanitary authority of the district in which the house is situated.

(2.) Any company which neglects to comply with the foregoing provision shall be liable to a fine not exceeding ten pounds, and it shall be the duty of the sanitary authority to take proceedings against any company in default.

(3.) This section shall apply to every water company which is a trading company supplying water for profit.

50. *Cleansing of cisterns.*—Every sanitary authority shall make byelaws for securing the cleanliness and freedom from pollution of tanks, cisterns, and other receptacles used for storing of water used or likely to be used by man for drinking or domestic purposes, or for manufacturing drink for the use of man.

51. *Power of sanitary authority as to public fountains.*—(1.) All existing public cisterns, reservoirs, wells, fountains, pumps, and works used for the gratuitous supply of water to the inhabitants of the district of any sanitary authority, and not vested in any person or authority other than the sanitary authority, shall vest in and be under the control of the sanitary authority; and that authority may maintain the same and plentifully supply them with pure and wholesome water, or may substitute, maintain, and plentifully supply with pure and wholesome water other such works equally convenient, and may maintain and supply with water as aforesaid other public cisterns, reservoirs, wells, fountains, pumps, and other such works within their district.

(2.) The sanitary authority may provide and maintain public wells, pumps, and drinking fountains in such convenient and suitable situations as they may deem proper.

(3.) If any person wilfully damages any of the said wells, pumps, or fountains, or any part thereof, he shall, in addition to any punishment to which he is liable, pay to the sanitary authority the expenses of repairing or reinstating such well, fountain, pump, or part thereof.

52. *Penalty for causing water to be corrupted by gas washings.*—(1.) If any person engaged in the manufacture of gas—

(*a.*) causes or suffers to be brought or to flow into any source of water supply, or into any drain or pipe communicating therewith, any washing or other substance produced in making or supplying gas; or,

(*b.*) wilfully or negligently does any act connected with the making or supplying of gas whereby the water in any source of water supply is fouled,

he shall for every such offence be liable to a fine of two hundred pounds, and, after the expiration of twenty-four hours' notice from the sanitary authority or the person to whom the water belongs in that behalf, to a further fine of twenty pounds for every day during which the offence continues.

(2.) Every such fine may be recovered, with full costs of action, in the High Court, in the case of water belonging to or under the control of the sanitary authority by that authority, and in any other case by the person into whose water such washing or other substance is brought or flows, or whose water is fouled by any such act as aforesaid, or in default of proceedings by such person after notice to him from the sanitary authority of their intention to proceed for such fine, by the sanitary authority; but such fine shall not be recoverable unless it is sued for during the continuance of the offence, or within six months after it has ceased.

53. *Penalty for fouling water.*—If any person does any act whereby any fountain or pump is wilfully or maliciously damaged, or is guilty of any act or neglect whereby the water of any well, fountain, or pump used or likely to be used by man for drinking or domestic purposes, or for manufacturing drink for the use of man, is polluted or fouled, he shall be liable to a fine not exceeding five pounds for each offence, and a further fine not exceeding twenty shillings for every day during which the offence continues after notice is served on him by the sanitary authority in relation thereto, but this section shall not extend to offences against the last preceding section by persons engaged in the manufacture of gas.

54. *Power to close polluted wells, &c.*—(1.) On the representation of any person to a sanitary authority that within their district the water in any well, tank, or cistern, public or private, or supplied from any public pump, is used or likely to be used by man for drinking or domestic purposes, or for manufacturing drink for the use of man, and is so polluted, or is likely to be so polluted, as to be injurious or dangerous to health, a petty sessional court, on complaint by such authority and after hearing the person who is the owner or occupier of the premises to which the well, tank, or cistern belongs, if it be private, or in the case of a public well, tank, cistern, or pump, is alleged in the complaint to be interested in the same, or after giving him an opportunity of being heard, may by summary order direct the well, tank, cistern, or pump to be permanently or temporarily closed, or make such other order as appears to the court requisite to prevent injury or danger to the health of persons drinking the water.

(2.) The court may, if they see fit, cause the water complained of to be analysed at the cost of the sanitary authority complaining.

(3.) If the person on whom the order is made fails to comply therewith, he shall be liable to a fine not exceeding twenty pounds, and a petty sessional court on complaint by the sanitary authority may authorise that authority to execute the order, and any expenses incurred by them in so doing may be recovered in a summary manner from the said person.

Infectious Diseases—Notification.

55. *Notification of infectious disease.*—(1.) Where an inmate of any house within the district of a sanitary authority is suffering from an infectious disease to which this section applies, the following provisions shall have effect, that is to say:—

(*a.*) The head of the family to which such inmate (in this section referred to as the patient) belongs, and in his default the nearest relatives of the patient present in the house or being in attendance on the patient, and in default of such relatives, every person in charge of or in attendance on the patient, and in default of any such person the master of the house, shall, as soon as he becomes aware that the patient is suffering from an infectious disease to which this section applies, send notice thereof to the medical officer of health of the district:

(*b*.) Every medical practitioner attending on or called in to visit the patient shall forthwith, on becoming aware that the patient is suffering from an infectious disease to which this section applies, send to the medical officer of health of the district a certificate stating the full name and the age and sex of the patient, the full postal address of the house, and the infectious disease from which in the opinion of such medical practitioner the patient is suffering, and stating also whether the case occurs in the private practice of such practitioner or in his practice as a medical officer of any public body or institution, and where the certificate refers to the inmate of a hospital it shall specify the place from which and the date at which the inmate was brought to the hospital, and shall be sent to the medical officer of health of the district in which the said place is situate:

Provided that, in the case of a hospital of the Metropolitan Asylum Managers, a notice or certificate need not be sent respecting any inmate with respect to whom a copy of the certificate has been previously forwarded by the medical officer of health of the district to the said Managers.

(2.) Every person required by this section to send a notice or certificate, who fails forthwith to send the same, shall be liable to a fine not exceeding forty shillings: Provided that if a person is not required to send notice in the first instance, but only in default of some other person, he shall not be liable to any fine if he satisfies the court that he had reasonable cause to suppose that the notice had been duly sent.

(3.) The Local Government Board may prescribe forms for the purpose of certificates to be sent in pursuance of this section, and if such forms are so prescribed, they shall be used in all cases to which they apply. The sanitary authority shall gratuitously supply forms of certificate to any medical practitioner residing or practising in their district who applies for the same, and shall pay to every medical practitioner for each certificate duly sent by him in accordance with this section a fee of two shillings and sixpence if the case occurs in his private practice, and of one shilling if the case occurs in his practice as medical officer of any public body or institution.

(4.) Where a medical officer of health receives a certificate under this section relating to a patient within the Metropolitan Asylum district, he shall, within twelve hours after such receipt, send a copy thereof to the Metropolitan Asylum Managers, and to the head teacher of the school attended by the patient (if a child), or by any child who is an inmate of the same house as the patient. The Metropolitan Asylum Managers shall repay to the sanitary authority the fees paid by that authority in respect of the certificates whereof copies have been so sent to the Managers. The Managers shall send weekly to the county council, and to every medical officer of health, such return of the infectious diseases of which they receive certificates in pursuance of this section as the county council require.

(5.) Where in any district of a sanitary authority there are two or more medical officers of health of that authority, a certificate under this section shall be sent to such one of those officers as has charge of the area in which is the patient referred to in the certificate, or to such other of those officers as the sanitary authority may direct.

(6.) A notice or certificate to be sent to a medical officer in pursuance of this section may be sent to such officer at his office or residence.

(7.) This section shall apply to every building, vessel, tent, van, shed, or similar structure used for human habitation, in like manner as nearly as may be as if it were a house; but nothing in this section shall extend to any house, building, vessel, tent, van, shed, or similar structure belonging to Her Majesty the Queen, or to any inmate thereof, nor to any vessel belonging to any foreign government.

(8.) In this section the expression "infectious disease to which this section applies" means any of the following diseases, namely, small-pox, cholera, diphtheria, membranous croup, erysipelas, the disease know as scarlatina or scarlet fever, and the fevers known by any of the following names, typhus, typhoid, enteric, relapsing, continued, or puerperal, and includes as respects any particular district any infectious disease to which this section has been applied by the sanitary authority of the district in manner provided by this Act.

56. *Power of sanitary authority to add to number of infectious diseases of which notification is required.*—(1.) The sanitary authority of any district may, by resolution passed at a meeting of that authority, of which such notice has been given as in this section mentioned, order that the foregoing section with respect to the notification of infectious disease shall apply in their district to any infectious disease other than a disease specifically mentioned in that section; any such order may be permanent or temporary, and, if temporary, the period during which it is to continue in force shall be specified therein, and any such order may be revoked or varied by the sanitary authority which made the same.

(2.) Fourteen clear days at least before the meeting at which such resolution is proposed special notice of the meeting, and of the intention to propose the making of such order, shall be given to every member of the sanitary authority, and the notice shall be deemed to have been duly given to a member if it is given in the mode in which notices to attend meetings of the sanitary authority are usually given.

(3.) An order under this section and the revocation and variation of any such order shall not be of any validity until it has been approved by the Local Government Board, and when it is so approved the sanitary authority shall give public notice thereof by advertisement in a local newspaper, and by handbills, and otherwise in such manner as the sanitary authority think sufficient for giving information to all persons interested; they shall also send a copy thereof to each legally qualified medical practitioner whom, after due inquiry, they ascertain to be residing or practising in their district.

(4.) The said order shall come into operation at such date not earlier than one week after the publication of the first advertisement of the approved order as the sanitary authority may fix, and upon the order coming into operation, and during the continuance thereof, an infectious disease mentioned in the order shall, within the district of the authority, be an infectious disease to which the foregoing section with respect to the notification of infectious disease applies.

(5.) In the case of emergency three clear days notice of the meeting and of the intention to propose the making of the order shall be sufficient, and the resolution shall declare the cause of the emergency and shall be for a temporary order, and a copy thereof shall be forthwith sent to the Local Government Board and advertised, and the order shall come into operation at the expiration of one week from the date of the advertisement; but unless approved by the Local Government Board shall cease to be in force at the expiration of one month after it is passed, or any earlier date fixed by the Local Government Board; if it is approved by the Local Government Board that approval shall be conclusive evidence that the case was one of emergency.

(6.) The county council shall, as respects London, have the same power of extending the foregoing section by order to any infectious disease, and the same power of revoking and varying the order, as a sanitary authority have under this section as respects their district; and the foregoing section when so extended by the county council shall be construed as if it had been applied under this section as respects every district in London by the sanitary authority thereof.

57. *Non-disqualification of medical officer by receipt of fees.*—(1.) A payment made to any medical practitioner in pursuance of the provisions of this Act with respect to the notification of infectious disease shall not disqualify that practitioner for serving as member of the county council, or of a sanitary authority, or as guardian of a poor law union, or in any other public office.

(2.) Where a medical practitioner attending on a patient is himself the medical officer of health of the district, he shall be entitled to the same fee as if he were not such medical officer.

Infectious Diseases.—Prevention.

58. *Application of special provisions to certain infectious diseases.*—The following provisions of this Act relating to dangerous infectious diseases shall apply to the infectious diseases specifically mentioned in the foregoing enactment of this Act relating to the notification of infectious disease, and all or any of such provisions may be applied by order to any other infectious disease in the same manner as that enactment may be applied to such disease, subject to the same power of revoking and varying the order, and every such infectious disease is in this Act referred to as a dangerous infectious disease.

59. *Provision of means for disinfecting of bedding, &c.*—(1.) Every sanitary authority shall provide, either within or without their district, proper premises with all necessary apparatus and attendance for the destruction and for the disinfection, and carriages or vessels for the removal, of articles (whether bedding, clothing, or other) which have become infected by any dangerous infectious disease, and may provide the same for the destruction, disinfection, and removal of such articles when infected by any other disease; and shall cause any such articles brought for destruction or disinfection, whether alleged to be infected by any dangerous infectious disease or by any other disease, to be destroyed or to be disinfected and returned, and may remove, and may destroy, or disinfect and return, such articles free of charge.

(2.) Any sanitary authorities may execute their duty under this section by combining for the purposes thereof, or by contracting for the use by one of the contracting authorities of any premises provided for the purpose of this section by another of such contracting authorities, and may so combine or contract upon such terms as may be agreed upon.

