2nd EDITION.

The Practice of Ventilation.

With a Comparison of the Advantages and Limits of Natural and Mechanical Systems.

(Illustrated.)

A Paper

Read at the 1905 Annual Meeting of the Institution of Heating and Ventilating Engineers, and before the Manchester Society of Architects, by

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HERALD & WALKER, MANCHESTER

PUBLISHERS' NOTE.

We re-publish this Paper because we believe it deals for the first time, in an unbiassed manner, with a difficult problem.

We trust it will be of service to Architects and Ventilating Engineers, as it embodies much practical information that cannot fail to be of interest to all who have to deal with Ventilation and its sister subject—Warming.

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THE PRACTICE OF VENTILATION.

The Advantages and Limits of "Natural" and "Mechanical" Systems compared.

PAPER BY J. D. SUTCLIFFE,

Read before

THE INSTITUTION OF HEATING AND VENTILATING ENGINEERS,

at the Annual General Meeting, 1905.

Also before the MANCHESTER SOCIETY OF ARCHITECTS.

The practice of ventilation is a big subject, and no system is suitable for all buildings and every circumstance. It is a pity that in recent discussions real issues have been kept back by those commercially interested in some particular system, who have strung perverted quotations together to prove their own case or to damage other systems. As a case in point, no doubt many of you have received a little Blue Book purporting to be a report on the House of Commons' ventilation, in which it is sought to prove that a Committee of the House of Commons decided against mechanical ventilation, whereas their recommendations were :—First, to increase the size of the fan propelling fresh air into the House; and second, to fix fans for exhausting the air instead of heated up-cast shafts which had been in use up to that time.

Holding no brief for either the "Mechanical" or "Natural" systems, I propose to place before you the advantages and limitations of both so far as my experience and practice will allow.

VENTILATION DEFINED.

Ventilation has been variously defined, but I take it that all reasonable men are agreed that it is the passing into and through a room of sufficient fresh air to keep the air in that room reasonably pure and fit for use. Fortunately, in judging the purity of air breathed in rooms it is not necessary to determine more than the amount of CO_2 present, as this forms a sufficient indication of its quality.

HOW TO TEST AIR FOR PURITY.

In 1802 Dalton devised a method which, improved later by Pettenkoffer, is still in use by chemists for exact determinations. To those who have no chemical knowledge I can recommend the apparatus illustrated in Fig. 1.

Each of the tubes shewn contains an equal amount of a weak solution of baryta an alkali, coloured pink with the indicator phenol-phthaleine, and as the acid in the air acts on the baryta and neutralizes it, the pink colour gradually disappears. In using the apparatus, one of the tubes is connected to the can filled with water, and by an arrangement of piping the water is drawn off, causing the air by which it is displaced to pass through the solution, the amount of air passed through being measured by the amount of water run off.

This is done inside the room tested and also outside in the free atmosphere, and it can readily be seen that if it requires only one-third as much air to discolourise the solution inside the room as outside, the air in the room must contain three times the impurity present in normal air.