60. *Cleansing and disinfecting of premises, &c.*—(1.) Where the medical officer of health of any sanitary authority, or any other legally qualified medical practitioner, certifies that the cleansing and disinfecting of any house, or part thereof, and of any articles therein likely to retain infection, or the destruction of such articles, would tend to prevent or check any dangerous infectious disease, the sanitary authority shall serve notice on the master, or where the house or part is unoccupied on the owner, of such house or part that the same and any such articles therein will be cleansed and disinfected or (as regards the articles) destroyed, by the sanitary authority, unless he informs the sanitary authority within twenty-four hours from the receipt of the notice that he will cleanse and disinfect the house or part and any such articles or destroy such articles to the satisfaction of the medical officer of health, or of any other legally qualified medical practitioner, within a time fixed in the notice.

(2.) If either—

(*a*) within twenty-four hours from the receipt of the notice, the person on whom the notice is served does not inform the sanitary authority as aforesaid, or

(*b*) having so informed the sanitary authority he fails to have the house or part thereof and any such articles disinfected or such articles destroyed as aforesaid within the time fixed in the notice, or

(*c*) the master or owner without such notice gives his consent,

the house or part and articles shall be cleansed and disinfected or such articles destroyed by the officers and at the cost of the sanitary authority under the superintendence of the medical officer of health.

(3.) For the purpose of carrying into effect this section the sanitary authority may enter by day on any premises.

(4.) The sanitary authority shall provide, free of charge, temporary shelter or house accommodation with any necessary attendants for the members of any family in which any dangerous infectious disease has appeared, who have been compelled to leave their dwellings, for the purpose of enabling such dwellings to be disinfected by the sanitary authority.

(5.) When the sanitary authority have disinfected any house, part of a house, or article, under the provisions of this section, they shall compensate the master or owner of such house, or part of a house, or the owner of such article, for any unnecessary damage thereby caused to such house, part of a house, or article; and when the authority destroy any article under this section they shall compensate the owner thereof; and the amount of any such compensation shall be recoverable in a summary manner.

61. *Disinfection of bedding, &c.*—(1.) Any sanitary authority may serve a notice on the owner of any bedding, clothing, or other articles which have been exposed to the infection of any dangerous infectious disease, requiring the delivery thereof to an officer of the sanitary authority for removal for the purpose of destruction or disinfection; and if any person fails to comply with such notice he shall, on the information of the sanitary authority, be liable to a fine not exceeding ten pounds.

(2.) The bedding, clothing, and articles if so disinfected by the sanitary authority shall be brought back and delivered to the owner free of charge, and if any of them suffer any unnecessary damage the authority shall compensate the owner for the same, and the authority shall also compensate the owner for any articles destroyed; and the amount of compensation shall be recoverable in a summary manner,

62. *Infectious rubbish thrown into ash-pits, &c., to be disinfected.*—(1.) If a person knowingly casts, or causes or permits to be cast, into any ash-pit any rubbish infected by a dangerous infectious disease without previous disinfection, he shall be liable to a fine not exceeding five pounds, and, if the offence continues, to a further fine not exceeding forty shillings for every day during which the offence so continues after the notice hereafter in this section mentioned.

(2.) The sanitary authority shall cause their officers to serve notice of the provisions of this section on the master of any house or part of a house in which they are aware that there is a person suffering from a dangerous infectious disease, and on the request of such master shall provide for the removal and disinfection or destruction of the aforesaid rubbish.

63. *Penalty on letting houses in which infected persons have been lodging.*—(1.) Any person who knowingly lets for hire any house, or part of a house, in which any person has been suffering from any dangerous infectious disease, without having such house or part of a house, and all articles therein liable to retain infection, disinfected to the satisfaction of a legally qualified medical practitioner, as testified by a certificate signed by him, or (as regards the articles) destroyed, shall be liable to a fine not exceeding twenty pounds.

(2.) For the purposes of this section, the keeper of an inn shall be deemed to let for hire part of a house to any person admitted as a guest into such inn.

64. *Penalty on persons letting houses making false statements as to infectious disease.*—Any person letting for hire, or showing for the purpose of letting for hire, any house or part of a house, who, on being questioned by any person negotiating for the hire, as to the fact of there being, or within six weeks previously having been, therein any person suffering from any dangerous infectious disease, knowingly makes a false answer to such question, shall be liable, at the discretion of the court, to a fine not exceeding twenty pounds, or to imprisonment, with or without hard labour, for a period not exceeding one month.

65. *Penalty on ceasing to occupy house without disinfection or notice to owner, or making false answer.*—(1.) Where a person ceases to occupy any house, or part of a house, in which any person has within six weeks previously been suffering from any dangerous infectious disease, and either—

(*a.*) fails to have such house, or part of a house, and all articles therein liable to retain infection, disinfected to the satisfaction of a legally qualified medical practitioner, as testified by a certificate signed by him, or such articles destroyed, or

(*b.*) fails to give to the owner or master of such house, or part of a house, notice of the previous existence of such disease, or

(*c.*) on being questioned by the owner or master of, or by any person negotiating for the hire of, such house or part of a house, as to the fact of there having within six weeks previously been therein any person suffering from any dangerous infectious disease, knowingly makes a false answer to such question,

he shall be liable to a fine not exceeding ten pounds.

(2.) The sanitary authority shall cause their officers to serve notice of the provisions of this section on the master of any house or part of a house in which they are aware that there is a person suffering from a dangerous infectious disease.

66. *Removal to hospital of infected persons without proper lodging.*—(1.) A person suffering from any dangerous infectious disease, who is without proper lodging or accommodation, or is lodged in a tent or van, or is on board a vessel, may, on a certificate signed by a legally qualified medical practitioner, and with the consent of the superintending body of the hospital to which he is to be removed, be removed by order of a justice, and at the cost of the sanitary authority of the district where such person is found, to any hospital in or within a convenient distance of London.

(2.) The order may be addressed to such constable or officer of the sanitary authority as the justice making the same thinks expedient; and if any person wilfully disobeys or obstructs the execution of such order he shall be liable to a fine not exceeding ten pounds.

(3.) Any sanitary authority may make byelaws for removing to any hospital to which that authority are entitled to remove patients, and for keeping in that hospital so long as may be necessary, any persons brought within their district by any vessel who are infected with a dangerous infectious disease.

67. *Detention of infected person without proper lodging in hospital.*—(1.) A justice, on being satisfied that a person suffering from any dangerous infectious disease is in a hospital, and would not on leaving the hospital be provided with lodging or accommodation in which proper precautions could be taken to prevent the spreading of the disease by such person, may direct such person to be detained in the hospital at the cost of the Metropolitan Asylum Managers during the time limited by the justice. Any justice may enlarge the time as often as appears to him necessary for preventing the spread of the disease.

(2.) The direction may be carried into execution by any officer of any sanitary authority, or of the Metropolitan Asylum Managers, or by any inspector of police, or any officer of the hospital.

68. *Penalty on exposure of infected persons and things.*—(1.) If any person—

(*a.*) while suffering from any dangerous infectious disease wilfully exposes himself without proper precautions against spreading the said disease in any street, public place, shop, or inn; or

(*b.*) being in charge of any person so suffering, so exposes such sufferer; or

(*c.*) gives, lends, sells, transmits, removes, or exposes, without previous disinfection, any bedding, clothing, or other articles which have been exposed to infection from any such disease;

he shall be liable to a fine not exceeding five pounds.

(2.) Provided that proceedings under this section shall not be taken against persons transmitting with proper precautions any bedding, clothing, or other articles for the purpose of having the same disinfected.

69. *Prohibition on infected person carrying on business.*

A person who knows himself to be suffering from a dangerous infectious disease shall not milk any animal or pick fruit, and shall not engage in any occupation connected with food or carry on any trade or business in such a manner as to be likely to spread the infectious disease, and if he does so he shall be liable to a fine not exceeding ten pounds.

70. *Prohibition on conveyance of infected person in public conveyance.*—It shall not be lawful for any owner or driver of a public conveyance knowingly to convey, or for any other person knowingly to place, in any public conveyance, a person suffering from any dangerous infectious disease, or for a person suffering from any such disease to enter any public conveyance, and if he does so he shall be liable to a fine not exceeding ten pounds; and, if any person so suffering is conveyed in any public conveyance, the owner or driver thereof, as soon as it comes to his knowledge, shall give notice to the sanitary authority, and shall cause such conveyance to be disinfected, and if he fails so to do he shall be liable to a fine not exceeding five pounds, and the owner or driver of such conveyance shall be entitled to recover in a summary manner from the person so conveyed by him, or from the person causing that person to be so conveyed, a sum sufficient to cover any loss and expense incurred by him in connexion with such disinfection. It shall be the duty of the sanitary authority, when so requested by the owner or driver of such public conveyance, to provide for the disinfection of the same, and they may do so free of charge.

71. *Inspection of dairies, and power to prohibit supply of milk.*—(1.) If the medical officer of health of any district has evidence that any person in the district is suffering from a dangerous infectious disease attributable to milk supplied within the district from any dairy situate within or without the district, or that the consumption of milk from such dairy is likely to cause any such infectious disease to any person residing in the district, such medical officer shall, if authorised by an order of a justice having jurisdiction in the place where the dairy is situate, have power to inspect the dairy, and if accompanied by a veterinary inspector or some other proper qualified veterinary surgeon to inspect the animals therein; and, if on such inspection the medical officer of health is of opinion that any such infectious disease is caused from consumption of the milk supplied therefrom, he shall report thereon to the sanitary authority, and his report shall be accompanied by any report furnished to him by the said veterinary inspector or veterinary surgeon, and the sanitary authority may thereupon serve on the dairyman notice to appear before them within such time, not less than twenty-four hours, as may be specified in the notice, to show cause why an order should not be made requiring him not to supply any milk therefrom within the district until the order has been withdrawn by the sanitary authority.

(2.) The sanitary authority, if in their opinion he fails to show such cause, may make the said order, and shall forthwith serve notice of the facts on the county council of the county in which the dairy is situate, and on the Local Government Board, and, if the dairy is situate within the district of another sanitary authority, on such authority.

(3.) The said order shall be forthwith withdrawn on the sanitary authority or their medical officer of health on their behalf being satisfied that the milk supply has been changed, or that the cause of the infection has been removed.

(4.) If any person refuses to permit the medical officer of health, on the production of a justice's order under this section, to inspect any dairy, or if so accompanied as aforesaid to inspect the animals kept there, or, after any such order has been made, supplies any milk within the district in contravention of the order or sells it for consumption therein, he shall, on the information of the sanitary authority, be liable to a fine not exceeding five pounds, and, if the offence continues, to a further fine not exceeding forty shillings for every day during which the offence continues.

(5.) Provided that—

(*a.*) proceedings in respect of the offence shall be taken before a court having jurisdiction in the place where the dairy is situate, and

(*b.*) a dairyman shall not be liable to an action for breach of contract if the breach be due to an order under this section.

(6.) Proceedings may be taken under this section in respect of a dairy situate in the district of a local authority under the Public Health Acts, and the notice of the facts shall be served on the local authority as if they were a sanitary authority within the meaning of this Act.

(7.) Nothing in or done under this section shall interfere with the operation or effect of the Contagious Diseases (Animals) Acts, 1878 to 1886, or this Act, or of any order, licence, or act of the Board of Agriculture or the Local Government Board thereunder, or of any order, byelaw, regulation, licence, or act of a local authority made, granted, or done under any such order of the Board of Agriculture or the Local Government Board, or exempt any dairy, building, or thing or any person from the provisions of any general Act relating to dairies, milk, or animals.

72. *Prohibition of retention of dead body in certain cases.*—(1.) A person shall not without the sanction in writing of the medical officer of health, or of a legally qualified medical practitioner, retain unburied for more than forty-eight hours elsewhere than in a room not used at the time as a dwelling-place, sleeping-place, or work-room, the body of any person who has died of any dangerous infectious disease.

(2.) If a person acts in contravention of this section he shall, on the information of the sanitary authority, be liable to a fine not exceeding five pounds.

73. *Body of person dying of infectious disease in hospital, &c., to be removed only for burial.*—(1.) If a person dies in a hospital from any dangerous infectious disease, and the medical officer of health, or any legally qualified medical practitioner, certifies that in his opinion it is desirable, in order to prevent the risk of communicating such infectious disease, that the body be not removed from such hospital except for the purpose of being forthwith buried, it shall not be lawful for any person to remove the body except for that purpose; and the body when taken out of such hospital shall be forthwith taken direct to the place of burial, and there buried.

(2.) If any person wilfully offends against this section he shall, on the information of the sanitary authority, be liable to a fine not exceeding ten pounds.

(3.) Nothing in this section shall prevent the removal of a dead body from a hospital to a mortuary, and such mortuary shall, for the purposes of this section, be deemed part of such hospital.

74. *Disinfection of public conveyances if used for carrying corpses.*—If—

(*a.*) a person hires or uses a public conveyance other than a hearse for conveying the body of a person who has died from any dangerous infectious disease, without previously notifying to the owner or driver of the conveyance that such person died from infectious disease, or

(*b.*) the owner or driver does not, immediately after the conveyance has to his knowledge been used for conveying such body, provide for the disinfection of the conveyance,

he shall, on the information of the sanitary authority, be liable to a fine not exceeding five pounds, and if the offence continues to a further fine not exceeding forty shillings for every day during which the offence continues.

Hospitals and Ambulances.

75. *Power of sanitary authority to provide hospitals.*—(1.) Any sanitary authority may provide for the use of the inhabitants of their district hospitals temporary or permanent, and for that purpose may—

(*a.*) themselves build such hospitals, or

(*b.*) contract for the use of any hospital or part of a hospital, or

(*c.*) enter into any agreement with any person having the management of any hospital for the reception of the sick inhabitants of their district, on payment of such annual or other sum as may be agreed on.

(2.) Two or more sanitary authorities may combine in providing a common hospital.

76. *Recovery of cost of maintenance of non-infectious patient in hospital.*—Any expenses incurred by a sanitary authority in maintaining in a hospital (whether or not belonging to that authority) a patient who is not a pauper, and is not suffering from an infectious disease, shall be a simple contract debt due to the sanitary authority from that patient, or from any person liable by law to maintain him, but proceedings for its recovery shall not be commenced after the expiration of six months from the discharge of the patient, or if he dies in such hospital from the date of his death.

77. *Power to provide temporary supply of medicine.*—Any sanitary authority may, with the sanction of the Local Government Board, themselves provide, or contract with any person to provide, a temporary supply of medicine and medical assistance for the poorer inhabitants of their district.

78. *Provision of conveyance for infected persons.*—A sanitary authority may provide and maintain carriages suitable for the conveyance of persons suffering from any infectious disease, and pay the expense of conveying therein any person so suffering to a hospital or other place of destination.

79. *Power for Metropolitan Asylum Board to provide landing places, vessels, ambulances, &c.*—(1.) The Metropolitan Asylum Managers shall continue to maintain the wharves, landing-places, and approaches thereto heretofore provided by them, whether within or without London, and may use the same for the embarkation and landing of persons removed to or from any hospital belonging to the Managers, and for any other purpose in relation thereto.

(2.) The Managers may also provide and maintain vessels for use in connexion with the said wharves or landing-places, and with the hospitals of the Managers, and also carriages suitable for the conveyance of persons suffering from any dangerous infectious disease, and shall cause the vessels and carriages to be from time to time properly cleansed and disinfected, and may provide and maintain such buildings and horses, and employ such persons, and do such other things as are necessary or proper for the purposes of such conveyance.

(3.) The Metropolitan Asylum Managers may allow any of the said carriages with the necessary attendants to be also used for the conveyance of persons suffering from any dangerous infectious disease to and from hospitals and places other than hospitals provided by the Managers, and may make a reasonable charge for that use.

80. *Reception of non-pauper fever and small-pox patients into hospital in Metropolitan district.*—(1.) The Metropolitan Asylum Managers, subject to such regulations and restrictions as the Local Government Board prescribe, may admit any person, who is not a pauper, and is reasonably believed to be suffering from fever or small-pox or diphtheria, into a hospital provided by the Managers.

(2.) The expenses incurred by the Managers for the maintenance of any such person shall be paid by the board of guardians of the poor law union from which he is received.

(3.) The said expenses shall be repaid to the board of guardians out of the metropolitan common poor fund.

(4.) The admission of a person suffering from an infectious disease into any hospital provided by the Metropolitan Asylum Managers, or the maintenance of any such person therein, shall not be considered to be parochial relief, alms, or charitable allowance to any person, or to the parent or husband of any person; nor shall any person or his or her parent or husband be by reason thereof deprived of any right or privilege, or be subjected to any disability or disqualification.

81. *Reception into hospital in Metropolitan district of child from school outside London.*—(1.) Where the London School Board send any child to an industrial school which is provided by them outside London, such child shall for the purpose of the enactments relating to the Metropolitan Asylum Managers be deemed to continue to be an inhabitant of London, and if such child is sent to any hospital of those Managers he shall be deemed to have been sent from that place in London from which he was sent to the said industrial school.

(2.) This section shall apply to that part of London which is not within the Metropolitan Asylum district as if it were within that district, and the board of guardians of the poor law union comprising that part shall pay for such child accordingly.

Prevention of Epidemic Diseases.

82. *Sanitary authority to execute epidemic regulations.*—(1.) The sanitary authority of any district within which or part of which regulations issued by the Local Government Board in pursuance of section one hundred and thirty-four of the Public Health Act, 1875 (38 & 39 Vict. c. 55), set out in the First Schedule to this Act (in this Act referred to as the epidemic regulations) are in force, shall superintend and see to the execution thereof, and shall appoint and pay such medical or other officers or persons, and do and provide all such acts, matters, and things, as may be necessary for mitigating any disease to which the regulations relate, or for superintending or aiding in the execution of such regulations, or for executing the same, as the case may require.

(2.) The sanitary authority may direct any prosecution or legal proceedings for or in respect of the wilful violation or neglect of any such regulation.

(3.) The sanitary authority shall have power to enter on any premises or vessel for the purpose of executing or superintending the execution of any of the epidemic regulations.

83. *Poor law medical officers entitled to costs of attendance on board vessels.*—(1.) Whenever, in compliance with the epidemic regulations, any poor law medical officer performs any medical service on board any vessel, he shall be entitled to charge extra for such service, at the general rate of his allowance for services for the poor law union for which he is appointed; and such charges shall be paid by the master of the vessel on behalf of the owners thereof, together with any reasonable expenses for the treatment of the sick.

(2.) Where such service is rendered by any medical practitioner who is not a poor law medical officer, he shall be entitled to charge for the service with extra remuneration on account of distance, at the rate which he is in the habit of receiving from private patients of the class of those attended and treated on shipboard, and such charge shall be paid as aforesaid. Any dispute in respect of such charge may, where the charges do not exceed twenty pounds, be determined by a petty sessional court; and that court shall determine summarily the amount which is reasonable, according to the accustomed rate of charge within the place where the dispute arises for attendance on patients of the like class as those in respect of whom the charge is made.

84. *Local Government Board may combine sanitary authorities.*—The Local Government Board may, if they think fit, by order authorise or require any two or more sanitary authorities to act together for the purposes of the epidemic regulations and prescribe the mode of such joint action, and of defraying the cost thereof, and generally may make any regulations necessary or proper for carrying into execution this section.

85. *Metropolitan Asylum Managers a sanitary authority for prevention of epidemic diseases.*—(1.) The Metropolitan Asylum Managers shall within their district have for the purpose of the epidemic regulations such powers and duties of a sanitary authority as may be assigned to them by the regulations; and the Local Government Board may make regulations for that purpose and thereby provide for the adjustment of the functions of the Managers relatively to those of any sanitary authorities.

(2.) Subject to such regulations the Metropolitan Asylum Managers may use any of their property, real or personal, and their staff, for the execution of any powers or duties conferred or imposed on them under this section.

86. *Power to let hospitals, &c.*—Any authority or body of persons having the management and control of any hospital, infirmary, asylum, or workhouse may let the same or any part thereof to the Metropolitan Asylum Managers, and enter into and carry into effect contracts with those Managers for the reception, treatment, and maintenance therein of persons suffering from cholera or choleraic diarrhœa within the district of the Managers:

Provided that the power conferred by this section shall not, without the consent of the Local Government Board, be exercised with respect to any asylum under the Metropolitan Poor Act, 1867 (30 & 31 Vict. c. 6.) or any workhouse.

87. *Repayment to sanitary authorities of certain expenses.*—The amount expended in pursuance of the epidemic regulations by any sanitary authority in providing any building for the reception of patients or other persons shall, to such extent as may be determined by the Local Government Board, together with two thirds of the salaries or remuneration of any officers or servants employed in any such building under this Act, be repaid to such sanitary authority from the metropolitan common poor fund by the receiver of that fund, out of any moneys for the time being in his hands, on the precept of the said Board, to be issued after the production of such evidence in support of the expenditure as they may deem satisfactory, and the said Board may require contributions for the purpose of raising the sums so repayable.

Mortuaries, &c.

88. *Power of local authority to provide mortuaries.*—Every sanitary authority shall provide and fit up a proper place for the reception of dead bodies before interment (in this Act called a mortuary), and may make byelaws with respect to the management and charges for the use of the same; they may also provide for the decent and economical interment, at charges to be fixed by such byelaws, of any dead body received into a mortuary.

89. *Power of justice in certain cases to order removal of dead body to mortuary.*—(1.) Where either—

(*a*.) the body of a person who has died of any infectious decease is retained in a room in which persons live or sleep; or

(*b*.) the body of a person who has died of any dangerous infectious disease is retained without the sanction of the medical officer of health or any legally qualified medical practitioner for more than forty-eight hours, elsewhere than in a room not used at the time as a dwelling-place, sleeping-place, or work-room; or

(*c*.) any dead body is retained in any house or room, so as to endanger the health of the inmates thereof, or of any adjoining or neighbouring house or building,

a justice may, on a certificate signed by a medical officer of health or other legally qualified medical practitioner, direct that the body be removed, at the cost of the sanitary authority, to any available mortuary, and be buried within the time limited by the justice; and may if it is the body of a person who has died of an infectious disease, or if he considers immediate burial necessary, direct that the body be buried immediately, without removal to the mortuary.

(2.) Unless the friends or relations of the deceased undertake to bury and do bury the body within the time so limited, it shall be the duty of the relieving officer to bury such body, and any expense so incurred shall be paid (in the first instance) by the board of guardians of the poor law union, but may be recovered by them in a summary manner from any person legally liable to pay the expense of such burial.

(3.) If any person obstructs the execution of any direction given by a justice under this section, he shall be liable to a fine not exceeding five pounds.

90. *Power of sanitary authority to provide places for* *post-mortem examinations.*—(1.) Any sanitary authority may, and if required by the county council shall, provide and maintain a proper building (otherwise than at a workhouse) for the reception of dead bodies during the time required to conduct any post-mortem examination ordered by a coroner or other constituted authority, and may make regulations with respect to the management of such building.

(2.) Any such building may be provided in connexion with a mortuary, but this enactment shall not authorise the conducting of any post-mortem examination in a mortuary.

91. *Power to sanitary authorities to unite for providing mortuary.*—Any sanitary authorities may, with the approval of the county council, execute their duty under this Act with respect to mortuaries and buildings for post-mortem examinations by combining for the purpose thereof, or by contracting for the use by one of the contracting authorities of any such mortuary or building provided by another of such contracting authorities, and may so combine or contract upon such terms as may be agreed upon.

92. *Place for holding inquests.*—The county council shall provide and maintain proper accommodation for the holding of inquests, and may by agreement with a sanitary authority provide and maintain the same in connexion with a mortuary or a building for post-mortem examinations provided by that authority, or with any building belonging to that authority, and may do so on such terms as may be agreed on with the authority.

93. *Mortuary for unidentified bodies.*—(1.) The county council may provide and fit up in London one or two suitable buildings to which dead bodies found in London and not identified, together with any clothing, articles, and other things found with or on such dead bodies, may on the order of a coroner be removed, and in which they may be retained and preserved with a view to the ultimate identification of such dead bodies.

(2.) A Secretary of State may make regulations as to—

(*a*.) the manner in which and conditions subject to which any such bodies shall be removed to any such building, and the payments to be made at such building to persons bringing any unidentified dead body for reception; and

(*b*.) the fees and charges to be paid upon the removal or interment of any such dead body which has been identified after its reception, and the persons by whom such fees and payments are to be made, and the manner and method of recovering the same; and

(*c*.) the disposal and interment of any such bodies.

(3.) The county council may provide at the said buildings all such appliances as they think expedient for the reception and preservation of bodies, and may make regulations (subject to the provisions aforesaid) as to the management of the said buildings and the bodies therein, and as to the conduct of persons employed therein or resorting thereto for the purpose of identifying any body.

(4.) Subject to and in accordance with such regulations as may be made by a Secretary of State, any such body found in London may (on the order in writing of a coroner holding or having jurisdiction to hold the inquest on the same) be removed to any building provided under this section, and subject as aforesaid the inquest on any such body shall be held by the same coroner and in the same manner as if the said building were within the district of such coroner.

BYELAWS AS TO HOUSES LET IN LODGINGS.