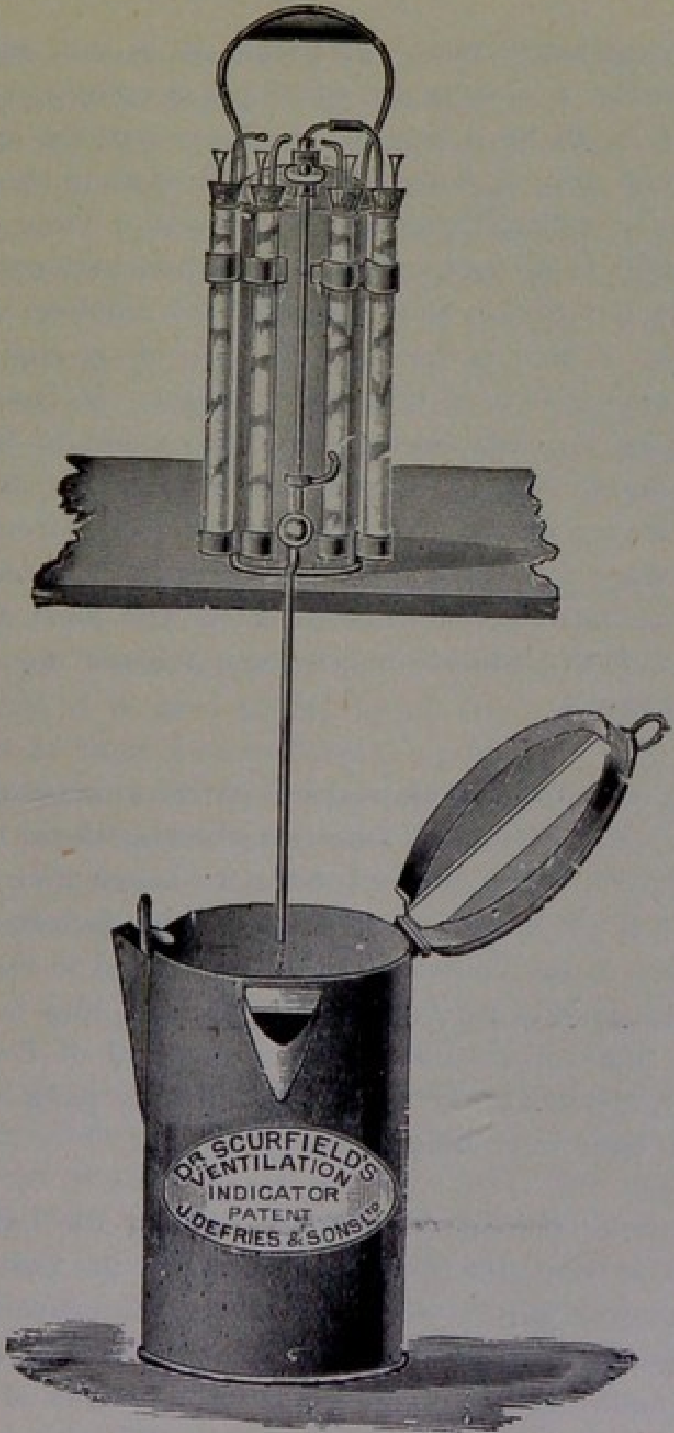


Fig. 1.—Dr. Scurfield's Air Testing Apparatus.

STANDARDS OF EFFICIENT VENTILATION.

In specifying satisfactory ventilation it is not enough to merely prescribe a certain air space per person, though this is good, or even to fix a certain supply or renewal of air per person, though this is better, but in all cases a standard of CO_2 should be definitely fixed. In schools a cubic space of 120ft. per child is deemed sufficient by our educational authorities who do not realize that the place for children is in the open air, and if this is not possible then they should have the nearest approach to it that can be given. In factories the minimum space for each worker varies from 250 to 500 cubic feet, according to the healthiness or otherwise of the trade. All authorities are agreed that 3,000 cubic feet of fresh air per hour is necessary for a man if he is to breathe reasonably pure air. The standard in the Massachuesetts and most American schools is 2,000ft., whilst in our own schools we have no standard whatever.

Now with regard to the standard of purity which ought to be maintained. In cotton cloth factories where artificial humidity is used, the CO_2 must be kept down to below nine parts in 10,000 parts of air, and so far as I know these factories are the only buildings in the United Kingdom compelled to ventilate to a definite standard of purity by law. My own idea is that the ventilating engineer should aim at a standard of five or six parts of CO_2 under normal conditions and nine parts of CO_2 as a maximum under any circumstances.

There is not the least difficulty in keeping the CO_2 in any room down to below the standard required by the Cotton Cloth Factory Act, and this is shewn clearly by the report of Mr. Scudder, the chemist who was recently requested by a committee of employers and employés to take samples of air from 30 different factories. Mr. Scudder took 287 samples in all and found that only five exceeded the amount allowed by the Act. Further proof is given on page 161 of the Chief Factory Inspector's Report (1903), where the results of over 50 different tests are given. Some are as low as 4·6 parts of CO_2, the majority between six and eight parts, and only nine above the standard allowed.

It seems somewhat hard on cotton cloth factory owners to be compelled to keep the CO_2 down to nine parts in 10,000 of air when it is safe to say there are very few schools in England (certainly not 5%) that would pass the same test two hours after lessons had commenced, and there are many schools where the CO_2 reaches 18 or 20 parts per 10,000 before the end of the afternoon. The nose is usually an excellent guide to the presence of impure air, as when anybody fresh from the outside enters a room a faint smell is perceived if the air contains seven parts of CO_2 per 10,000, and when it reaches eight or nine parts we usually say the room is "close."

NATURAL OR AUTOMATIC VENTILATION?