94.—*Power of sanitary authority to make byelaws as to lodging-houses.*—(1.) Every sanitary authority shall make and enforce such byelaws as are requisite for the following matters; (that is to say),

(*a*.) for fixing the number of persons who may occupy a house or part of a house which is let in lodgings or occupied by members of more than one family, and for the separation of the sexes in a house so let or occupied:

(*b*.) for the registration of houses so let or occupied:

(*c*.) for the inspection of such houses:

(*d*.) for enforcing drainage for such houses, and for promoting cleanliness and ventilation in such houses:

(*e*.) for the cleansing and lime-washing at stated times of the premises:

(*f*.) for the taking of precautions in case of any infectious disease.

(2.) This section shall not apply to common lodging-houses within the Common Lodging Houses Act, 1851 (14 & 15 Vict. c. 28, 16 & 17 Vict. c. 41), or any Act amending the same.

TENTS AND VANS.

95.—*Tents and vans used for human habitation.*—(1.) A tent, van, shed, or similar structure used for human habitation, which is in such a state as to be a nuisance or injurious or dangerous to health, or is so overcrowded as to be injurious or dangerous to the health of the inmates, whether or not members of the same family, shall be a nuisance liable to be dealt with summarily under this Act.

(2.) A sanitary authority may make byelaws for promoting cleanliness in, and the habitable condition of tents, vans, sheds, and similar structures used for human habitation, and for preventing the spread of infectious disease by the persons inhabiting the same, and generally for the prevention of nuisances in connexion with the same.

(3.) Where any person duly authorised by a sanitary authority or by a justice has reasonable cause to suppose either—

(*a*.) that any tent, van, shed, or similar structure used for human habitation is in such a state or so overcrowded as aforesaid, or that there is any contravention therein of any byelaw made under this section; or

(*b*.) that there is in any such tent, van, shed, or structure any person suffering from a dangerous infectious disease,

he may enter by day such tent, van, shed, or structure, and examine the same and every part thereof in order to ascertain whether such tent, van, shed, or structure is in such a state or so overcrowded as aforesaid, or whether there is therein any such contravention, or a person suffering from a dangerous infectious disease, and the provisions of this Act with respect to the entry into any premises by an officer of the sanitary authority shall apply to the entry by any person duly authorised as aforesaid.

(4.) Nothing in this section shall apply to any tent, van, shed, or structure erected or used by any portion of Her Majesty's naval or military forces.

UNDERGROUND ROOMS.

96: *Provisions as to the occupation of underground* *rooms as dwellings.*—(1.) Any underground room, which was not let or occupied separately as a dwelling before the passing of this Act, shall not be so let or occupied unless it possesses the following requisites; that is to say,

(*a*.) unless the room is in every part thereof at least seven feet high measured from the floor to the ceiling, and has at least three feet of its height above the surface of the street or ground adjoining or nearest to the room: Provided that, if the width of the area herein-after mentioned is not less than the height of the room from the floor to the said surface of the street or ground, the height of the room above such surface may be less than three feet, but it shall not in any case be less than one foot, and the width of the area need not in any case be more than six feet;

(*b*.) unless every wall of the room is constructed with a proper damp course, and, if in contact with the soil, is effectually secured against dampness from that soil;

(*c*.) unless there is outside of and adjoining the room and extending along the entire frontage thereof and upwards from six inches below the level of the floor thereof an open area properly paved at least four feet wide in every part thereof: Provided that in the area there may be placed steps necessary for access to the room, and over and across such area there may be steps necessary for access to any building above the underground room, if the steps in each case be so placed as not to be over or across any external window;

(*d*.) unless the said area and the soil immediately below the room are effectually drained;

(*e*.) unless, if the room has a hollow floor, the space beneath it is sufficiently ventilated to the outer air;

(*f*.) unless any drain passing under the room is properly constructed of a gas-tight pipe;

(*g*.) unless the room is effectually secured against the rising of any effluvia or exhalation;

(*h*.) unless there is appurtenant to the room the use of a water-closet and a proper and sufficient ash-pit;

(*i*.) unless the room is effectually ventilated;

(*j*.) unless the room has a fire-place with a proper chimney or flue;

(*k*.) unless the room has one or more windows opening directly into the external air with a total area clear of the sash frames equal to at least one tenth of the floor area of the room, and so constructed that one half at least of each window of the room can be opened, and the opening in each case extends to the top of the window.

(2.) If any person lets or occupies, or continues to let, or knowingly suffers to be occupied, any underground room contrary to this enactment, he shall be liable to a fine not exceeding twenty shillings for every day during which the room continues to be so let or occupied.

(3.) The foregoing provisions shall at the expiration of six months after the commencement of this Act extend to underground rooms let or occupied separately as dwellings before the passing of this Act, except that the sanitary authority, either by general regulations providing for classes of underground rooms, or on the application of the owner of such room in any particular case, may dispense with or modify any of the said requisites which involve the structural alteration of the building, if they are of opinion that they can properly do so having due regard to the fitness of the room for human habitation, to the house accommodation in the district, and to the sanitary condition of the inhabitants and to other circumstances, but any requisite which was required before the passing of this Act shall not be so dispensed with or modified.

(4.) The dispensations and modifications may be allowed either absolutely or for a limited time, and may be revoked and varied by the sanitary authority, and shall be recorded together with the reasons in the minutes of the sanitary authority.

(5.) If the owner of any room feels aggrieved by a dispensation or modification not being allowed as regards that room, he may appeal to the Local Government Board, and that Board may refuse the dispensation or modification, or allow it wholly or partly, as if they were the sanitary authority. Such allowance may be revoked or varied by the Board, but not by the sanitary authority.

(6.) Where two or more underground rooms are occupied together, and are not occupied in conjunction with any other room or rooms on any other floor of the same house, each of them shall be deemed to be separately occupied as a dwelling within the meaning of this section.

(7.) Every underground room in which a person passes the night shall be deemed to be occupied as a dwelling within the meaning of this section; and evidence giving rise to a probable presumption that some person passes the night in an underground room shall be evidence, until the contrary is proved, that such has been the case.

(8.) Where it is shown that any person uses an underground room as a sleeping-place, it shall, in any proceeding under this section, lie on the defendant to show that the room is not separately occupied as a dwelling.

(9.) For the purpose of this section the expression "underground room" includes any room of a house the surface of the floor of which room is more than three feet below the surface of the footway of the adjoining street, or of the ground adjoining or nearest to the room.

97. *Enforcement of provisions as to underground rooms.*—(1.) Any officer of a sanitary authority appointed or determined by that authority for the purpose shall, without any fee or reward, report to the sanitary authority, at such times and in such manner as the sanitary authority may order, all cases in which underground rooms are occupied contrary to this Act in the district of such authority.

(2.) Any such officer or any other person having reasonable grounds for believing that any underground room is occupied in contravention of this Act may enter and inspect the same at any hour by day; and if admission is refused to any person other than an officer of the sanitary authority the like warrant may be granted by a justice under this Act as in case of refusal to admit any such officer.

(3.) A warrant of a justice authorising an entry into an underground room may authorise the entry between any hours specified in the warrant.

98. *Provision in case of two convictions for unlawfully occupying underground room.*—Where two convictions for an offence relating to the occupation of an underground room as a dwelling have taken place within a period of three months (whether the persons convicted were or were not the same), a petty sessional court may direct the closing of the underground room for such period as the court may deem necessary, or may empower the sanitary authority of the district permanently to close the same, in such manner as they think fit, at their own cost.

AUTHORITIES FOR EXECUTION OF ACT.

99. *Definition of sanitary authority.*—(1.) Subject to the provisions of this Act, the sanitary authority for the execution of this Act (in this Act referred to as "the sanitary authority") shall be as follows; (namely),

(*a.*) in the City of London the commissioners of sewers; and

(*b.*) in each of the parishes mentioned in Schedule (A.) to the Metropolis Management Act, 1855 (18 and 19 Vict. c. 120), as amended by the Metropolis Management Amendment Act, 1885 (48 and 49 Vict. c. 33), and the Metropolis Management (Battersea and Westminster) Act, 1887 (50 and 51 Vict. c. 17), other than Woolwich, the vestry of the parish; and

(*c.*) in each of the districts mentioned in Schedule (B.) to the same Act, as so amended, the district board for the district; and

(*d.*) in the parish of Woolwich, the local board of health; and

(*e.*) in any place mentioned in Schedule (C.) to the Metropolis Management Act, 1855, the board of guardians for such place or for any parish or poor law union of which it forms part, or, if there is no such board of guardians, the overseers of the poor for such place, or for the parish in which it is situate, and the said guardians and overseers respectively shall have the same powers for the purposes of this Act as a vestry or district board have under this Act, and their expenses shall be defrayed in the same manner as the expenses of the execution of the Acts relating to the relief of the poor are defrayed in the said place.

(2.) The area within which this Act is executed by any sanitary authority is in this Act referred to as the district of that authority.

(3.) The purposes for which a committee of a vestry or district board may be appointed under the Metropolis Management Act, 1855, and the Acts amending the same, shall include the purposes of this Act, and the provisions of those Acts with respect to committees shall apply accordingly.

(4.) Where a sanitary authority appoint a committee for the purposes of this Act, that committee, subject to the terms of their appointment, may serve and receive notices, take proceedings, and empower any officer of the authority to make complaints and take proceedings in their behalf, and otherwise to execute this Act.

(5.) A sanitary authority may acquire and hold land for the purposes of their duties without any licence in mortmain.

100. *Power of county council to prosecute on default of sanitary authority.*—The county council, on it being proved to their satisfaction that any sanitary authority have made default in doing their duty under this Act with respect to the removal of any nuisance, the institution of any proceedings, or the enforcement of any byelaw, may institute any proceeding and do any act which the authority might have instituted or done for that purpose, and shall be entitled to recover from the sanitary authority in default all such expenses in and about the said proceeding or act as the county council incur, and are not recovered from any other person, and have not been incurred in any unsuccessful proceeding.

101. *Proceedings on complaint to Local Government Board of default of sanitary authority.*—(1.) Where complaint is made by the county council to the Local Government Board that a sanitary authority have made default in executing or enforcing any provisions which it is their duty to execute or enforce of this Act, or of any byelaw made in pursuance thereof, the Local Government Board, if satisfied after due inquiry that the authority have been guilty of the alleged default, and that the complaint cannot be remedied under the other provisions of this Act, shall make an order limiting a time for the performance of the duty of such authority in the matter of such complaint. If such duty is not performed by the time limited in the order, the order may be enforced by writ of Mandamus, or the Local Government Board may appoint the county council to perform such duty.

(2.) Where such appointment is made, the county council shall, for the purpose of the execution of their duties under the said appointment, have all the powers of the defaulting sanitary authority, and all expenses incurred by the county council in the execution of the said duties, together with the costs of the previous proceedings, so far as not recovered from any other person, shall be a debt from the sanitary authority in default to the county council, and shall be paid by the sanitary authority out of any moneys or rate applicable to the payment of the expenses of performing the duty in which they have made default.

(3.) For the purpose of recovering such debt the county council, without prejudice to any other power of recovery, shall have the same power of levying the amount by a rate, and of requiring officers of the defaulting authority to pay over money in their hands, as the defaulting authority would have in the case of expenses legally payable out of a rate raised by that authority.

(4.) The county council shall pay any surplus of the rate so levied to or to the order of the defaulting authority.

(5.) If any loan is required to be raised for the purpose of the execution of their duties under the said appointment, the county council with the consent of the Local Government Board may raise the same, and may for that purpose borrow the required sum in the name of the defaulting authority for the same period, on the same security, and on the same terms as that authority might have borrowed, and the principal and interest of such loan shall be a debt due from the defaulting authority, and shall be secured and may be recovered in like manner as if the loan had been borrowed by that authority.

(6.) The surplus (if any) of any loan not applied for the purpose for which it is raised shall, after payment of the expenses of raising the same, be paid to or to the order of the defaulting authority, and be applied as if it were the surplus of a loan raised by that authority.

102. *Application of Public Health Acts to Woolwich.*—(1.) The provisions of the Public Health Acts, which are set out in the Second Schedule to this Act, except so far as they are superseded by this Act, shall extend to the parish of Woolwich, and to the local board of health thereof, in like manner as they apply to any urban sanitary district elsewhere, and the sanitary authority thereof, without prejudice to the existing effect of the Metropolis Management Act, 1855, and the Acts amending the same, or to the powers, duties, and liabilities of the county council and the local board of health of Woolwich under the latter Acts.

(2.) The Woolwich Local Board may borrow for the purposes of this Act in like manner as if those purposes were purposes of the Public Health Acts.

103. *Expenses of execution of Act.*—The expenses incurred by sanitary authorities in London under this Act shall, save as otherwise in this Act mentioned, be defrayed as follows; (namely),

In the case of the commissioners of sewers, out of their sewer rate and consolidated rate, or either of such rates:

In the case of any vestry or district board, out of their general rate:

In the case of the local board of health of Woolwich, out of the district fund or general district rate.

104. *Expenses of Metropolitan Asylum Board.*—(1.) All expenses incurred by the Metropolitan Asylum Managers in the execution of the provisions of this Act relating to the provision and maintenance of carriages, buildings, and horses, and the conveyance in such carriages of persons suffering from any dangerous infectious disease shall to such extent as the Local Government Board may sanction be defrayed out of the Metropolitan common poor fund.

(2.) Save as aforesaid, all expenses incurred by the said Managers in the execution of this Act shall so far as they are not recovered from guardians in pursuance of this Act be defrayed in the same manner as the expenses mentioned in section thirty-one of the Metropolitan Poor Act, 1867 (30 & 31 Vict. c. 6), are to be defrayed under that section; and shall be raised and be recoverable in the same manner as expenses under that Act.

(3.) The provision of vessels and buildings in pursuance of this Act shall be purposes for which the Metropolitan Asylum Managers may borrow in pursuance of the Metropolitan Poor Act, 1867, and any Acts amending the same.

105. *Power of vestries and district boards to borrow.*—(1.) The provision of hospitals and of mortuaries under this Act, and the purposes of the epidemic regulations under this Act, shall be purposes for which vestries and district boards are authorised to borrow.

(2.) A sanitary authority, with the consent of the Local Government Board, may borrow for the purpose of providing, as required or authorised by this Act—

(*a.*) sanitary conveniences, lavatories, and ashpits, and

(*b.*) premises, apparatus, carriages, and vessels for the disinfection, destruction, and removal of infected articles, and

(*c.*) a building for post-mortem examinations and accommodation for the holding of inquests.

(3.) The purposes for which a sanitary authority are authorised under this Act to borrow shall be purposes for which that authority may borrow under the Acts relating to the execution of the other duties of that authority, and, where the consent of the Local Government Board is required and given to any such loan, the consent of any other authority shall not be required.

106. *Appointment of medical officers of health.*—(1.) Every sanitary authority shall appoint one or more medical officers of health for their district.

(2.) The same person may, with the sanction of the Local Government Board, be appointed medical officer of health for two or more districts, by the sanitary authorities of such districts; and the Local Government Board shall prescribe the mode of such appointment and the proportions in which the expenses of such appointment and the salary and charges of such officer shall be borne by such authorities.

(3.) Every person appointed or re-appointed after the commencement of this Act as medical officer of health of a district shall (except during the two months next after the time of his appointment, or except in cases allowed by the Local Government Board) reside in such district or within one mile of the boundary thereof, and, if while not so residing as required by this enactment he assumes to act or receives any remuneration as such medical officer of health, he shall cease to hold the office.

(4.) A medical officer of health may exercise any of the powers with which a sanitary inspector is invested.

(5.) The annual report of a medical officer of health to the sanitary authority shall be appended to the annual report of the sanitary authority.

107. *Appointment of sanitary inspectors.*—(1.) Every sanitary authority shall appoint an adequate number of fit and proper persons as sanitary inspectors, and may distribute among them the duties to be performed by sanitary inspectors, and every such inspector shall be a person qualified and competent by his knowledge and experience to perform the duties of his office.

(2.) Where the Local Government Board, on a representation from the county council, and after local inquiry, are satisfied that any sanitary authority have failed to appoint a sufficient number of sanitary inspectors, the Board may order the authority to appoint such number of additional sanitary inspectors and to allow them such remuneration as the order directs, and the sanitary authority shall comply with the order.

(3.) The sanitary inspectors shall report to the sanitary authority the existence of any nuisances; and the sanitary authority shall cause a book to be kept in which shall be entered all complaints made of any infringement of the provisions of this Act or of any byelaws made thereunder, or of nuisances; and every such inspector shall forthwith inquire into the truth or otherwise of such complaints, and report upon the same, and such report shall be laid before the sanitary authority at their next meeting, and together with the order of the sanitary authority thereon shall be entered in a book, which shall be kept at their office, and shall be open at all reasonable times to the inspection of any inhabitant of the district, and of any officer either generally or specially authorised for the purpose by the county council; and it shall be the duty of such inspector, subject to the direction of the sanitary authority, or of a committee thereof, to make complaints before justices and take legal proceedings for the punishment of any person for any offence under this Act or any such byelaws.

108. *Provisions as to medical officers and sanitary inspectors.*—(1.) Subject to the provisions of this Act as to existing officers, the Local Government Board shall have the same powers as they have in the case of a district medical officer of a poor law union with regard to the qualification, appointment, duties, salary, and tenure of office of every medical officer of health and sanitary inspector, and one-half of the salary of every such medical officer and sanitary inspector shall be paid by the county council out of the Exchequer contribution account in accordance with section twenty-four of the Local Government Act, 1888 (51 & 52 Vict. c. 41), and that section shall be construed as if in subsection two thereof the reference to the Public Health Act, 1875, included a reference to this Act.

(2.) Provided that—

(*a*.) A medical officer of health shall be legally qualified for the practice of medicine, surgery, and midwifery, and also either be registered in the Medical Register as the holder of a diploma in sanitary science, public health, or State medicine under section twenty-one of the Medical Act, 1886 (49 & 50 Vict. c. 48), or have been during three consecutive years preceding the year one thousand eight hundred and ninety-two a medical officer of a district or combination of districts in London or elsewhere with a population according to the last published census of not less than twenty thousand, or have before the passing of the Local Government Act, 1888, been for not less than three years a medical officer or inspector of the Local Government Board; and

(*b*.) A medical officer of health shall be removable by the sanitary authority with the consent of the Local Government Board, or by that Board, and not otherwise:

Provided that the Local Government Board shall take into consideration every representation made by the sanitary authority for the removal of any medical officer, whether based on the general interests of the district, on the conduct of such officer, or on any other ground; and

(*c*.) Any such medical officer shall not be appointed for a limited period only; and

(*d*.) A sanitary inspector appointed after the first day of January one thousand eight hundred and ninety-five shall be holder of a certificate of such body as the Local Government Board may from time to time approve, that he has by examination shown himself competent for such office, or shall have been, during three consecutive years preceding the year one thousand eight hundred and ninety-five, a sanitary inspector or inspector of nuisances of a district in London, or of an urban sanitary district out of London containing according to the last published census a population of not less than twenty thousand inhabitants.

109. *Temporary arrangement for duties of medical officer or sanitary inspector.*—A sanitary authority, where occasion requires, may, with the sanction of the Local Government Board, make any temporary arrangement for the performance of all or any of the duties of a medical officer of health or sanitary inspector, and any person appointed by virtue of any such arrangement to perform those duties, or any of them, shall, subject to the terms of his appointment, have all the powers, duties, and liabilities of a medical officer of health or sanitary inspector as the case may be.

110. *Jurisdiction as to ships.*—(1.) For the purposes of this Act any vessel lying in any river or other water within the district of a sanitary authority shall (subject to the provisions of this Act with respect to the port sanitary authority of the port of London) be subject to the jurisdiction of that authority in the same manner as if it were a house within such district.

(2.) The master of any such vessel shall be deemed or the purposes of this Act to be the occupier of such vessel.

(3.) This section shall not apply to any vessel under the command or charge of any officer bearing Her Majesty's commission, or to any vessel belonging to any foreign government.

PORT SANITARY AUTHORITY OF PORT OF LONDON.

111. *Port sanitary authority of port of London.*—The Mayor, Commonalty, and Citizens of the City of London shall continue to be the port sanitary authority of the port of London, as established for the purposes of the laws relating to the customs of the United Kingdom, and shall pay out of their corporate funds all their expenses as such port sanitary authority.

112. *Powers of port sanitary authority of port of London.*—(1.) The Local Government Board may by order assign to the port sanitary authority of the port of London any powers, rights, duties, capacities, liabilities, or obligations of a sanitary authority under this Act, or of a sanitary authority under the Public Health Act, 1875 (38 & 39 Vict. c. 55), and any Act extending or amending the same respectively, with such modifications and additions (if any) as may appear to the Board to be required, and the order may extend to the said port a byelaw made under this Act otherwise than by the port sanitary authority, and any such byelaw until so extended shall not extend to the said port; and the said port sanitary authority shall have the powers, rights, duties, capacities, liabilities, and obligations assigned by such order in and over all waters within the limits of the said port, and also in and over such districts or parts of districts of riparian authorities as may be specified in any such order, and the order may extend this Act, and any part thereof, and any byelaw made thereunder, to such waters and districts and parts of districts when not situate in London.

(2.) The said port sanitary authority may acquire and hold land for the purposes of their constitution without any licence in mortmain.

(3.) The said port sanitary authority may, with the sanction of the Local Government Board, delegate to any riparian authority the exercise of any powers conferred on the port sanitary authority by the order of the Board, but except in so far as such delegation extends no other authority shall exercise any powers conferred on such port sanitary authority by the order of the Board within the limits of the port of London.

(4.) "Riparian authority" in this section means any sanitary authority under this Act and any sanitary authority under the Public Health Act, 1875, whose district or part of whose district forms part of or abuts on any part of the said port, and any conservators, commissioners, or other persons having authority in or over any part of the said port.

APPLICATION OF PUBLIC HEALTH ACTS AS TO CHOLERA, &c.

113. *Powers of Local Government Board as to epidemic diseases.*—The sections of the Public Health Acts (relating to regulations and orders of the Local Government Board with respect to cholera, or other epidemic, endemic, or infectious diseases) set out in the First Schedule to this Act, shall extend to London, and shall apply in like manner as if a sanitary authority under this Act were a local authority within the meaning of those sections.

Byelaws.

114. *Byelaws.*—All byelaws made by the county council or by any sanitary authority under this Act shall be made subject and according to the provisions with respect to byelaws contained in sections one hundred and eighty-two to one hundred and eighty-six of the Public Health Act, 1875 (38 and 39 Vict. c. 55), and set forth in the First Schedule to this Act; and those sections shall apply in like manner as if the county council or sanitary authority were a local authority:

Provided that the county council, in making any byelaws which will have to be observed and enforced by any sanitary authority, shall consider any representations made to the council by that authority, and not less than two months before applying to the Local Government Board for the confirmation of any such byelaws shall send a copy of the proposed byelaws to every such authority.

Legal Proceedings.

115. *General provisions as to powers of entry.*—(1.) Where a sanitary authority have by virtue of this Act power to examine or enter any premises, whether a building, vessel, tent, van, shed, structure, or place open or enclosed, they may examine or enter by any members of the authority, or by any officers or persons authorised by them, either generally or in any particular case.

(2.) Where a sanitary authority, or their officers, or any persons acting under such authority, or under any of their officers, have by virtue of any enactment in this Act, a right to enter any premises, whether a building, vessel, tent, van, shed, structure, or place open or enclosed, then, subject to any special provisions contained in such enactment, the following provisions shall apply, that is to say—

(*a.*) The person so claiming the right to enter shall, if required, produce some written document, properly authenticated on the part of the sanitary authority, showing the right of the person producing the same to enter;

(*b.*) Any person refusing or failing to admit any person who is authorised and claims to enter the premises shall if—

(i.) the entry is for the purpose of carrying into effect an order of a court of summary jurisdiction, and either is stated in the said document to be for that purpose or is claimed by an officer of the sanitary authority, or

(ii.) it is proved that the refusal or failure is with intent to prevent the discovery of some contravention of this Act or any byelaw under this Act, or

(iii.) the refusal or failure is declared by the enactment conferring the right of entry to render the person refusing or failing subject to a fine,

be liable to a fine not exceeding five pounds.

(3.) If a justice is satisfied by information on oath—

(*a.*) that there is reasonable ground for such entry, and that there has been a refusal or failure to admit to such premises, and either that reasonable notice of the intention to apply to a justice for a warrant has been given, or that the giving of notice would defeat the object of entry, or

(*b.*) that there is reasonable cause to believe that there is on the said premises some contravention of this Act or of any byelaw under this Act, and that an application for admission or notice of an application for the warrant would defeat the object of the entry,

the justice may by warrant under his hand authorise the sanitary authority or their officers or other person, as the case may require, to enter the premises, and if need be by force, with such assistants as they or he may require, and there execute their duties under this Act.

(4.) Any person obstructing the execution of any such warrant, or of any warrant granted by a justice in pursuance of any other provision of this Act, and authorising the entry by the sanitary authority or their officer or any other person into any premises, shall be liable to a fine not exceeding twenty pounds, or, in a case where a greater punishment is imposed by this Act or any other enactment, either to such fine or to that greater punishment.