"Natural" ventilation is not the correct term to use in the sense that it is used to-day by all the makers of cowls who arrogate to their own particular system the word "natural." A much better term is "automatic" ventilation, to distinguish it from "mechanical" or "fan" ventilation. My idea is that the only "natural" ventilation is outside a building in the fresh sunlit air of heaven.

THE SONG OF THE OPEN WINDOW.

Of all kinds or systems of ventilation, my preference is for the open window. Some of my hearers may say what has the science of ventilation to do with this, but the ventilating engineer if he is wise thinks a good deal of the open window, and in my opinion there is no system either automatic or mechanical to compare with it. I preach this gospel in season and out, and practice it with great benefit to myself and my family.

We have been told so frequently that if we sit in a draught we shall catch cold that we have come to believe it, whereas the true explanation of why we "take cold" is a very different matter. A cold is a germ disease, and the surest way to resist an attack is to be surrounded by pure air. I never catch a cold unless I am compelled to stay in a close and stuffy atmosphere, such as we sometimes get in a dining car, where the windows are not allowed to be open, or in a crowded hall or theatre. When the vital forces are lowered by breathing impure air, disease germs gain an advantage over otherwise healthy tissues and rapidly spread their baneful effects over the whole system, and this is how we "catch cold." It is this bogey of taking cold that makes so many people shut themselves up in almost air-tight rooms and yet, strange as it may seem, this is the very surest way of catching what they desire so much to avoid.

I am going to go further, and say not only that draughts are not dangerous, but since they are inseparable from a constant and plentiful supply of fresh air they are to be cultivated.

Look at the thousands of consumptives who are now living this open air life, and if anyone suffered from it, surely these frail mortals would. A year ago last October, a friend of mine who was threatened with consumption went to spend some months at a Sanatorium on the most exposed portion of the Cotswolds. He had been used to being coddled by his family, but the doctor at the Sanatorium told him at once he could put his overcoat and his hat away during his visit, as he would not require them. At first he felt very cold and miserable, as the house was without windows, but after a while he became used to the new conditions, and at the end of a week he was so much better in health that he felt life was worth living again. He stayed all through the winter and until the following April, and told me that he frequently played chess sitting under a hedge in the snow, and was always without overcoat or hat. He never had a cold during his visit, returned a healthy man, and is now a confirmed disciple of the open window and life in the open air.

After what I have said in praise of the open window, I fancy I can hear some of you asking: Well, but where is the work for the ventilating engineer if the open window is so desirable? There are, however, a large number of buildings, such as factories, theatres, and some schools, which cannot be ventilated by open windows, and later on I will give my experience of dealing with these.

AUTOMATIC VENTILATION.

Returning again to automatic ventilation, this can, as a rule, be very well applied to an ordinary house, and Fig. 3 shows a ground plan of my house, with the warming and ventilating arrangements clearly marked. There are two hot water

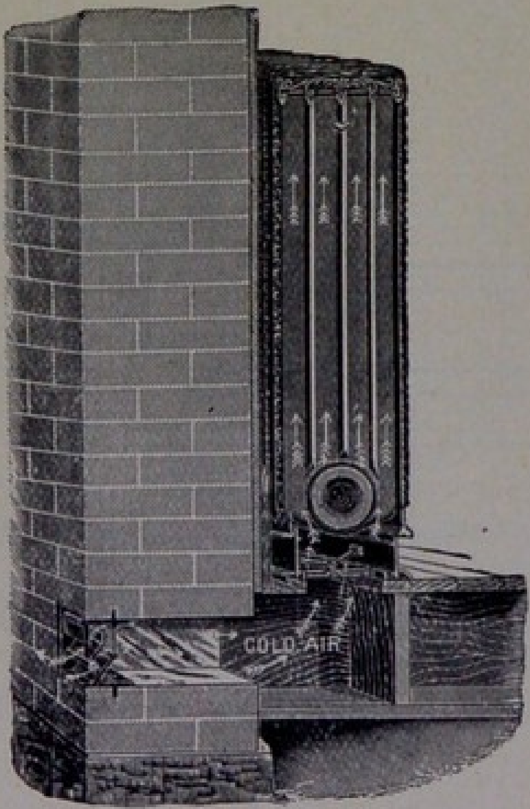


Fig. 2.—Ventilating Radiator.

radiators fixed in the hall, one near to the inner door and the other at the side of the staircase, while there are also radiators under each window and one in each room, with their backs to the hall. The four radiators in the rooms are all of a venti-