(5.) The warrant shall continue in force until the purpose for which the entry is necessary has been satisfied.

(6.) Where a house or part of a house is alleged to be overcrowded so as to be a nuisance liable to be dealt with summarily under this Act, a warrant under this section may authorise an entry into such house or part of a house at any hour of the day or night specified in the warrant.

116. *Penalty on obstructing execution of Act.*—(1.) If any person—

(*a.*) wilfully obstructs any member or officer of a sanitary authority or any person duly employed in the execution of this Act, or

(*b.*) destroys, pulls down, injures, or defaces any byelaw, notice, or other matter put up by authority of the Local Government Board or county council, or of a sanitary authority, or any board or other thing upon which such byelaw, notice, or matter is placed or inscribed, or

(*c.*) wilfully damages any works or property belonging to any sanitary authority,

he shall be liable to a fine not exceeding five pounds.

(2.) Where the occupier of any premises prevents the owner thereof from obeying or carrying into effect any provision of this Act, a petty sessional court, on complaint, shall by order require such occupier to permit the execution of any works which appear to the court necessary for the purpose of obeying or carrying into effect such provision of this Act; and if within twenty-four hours after service on him of the order such occupier fails to comply therewith, he shall be liable to a fine not exceeding five pounds for every day during the continuance of such non-compliance.

(3.) If the occupier of any premises, when requested by or on behalf of the sanitary authority to state the name and address of the owner of the premises, refuses or wilfully omits to disclose or wilfully misstates the same, he shall (unless he shows cause to the satisfaction of the court for his refusal) be liable to a fine not exceeding five pounds.

117. *Summary proceedings for offences, expenses, &c.*—(1.) All offences, fines, penalties, forfeitures, costs, and expenses under this Act or any byelaw made under this Act directed to be prosecuted or recovered in a summary manner, or the prosecution or recovery of which is not otherwise provided for, may be prosecuted and recovered in manner directed by the Summary Jurisdiction Acts.

(2.) Proceedings for the recovery of a demand not exceeding fifty pounds, which a sanitary authority or any person are or is empowered to recover in a summary manner, may, at the option of the authority or person, be taken in the county court as if such demand were a debt.

(3.) A proceeding under this Act shall not be taken by the county council against a sanitary authority save with the sanction of the Local Government Board, unless snch proceeding is for the recovery of expenses or of money due from the sanitary authority to the council.

118. *Evidence by defendant.*—Any person charged with an offence under this Act, and the wife or husband of such person, may, if such person thinks fit, be called, sworn, examined, and cross-examined as an ordinary witness in the case.

119. *Application of fines and disposal of things forfeited.*—(1.) All fines recovered under this Act shall, notwithstanding anything in any other Act, be paid to the sanitary authority and applied by them in aid of their expenses in the execution of this Act, except that any fine imposed on the sanitary authority shall be paid to the county council.

(2.) All things forfeited under this Act may be sold or disposed of in such manner as the court ordering the forfeiture may direct.

120. *Proceedings in certain cases against nuisances.*—(1.) Where any nuisance under this Act appears to be wholly or partially caused by the acts or defaults of two or more persons, the sanitary authority or other complainant may institute proceedings against any one of such persons, or may include all or any two or more of them in one proceeding; and any one or more of such persons may be ordered to abate the nuisance, so far as it appears to the court having cognizance of the case to be caused by his or their acts or defaults, or may be prohibited from continuing any acts or defaults which in the opinion of the court contribute to the nuisance, or may be fined or otherwise punished, notwithstanding that the acts or defaults of any one of such persons would not separately have caused a nuisance; and the costs may be distributed as to the court may appear fair and reasonable.

(2.) Proceedings against several persons included in one complaint shall not abate by reason of the death of any among the persons so included, but all such proceedings may be carried on as if the deceased person had not been originally so included.

(3.) Where some only of the persons by whose act or default any nuisance has been caused have been proceeded against under this Act, they shall, without prejudice to any other remedy, be entitled to recover in a summary manner from the other persons who were not proceeded against a proportionate part of the costs of and incidental to such proceedings and abating such nuisance, and of any fine and costs ordered to be paid by the court in such proceedings.

(4.) Whenever in any proceeding under the provisions of this Act relating to nuisances it becomes necessary to mention or refer to the owner or occupier of any premises, it shall be sufficient to designate him as the "owner" or "occupier" of such premises, without name or further description.

121. *Recovery of expenses by sanitary authority from owner or occupier.*—Any costs and expenses which are recoverable under this Act by a sanitary authority from an owner of premises may be recovered from the occupier for the time being of such premises; and the owner shall allow the occupier to deduct any money which he pays under this enactment out of the rent from time to time becoming due in respect of the premises, as if the same had been actually paid to the owner as part of the rent: Provided that—

(*a*.) the occupier shall not be so required to pay any further sum than the amount of rent which either is for the time being due from him, or which after demand from him of such costs or expenses, and notice not to pay any rent without first deducting the same, becomes payable by him, unless he refuses, on the application of the sanitary authority, truly to disclose the amount of his rent and the name and address of the person to whom such rent is payable; but the burden of proof that the sum demanded from any such occupier is greater than the aforesaid amount of rent shall lie on such occupier; and

(*b*.) nothing in this section shall affect any contract between any owner and occupier of any premises whereby the occupier agrees to pay or discharge all rates, dues, and sums of money payable in respect of such premises, or shall affect any contract whatsoever between landlord and tenant.

122. *Justice to act though member of sanitary authority or liable to contribute.*—A judge or justice of the peace shall not be incapable of acting in cases arising under this Act by reason of his being a member of any sanitary authority, or by reason of his being, as one of several ratepayers, or as one of any other class of persons, liable in common with the others to contribute to or to be benefited by any rate or fund, out of which any expenses incurred by a sanitary authority are to be defrayed.

123. *Appearance of sanitary authority in legal proceedings.* — The county council or a sanitary authority may appear before any court or in any legal proceeding by their clerk, or by any officer or member authorised generally or in respect of any special proceeding by resolution of such council or authority; and their clerk, or any officer or member so authorised, shall be at liberty to institute and carry on any proceeding which the county council or sanitary authority are authorised to institute and carry on under this Act.

124. *Protection of sanitary authority and their officers from personal liability.*—No matter or thing done, and no contract entered into by the county council or any sanitary authority, and no matter or thing done by any member of such council or authority, or by any officer of such council or authority or other person whomsoever acting under the direction of such council or authority, shall, if the matter or thing were done or the contract were entered into bonâ fide for the purpose of executing this Act, subject them or any of them personally to any action, liability, claim, or demand whatsoever; and any expense incurred by the county council or any such authority, member, officer, or other person acting as last aforesaid, shall be borne and repaid out of the rate applicable by that council or authority to the purposes of this Act:

Provided that nothing in this section shall exempt any member of the county council or of any such authority from liability to be surcharged with the amount of any payment which may be disallowed by the auditor in the accounts of such council or authority, and which that member authorised or joined in authorising.

APPEAL.

125. *Appeal to quarter sessions.*—Any person who deems himself aggrieved by any conviction or order made by a court of summary jurisdiction on determining any information or complaint under this Act may, save as otherwise provided in this Act, appeal therefrom to a court of quarter sessions.

126. *Provision as to appeals to county council.*—Any appeal to the county council against a notice or act of a sanitary authority under this Act shall be conducted in accordance with sections two hundred and eleven and two hundred and twelve of the Metropolis Management Act, 1855 (18 & 19 Vict. c. 120), which sections, as modified by the Local Government Act, 1888, are set out in the First Schedule to this Act.

NOTICES.

127. *Authentication of notices, &c.*—(1.) Notices, orders, and other such documents under this Act shall be in writing; and notices and documents other than orders, when issued by the county council or a sanitary authority, shall be sufficiently authenticated if signed by their clerk or by the officer by whom the same are given or served.

(2.) Orders shall be under the seal of the council or authority duly authenticated.

128. *Service of notices.*—(1.) Any notice, order, or other document required or authorised to be served under this Act may be served by delivering the same or a true copy thereof either to or at the usual or last known residence in England of the person to whom it is addressed, or, where addressed to the owner or occupier of premises, then to some person on the premises, or, if there is no person on the premises who can be so served, then by fixing the same or a true copy thereof on some conspicuous part of the premises; it may also be served by sending the same or a true copy thereof by post addressed to a person at such residence or premises as above mentioned.

(2.) Any notice required or authorised for the purposes of this Act to be served on a sanitary authority or on the county council shall be deemed to be duly served if in writing delivered at, or sent by post to, the office of the authority or council, addressed to such authority or council, or their clerk.

(3.) Any notice by this Act required to be given to or served on the owner or occupier of any premises may be addressed by the description of the "owner" or "occupier" of the premises (naming them) in respect of which the notice is given or served, without further name or description.

MISCELLANEOUS PROVISIONS.

129. *Inquiries by Local Government Board.*—Sections two hundred and ninety-three to two hundred and ninety-six of the Public Health Act, 1875 (38 & 39 Vict. c. 55), which are set forth in the First Schedule to this Act, shall apply to all inquiries which the Local Government Board may make in pursuance of or for the purposes of this Act.

130. *Forms.*—The forms in the Third Schedule to this Act, or forms to the like effect, varied as circumstances may require, may, unless other forms are prescribed under the Summary Jurisdiction Act, 1879 (42 & 43 Vict. c. 49), be used and shall be sufficient for all purposes.

131. *Provision for apportionment of certain expenses between hamlet of Penge and remainder of Lewisham district.*—Where the whole or any part of any expense incurred by the Lewisham District Board of Works, in pursuance of the epidemic regulations, may, under this Act, be repaid to that board out of the metropolitan common poor fund, the amount to be so repaid when ascertained shall be apportioned between the hamlet of Penge and the remainder of the Lewisham district in proportion to the rateable value of such hamlet and remainder, according to the valuation lists in force at the date of the apportionment, and the amount apportioned to the hamlet of Penge shall be repaid to the district board by the board of guardians for the Croydon Union out of the common fund of the union, in pursuance of a precept of the Local Government Board to be issued after the like proceedings and in the like manner as in the case of a repayment from the metropolitan common poor fund; and the amount apportioned to the remainder of the Lewisham district shall be repaid to the district board out of the metropolitan common poor fund.

132. *Extent of Act.*—This Act shall (save as otherwise expressly provided) extend only to London:

Provided that this Act shall extend to places elsewhere so far as is necessary for giving effect to any provisions thereof in their application to London and to any places to which such provisions are expressly applied.

CITY OF LONDON.

133. *Application of Act to City.*—In the application of this Act to the City of London the following modifications shall be made:

(*a.*) There shall be no appeal under this Act from the commissioners of sewers to the county council:

(*b.*) The byelaws made by the county council under this Act shall not extend to the city:

(*c.*) The county council shall not have power under this Act to require the commissioners of sewers to provide and maintain a building for post-mortem examinations:

(*d.*) The powers of the county council under this Act to proceed in case of default of a sanitary authority shall not extend to the commissioners of sewers.

134. *Power of City police to proceed in certain cases against nuisances.*—Where it is proved to the satisfaction of the Local Government Board that the commissioners of sewers have made default in doing their duty in relation to nuisances under this Act, the Board may authorise any officer of police of the City of London to institute any proceeding which the commissioners might institute with regard to such nuisances, and that officer may recover from the commissioners in a summary manner or in the county court or High Court any expenses incurred by him, and not paid by the person proceeded against. Such officer of police shall not for the purpose of this section be at liberty to enter any house or part of a house used as the dwelling of any person without either such person's consent, or the warrant of a justice.

135. *Proceedings on complaint to Local Government Board of default of Commissioners of Sewers.*—(1.) Where complaint is made to the Local Government Board that the commissioners of sewers have made default in executing or enforcing any provisions of this Act, the Local Government Board, if satisfied, after due inquiry, that those commissioners have been guilty of

the alleged default, shall make an order limiting a time for the performance of their duty in the matter of such complaint. If the duty is not performed by the time limited in the order, the order may be enforced by writ of Mandamus, or the Local Government Board may appoint some person to perform the duty, and shall by order direct that the expenses of performing the same, together with a reasonable remuneration to the person appointed for superintending the performance, and amounting to a sum specified in the order, together with the costs of the proceedings, shall be paid by the commissioners of sewers, and any order made for the payment of such expenses and costs may be removed into the High Court, and enforced as an order of that court.

(2.) Any person so appointed shall, in the performance and for the purposes of the said duty, be invested with all the powers of the commissioners of sewers other than (save as herein-after provided) the powers of levying rates; and the Local Government Board may by order change any person so appointed.

(3.) Any sum specified in an order of the Local Government Board for payment of the expenses of performing the duty of the commissioners of sewers, together with the costs of the proceedings, shall be deemed to be expenses properly incurred by those commissioners, and to be a debt due from them, and payable out of any moneys in their hands or the hands of their officers, or out of any rate applicable to the payment of any expenses properly incurred by the commissioners (which rate is in this section referred to as "the local rate"). If the commissioners refuse to pay any such debt for a period of fourteen days after demand, the Local Government Board may by order empower any person to levy, by and out of the local rate, such sum (to be specified in the order) as may, in the opinion of the Local Government Board, be sufficient to defray the debt, and all expenses incurred in consequence of the non-payment thereof.

(4.) Any person so empowered shall have the same powers of levying the local rate, and requiring all officers of the commissioners of sewers to pay over any money in their hands, as the commissioners would have in the case of expenses legally payable out of a local rate to be raised by them; and the said person, after repaying all sums of money so due in respect of the order, shall pay the surplus, if any (the amount to be ascertained by the Local Government Board), to or to the order of the commissioners of sewers.

(5.) The Local Government Board may certify the amount of expenses incurred, or an estimate of the expenses about to be incurred, by any person appointed by the Board under this section to perform the duty of the commissioners; also, the amount of any loan required to defray any expenses so incurred, or estimated as about to be incurred; and the certificate of the Board shall be conclusive as to all matters to which it relates.

(6.) Whenever the Local Government Board so certifies a loan to be required, that Board, or the person so appointed, may, by any instrument duly executed, charge the local rate with the repayment of the principal and interest due in respect of the loan, and every such charge shall have the same effect as if the commissioners of sewers were empowered to raise the loan on the security of the local rate, and had duly executed an instrument charging the same on that rate.

(7.) Any principal money or interest for the time being due in respect of a loan under this section shall be a debt due from the commissioners of sewers, and, in addition to any other remedies, may be recovered in the manner in which a debt due from those commissioners may be recovered in pursuance of this section.

(8.) The surplus (if any) of any such loan, after payment of the expenses aforesaid, shall, on the amount thereof being certified by the Local Government Board, be paid to or to the order of the commissioners of sewers.

(9.) "Expenses," for the purposes of this section, shall include all sums payable under this section by or by the order of the Local Government Board, or the person appointed by that Board.

Saving Clauses.

136. *Saving for water rights.*—Nothing in this Act shall be construed to authorise any sanitary authority to injuriously affect the navigation of any river or canal, or to divert or diminish any supply of water of right belonging to any river or canal; or to injuriously affect any reservoir, canal, river, or stream, or the feeders thereof, or the supply, quality, or fall of water, contained in any reservoir, canal, river, stream, or in the feeders thereof, in cases where any person would, if this Act had not been passed, have been entitled by law to prevent or be relieved against the injuriously affecting of such reservoir, canal, river, stream, feeders, or such supply, quality, or fall of water, unless the sanitary authority first obtain the consent in writing of the person so entitled as aforesaid.

137. *Saving for Thames Conservators.*—Nothing in this Act shall affect any power of the Conservators of the Thames under the Thames Navigation Act, 1870 (33 & 34 Vict. c. cxlix.) or otherwise.

138. *Powers of Act to be cumulative.*—All powers, rights, and remedies given by this Act shall be in addition to and not in derogation of any other powers, rights, and remedies conferred by any Act of Parliament, law, or custom, and all such other powers, rights, and remedies may be exercised and put in force in the same manner and by the same authority as if this Act had not been passed.

Temporary Provisions.

139. *Existing officers.*—(1.) In the case of any medical officer of health or inspector of nuisances who holds office under an appointment made before the commencement of this Act (in this section referred to as an existing officer), the provisions of this Act with respect to his salary and tenure of office shall be qualified as follows; that is say,

(*a.*) Where a portion of his salary is paid by the county council out of the Exchequer contribution account, the Local Government Board shall have the same powers as they have in the case of a district medical officer of a poor law union with regard to the qualification, appointment, duties, salary, and tenure of office of such officer:

(*b.*) In any other case the Local Government Board may prescribe the qualification and duties of a medical officer of health:

(*c.*) Subject to the said powers of the Local Government Board, the sanitary authority may make such payments as they think fit on account of the remuneration and expenses of such officer, and every such officer shall be removable by the sanitary authority at their pleasure:

(*d*.) Every such inspector of nuisances shall be called a sanitary inspector.

(2.) The requirements of this Act with respect to the qualification of medical officers shall not apply to medical officers appointed before the first day of January one thousand eight hundred and ninety-two; and this Act shall not prevent any person who at the commencement of this Act is both a district medical officer of a union and a medical officer of health from continuing to hold those appointments in like manner as if this Act had not been passed.

140. *Term of office of existing members of Woolwich board.*—Those members of the Woolwich Local Board whose term of office, if this Act had not been passed, would have expired in the month of August in any year, shall go out of office on the fifteenth day of April in the same year.

INTERPRETATION.

141. *Interpretation of terms.*—In this Act, unless the context otherwise requires,—

The expression "London" means the administrative county of London:

The expression "county council" means the London County Council:

The expression "the Metropolitan Asylum Managers" means the Managers of the Metropolitan Asylum District:

The expression "street" includes any highway, and any public bridge, and any road, lane, footway, square, court, alley, or passage, whether a thoroughfare or not, and whether or not there are houses in such street:

The expression "premises" includes messuages, buildings, lands, easements, and hereditaments of any tenure, whether open or enclosed, whether built on or not, and whether public or private, and whether maintained or not under statutory authority:

The expression "house" includes schools, also factories and other buildings in which persons are employed:

The expressions "building" and "house" respectively include the curtilage of a building or house, and include a building or house wholly or partly erected under statutory authority:

The expression "bakehouse" means any place in which are baked bread, biscuits, or confectionery, from the baking or selling of which a profit is derived:

The expression "vessel" includes a boat and every description of vessel used in navigation:

The expression "hospital" means any premises or vessels for the reception of the sick, whether permanently or temporarily applied for that purpose, and includes an asylum of the Metropolitan Asylum Managers:

The expression "master" means in the case of a building or part of a building, a person in occupation of or having the charge, management, or control of the building, or part of the building, and in the case of a house the whole of which is let out in separate tenements, or in the case of a lodging house the whole of which is let to lodgers, includes the person receiving the rent payable by the tenants or lodgers either on his own account or as the agent of another person, and in the case of a vessel means the master or other person in charge thereof:

The expression "house refuse" means ashes, cinders, breeze, rubbish, night soil, and filth, but does not include trade refuse:

The expression "trade refuse" means the refuse of any trade, manufacture, or business, or of any building materials:

The expression "street refuse" means dust, dirt, rubbish, mud, road scrapings, ice, snow, and filth:

The expression "owner" means the person for the time being receiving the rackrent of the premises in connexion with which the word is used, whether on his own account or as agent or trustee for any other person, or who would so receive the same if such premises were let at a rackrent:

The expression "rackrent" means rent which is not less than two-thirds of the full annual value of the premises out of which the rent arises; and the full annual value shall be taken to be the annual rent which a tenant might reasonably be expected, taking one year with another, to pay for the premises, if the tenant undertook to pay all usual tenant's rates and taxes, and tithe commutation rentcharge (if any), and if the landlord undertook to bear the cost of the repairs, and insurance, and the other expenses (if any) necessary to maintain the premises in a state to command such rent:

The expression "slaughterer of cattle or horses" means a person whose business it is to kill any description of cattle, or horses, asses, or mules, for the purpose of the flesh being used as butcher's meat; and the expression "slaughter-house" means any building or place used for the purpose of such business:

The expression "knacker" means a person whose business it is to kill any horse, ass, mule, or cattle which is not killed for the purpose of the flesh being used as butcher's meat; and the expression "knacker's yard" means any building or place used for the purpose of such business:

The expression "cattle" includes sheep, goats, and swine:

The expression "source of water supply" means any stream, reservoir, aqueduct, pond, well, tank, cistern, pump, fountain, or other work or means for the supply of water, whether actually used or capable of being used for the supply of water or not:

The expression "sanitary convenience" includes urinals, water-closets, earth closets, privies, and any similar conveniences:

The expression "day" means the period between six o'clock in the morning and the succeeding nine o'clock in the evening:

The expression "ashpit" means any ashpit, dust-bin, ash-tub, or other receptacle for the deposit of ashes or refuse matter:

The expression "cistern" includes a water-butt:

The expression "dairy" includes any farm, farm-house, cowshed, milk-store, milk-shop, or other place from which milk is supplied, or in which milk is kept for purposes of sale:

The expression "dairyman" includes any cow-keeper, purveyor of milk, or occupier of a dairy.

REPEAL.

142. *Repeal of enactments in schedule.*—(1.) The Acts specified in the Fourth Schedule to this Act are hereby repealed to the extent specified in the third column of that schedule, and shall be so repealed as from the date in that schedule mentioned, and where no date is mentioned as from the commencement of this Act;

(2.) Provided that—

(a.) where any enactment in the said schedule extends beyond London, such enactment shall not unless otherwise expressed be deemed to be hereby repealed, so far as it applies beyond London.

(b.) all securities given under and all orders, byelaws, rules, regulations, and notices duly made or issued under or having effect in pursuance of any Act hereby repealed shall be of the same validity and effect as if they had been given, made, or issued under this Act, and any penalties recoverable under any such order, byelaw, rule, regulation, or notice may be recovered as if they were imposed by byelaws under this Act.

(3.) Where the county council or a sanitary authority are required by this Act to make byelaws for any purpose for which there are no byelaws of the council or authority in force at the commencement of this Act, the first byelaws made by the county council or sanitary authority for that purpose under this Act shall be submitted to the Local Government Board for sanction not later than six months after the commencement of this Act.

(4.) Any enactment expressed in the Fourth Schedule to this Act to be repealed as from the coming into operation of any byelaw made for the like object shall, although no such byelaw is made, be repealed on the expiration of twelve months next after the commencement of this Act, or such later day, not exceeding eighteen months from such commencement, as may be fixed by Order in Council.

(5.) For the removal of doubts it is hereby declared that so much of the Public Health Act, 1875 (38 & 39 Vict. c. 55) as re-enacts sections fifty-one and fifty-two of the Sanitary Act, 1866 (29 & 30 Vict. c. 90) and sections thirty-four to thirty-six of the Public Health Act, 1872 (35 & 36 Vict. c. 79) extends to London.

(6.) Officers appointed under any enactment hereby repealed shall continue in office in like manner as if they were appointed in pursuance of this Act, subject nevertheless to the provisions of this Act respecting existing officers.

(7.) Where in any enactment or in any order made by a Secretary of State or by the Local Government Board, and in force at the time of the passing of this Act, or in any document, any Act or any provisions of an Act are mentioned or referred to which relate to London and are repealed by this Act, such enactment, order, or document shall be read as if this Act or the corresponding provisions of this Act were therein mentioned or referred to instead of such repealed provisions, and as if a sanitary authority under this Act were substituted for any nuisance authority mentioned in such repealed provisions.

143. *Commencement of Act.*—This Act shall come into operation on the first day of January next after the passing thereof.

144. *Short title.*—This Act may be cited as the Public Health (London) Act, 1891.

MODEL BYELAWS.

Interpretation of Terms.

1. Throughout these Byelaws the expression "the Sanitary Authority" means the and the expression "the District" means the Sanitary District of

For the Prevention of Nuisances arising from any Snow, Ice, Salt, Dust, Ashes, Rubbish, Offal, Carrion, Fish, or Filth, or other Matter or Thing in any Street.

2. The occupier of any premises fronting, adjoining, or abutting on any street not repairable by the inhabitants at large shall, as soon as conveniently may be after the cessation of any fall of snow, remove or cause to be removed from the footways and pavements adjoining such premises all snow fallen or accumulated on such footways and pavements in such a manner and with such precautions as will prevent any undue accumulation in any channel or carriage way or upon any paved crossing.

In the case of any premises, the person in occupation of or having the charge, management, or control of the same, or if there is no such person, then any person in occupation of or having the charge, maintenance or control of any part of the premises, and in the case of any premises the whole of which are let to lodgers, the person receiving the rent payable by the tenants or lodgers, either on his own account or as the agent of another person, shall for the purposes of this byelaw be deemed to be the occupier.

3. Every person who shall remove any snow from any premises shall deposit the same in such a manner and with such precautions as to prevent any accumulation thereof in any channel or upon any paved crossing.

If in the process of such removal any snow be deposited upon any footway or pavement, he shall forthwith remove such snow from such footway or pavement.