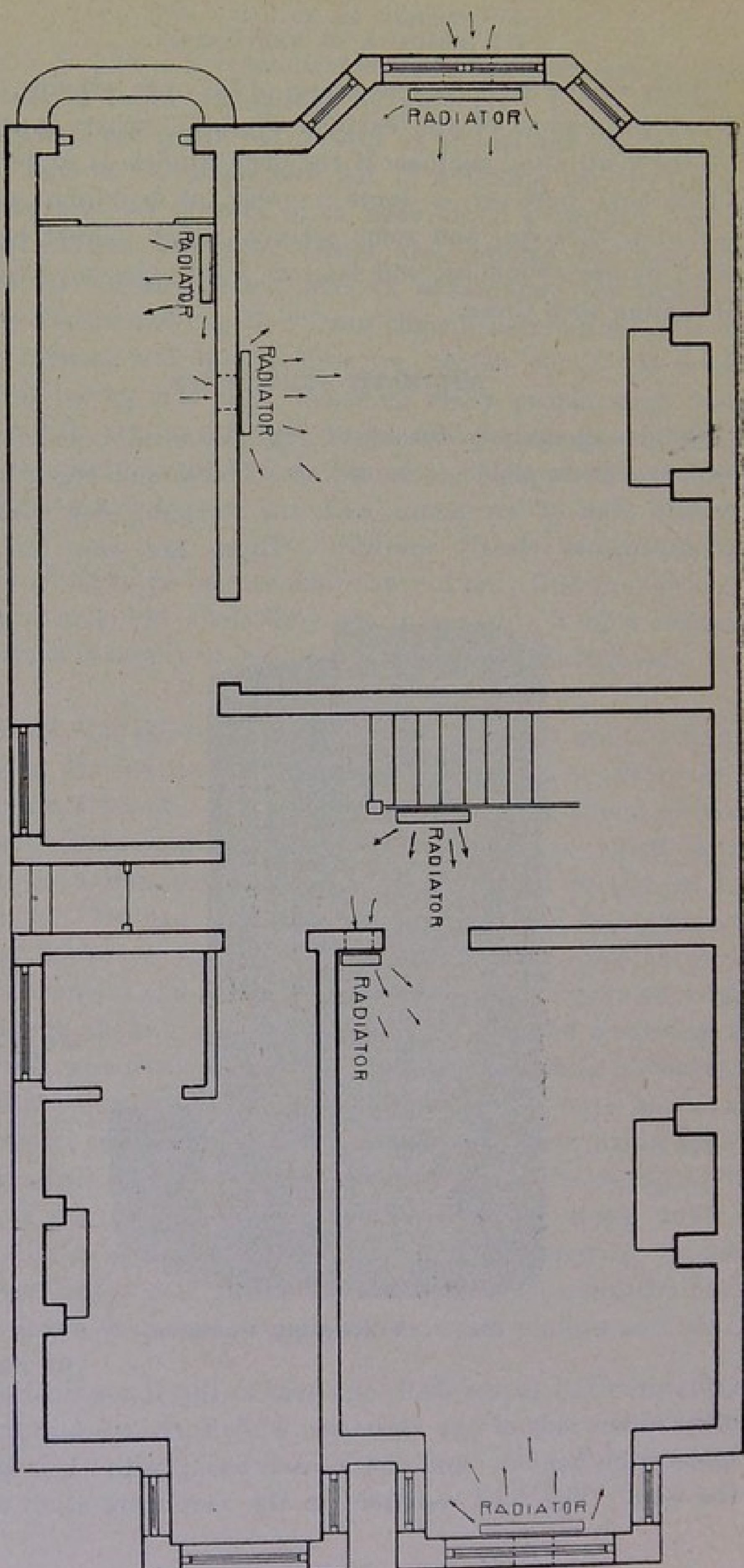


Fig. 3.—Ground Plan of House with best positions of Radiators.

lating pattern as Fig. 2, the two under the windows having fresh air brought to them from the outside, and the other two from the hall, where it is always fresh and pleasant. I have