4. Every person who shall throw any salt upon any snow on the footway of any street shall do so in such quantity and in such manner as effectually to dissolve the whole of such snow, and he shall forthwith effectually remove from the footway the whole of the deposit resulting from the mixture of the salt with the snow. He shall not place any part of such deposit on the carriageway of such street other than any channel at the side of such carriageway, and he shall not remove the same into any such channel unless it is sufficiently liquid to flow along such channel.

No person shall throw any salt upon any snow on the carriageway of any street, unless it shall be practicable forthwith effectually to remove from such carriageway the whole of the deposit resulting from the mixture of the salt with the snow. He shall forthwith effectually remove the whole of such deposit, but he shall not place any part thereof on the footway of such street, nor shall he place any part thereof in the channel at the side of the carriageway, unless it is sufficiently liquid to flow along such channel.

5. The occupier of any premises who shall remove or cause to be removed any dust, ashes, rubbish, offal, carrion, fish in an offensive condition, or filth or other like matter or thing from his premises, shall for the purpose of such removal in every case use or cause to be used a suitable vessel or receptacle, cart, or carriage properly constructed and furnished with a sufficient covering, so as to prevent the escape of the contents thereof.

If in the process of such removal any person shall slop or spill, or cause or allow to fall upon any footway, pavement, or carriageway, any such dust, ashes, rubbish, offal, carrion, fish in an offensive condition, or filth or other like matter or thing, he shall forthwith remove such dust, ashes, rubbish, offal, carrion, fish, or filth or other matter or thing from the place whereon the same may have been slopped or spilled, or may have fallen, and shall immediately thereafter thoroughly sweep or otherwise thoroughly cleanse such place.

6. Every person who shall lay or cause to be laid in any street any litter or other matter in case of sickness to prevent noise shall lay the same so that it may be evenly distributed over the surface of the part of the street intended to be covered, and shall, when the occasion ceases, remove or cause to be removed from such street the litter or other matter so laid in such street.

For Preventing Nuisances arising from any Offensive Matter running out of any Manufactory, Brewery, Slaughter-house, Knacker's Yard, Butcher's or Fishmonger's Shop, or Dunghill, into any uncovered place, whether or not surrounded by a wall or fence.

7. The occupier of a manufactory, brewery, slaughter-house, knacker's yard, butcher's or fishmonger's shop, or of any premises comprising a dunghill shall not cause or suffer any offensive matter to run out of such manufactory, brewery, slaughter-house, knacker's yard, butcher's or fishmonger's shop, or dunghill, into any uncovered place, whether or not surrounded by a wall or fence so as to be likely to become a nuisance.

For the Prevention of the keeping of Animals on any Premises so as to be a Nuisance or Injurious or Dangerous to Health.

8. The occupier of any premises shall not keep any animal on such premises in such a place or in such a manner as to pollute, or to be likely to pollute any water supplied for use or used or likely to be used by man for drinking or domestic purposes, or for manufacturing drink for the use of man, or any water used or likely to be used in any dairy.

9. Every occupier of a building or premises wherein or whereon any horse or other beast of draught or burden, or any cattle or swine may be kept, shall provide, in connexion with such building or premises, a suitable receptacle for dung, manure, soil, filth, or other offensive or noxious matter which may, from time to time, be produced in the keeping of any such animal in such building or upon such premises.

He shall cause such receptacle to be constructed so that the bottom or floor thereof shall not, in any case, be lower than the surface of the ground adjoining such receptacle.

He shall also cause such receptacle to be constructed in such a manner and of such materials, and to be maintained at all times in such a condition as to prevent any escape of the contents thereof, or any soakage therefrom into the ground or into the wall of any building.

He shall cause such receptacle to be furnished with a suitable cover, and, when not required to be open, to be kept properly covered.

He shall likewise provide in connexion with such building or premises a sufficient drain, constructed in such a manner, and of such materials, and maintained at all times in such a condition, as effectually to convey all urine or liquid filth, or refuse therefrom, into a sewer, or other proper receptacle.

He shall, once at least in every week, remove or cause to be removed from the receptacle provided in accordance with the requirements of this byelaw all dung, manure, soil, filth, or other offensive or noxious matter, produced in or upon such building or premises, and deposited in such receptacle.

As to the Paving of Yards and Open Spaces in Connexion with Dwelling-houses.

10. The owner of every dwelling-house in connexion with which there is any yard or open space, shall, where it is necessary for the prevention or remedy of insanitary conditions that all or part of such yard or open space shall be paved, forthwith cause the same to be properly paved with a hard, durable, and impervious pavement, evenly and closely laid upon a sufficient bed of good concrete, and so sloped to a properly constructed channel as effectually to carry off all rain or waste water therefrom.

Interpretation of Terms.

1. Throughout these Byelaws the expression "the Sanitary Authority" means the
and the expression "the District" means the Sanitary District of

With respect to the keeping of Waterclosets supplied with sufficient Water for their effective Action.

2. The occupier of any premises in or for which any watercloset shall be provided, shall cause such watercloset to be at all times properly supplied with a sufficient quantity of water for securing its effective action.

Where, however, any watercloset is provided for the use of persons occupying two or more separately occupied premises, and there is a person hav'ng the care and control of such watercloset, the foregoing requirement shall apply to such person.

PENALTIES.

3. Every person who shall offend against the foregoing Byelaw, shall be liable for every such offence to a penalty of five pounds, and in the case of a continuing offence to a further penalty of forty shillings for each day after written notice of the offence from the Sanitary Authority.

Provided, nevertheless, that the justices or court before whom any complaint may be made, or any proceedings may be taken in respect of any such offence, may, if they think fit, adjudge the payment as a penalty of any sum less than the full amount of the penalty imposed by this Byelaw.

INTERPRETATION OF TERMS.

1. Throughout these Byelaws the expression "Sanitary Authority" means the and the expression "the District" means the Sanitary District of

FOR SECURING THE CLEANLINESS AND FREEDOM FROM POLLUTION OF TANKS, CISTERNS, AND OTHER RECEPTACLES USED FOR STORING OF WATER USED OR LIKELY TO BE USED BY MAN FOR DRINKING OR DOMESTIC PURPOSES, OR FOR MANUFACTURING DRINK FOR THE USE OF MAN.

2. The occupier of any premises on which a tank, cistern, or other receptacle is used for storing of water used or likely to be used by man for drinking or domestic purposes, or for manufacturing drink for the use of man, shall empty and cleanse the same, or cause the same to be emptied and cleansed, once at least in every six months, and at such other times as may be necessary to keep the same in a cleanly state and free from pollution.

He shall cause every such tank, cistern, or other receptacle which is erected outside a building, or which, being erected inside a building, is not placed in a suitable chamber, or otherwise constructed or placed so as to prevent the pollution of the water therein, to be provided with a proper cover, and to be kept at all times properly covered.

Provided that in every case where two or more tenants of any premises are entitled to the use in common of any tank, cistern, or other receptacle used for storing of water used or likely to be used by man for drinking or domestic purposes, or for manufacturing drink for the use of man, the foregoing requirements shall apply to the owner of such premises instead of to any occupier thereof.

PENALTIES.

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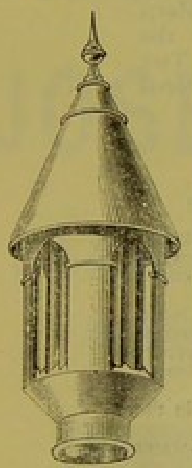

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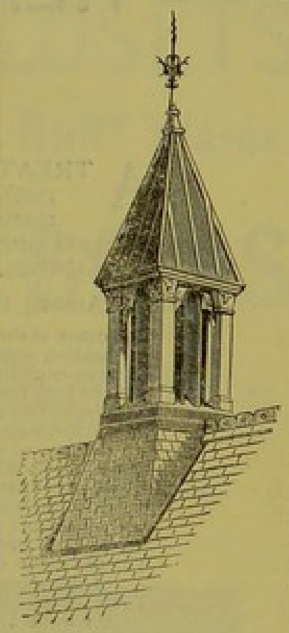

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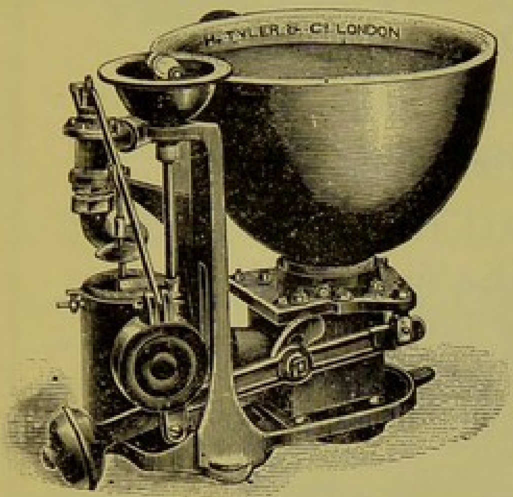

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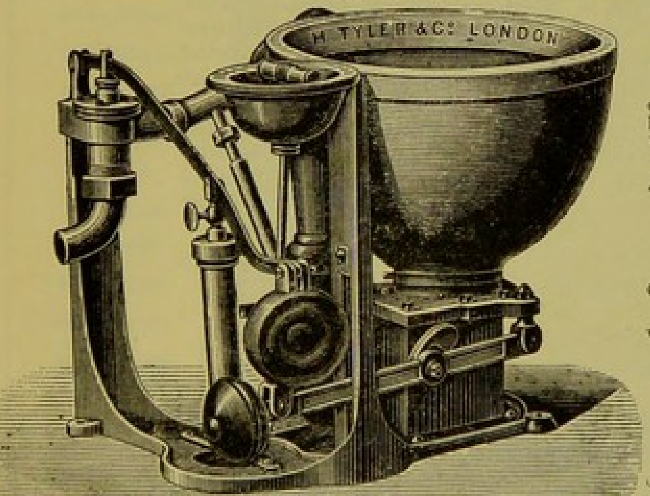

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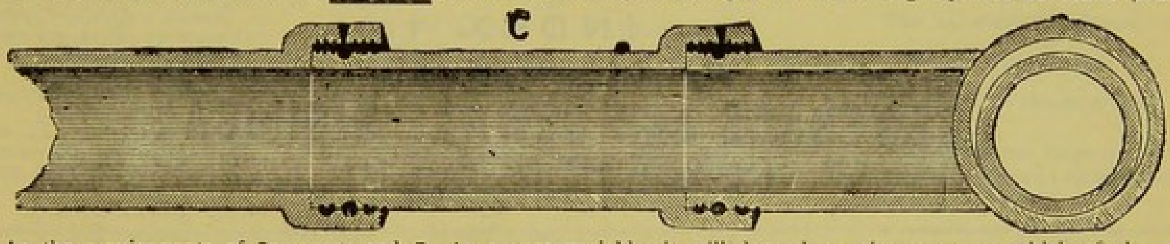

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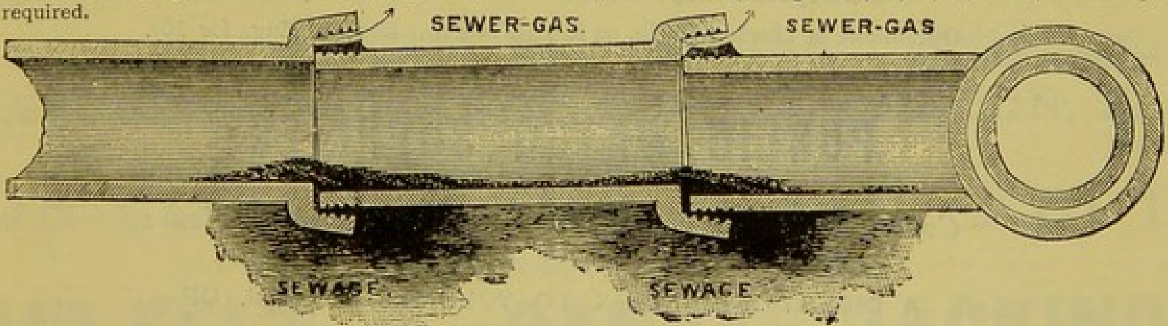

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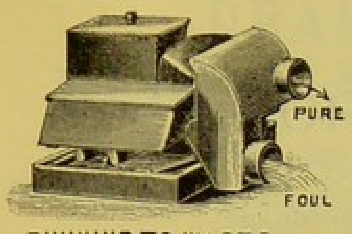

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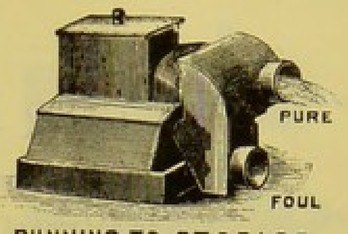

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