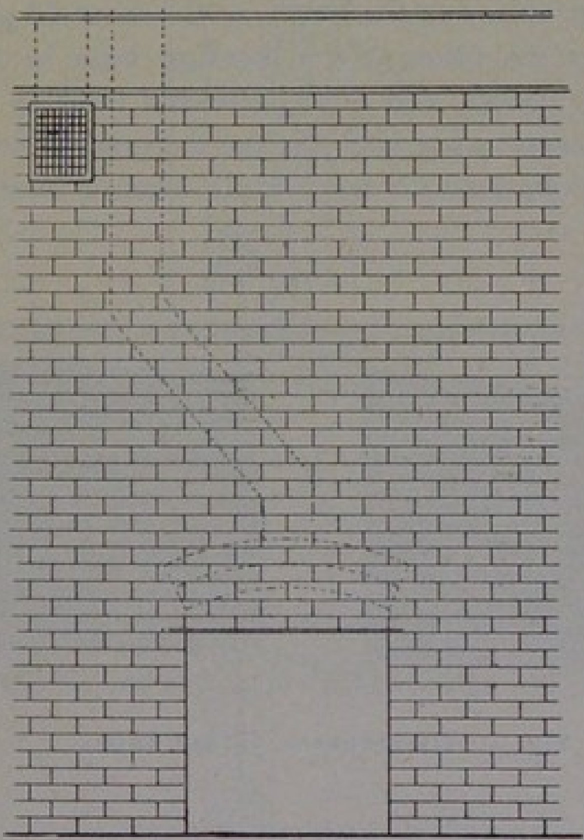


Fig 4.—Chimney Breast Air Outlet.

also fixed an outlet near the ceiling, as shown in Fig. 4, and this is an excellent plan of taking off the products of combustion from the burning gas.

AIR INLETS.

I am not greatly in favour of the ordinary Tobin Tube. It is unsightly, and if of sufficient length to be of any use, it is difficult to keep clean. I much prefer air inlets of the type shewn in Fig. 5, and if these are fixed about 6ft. 6in. from the floor, they answer their purpose well.

WINDOW INLET VENTILATION.

Better than these, however, is the window inlet shewn in Fig. 6. A piece of wood, say 3in. deep and the width of the window, is fixed opposite the bottom rail of the sash. Then the bottom sash is raised to the height of the inserted piece of wood, and air enters the room at the meeting bars in the direction shewn by the arrows, and a very efficient inlet is at once provided. Whatever is claimed for the ordinary Tobin Tube may be reasonably claimed for this simple window inlet.

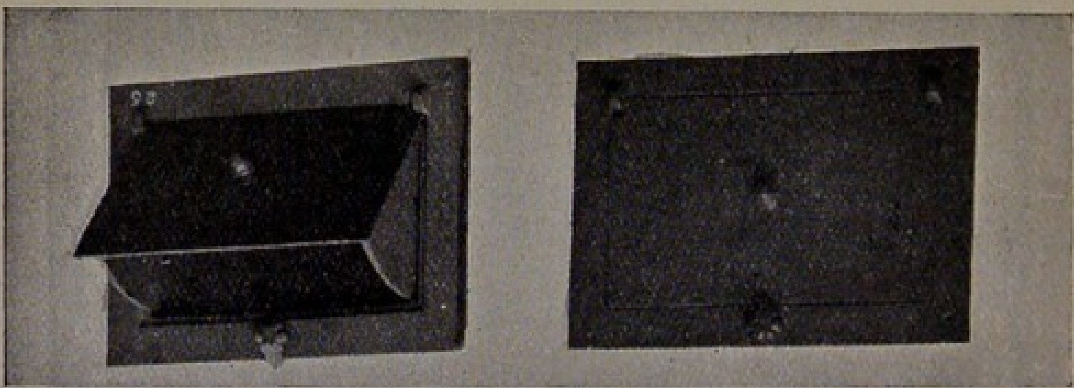


Fig. 5.—Simple form of Air Inlets.

WINDOW OUTLET VENTILATION.

I should like to mention here a point in the construction of windows that I think is worth attention. All windows should be carried up to the ceiling level, so that when they are opened at the top the heated and vitiated air of the room will have a much better chance of escape than if the top of the window were 18in. or 2ft. below the ceiling.

SOHOOLS OR OTHER ONE-STOREY BUILDINGS.

Schools, or similar buildings of reasonable size and width, can be very well ventilated by automatic appliances, but to ensure a thoroughly satisfactory system of automatic ventilation the school should be only one storey high, and not more than 30ft. wide. The warming and ventilation should be combined. The best plan is to use single-flue ventilating radiators, fixed under each window, with fresh air admitted

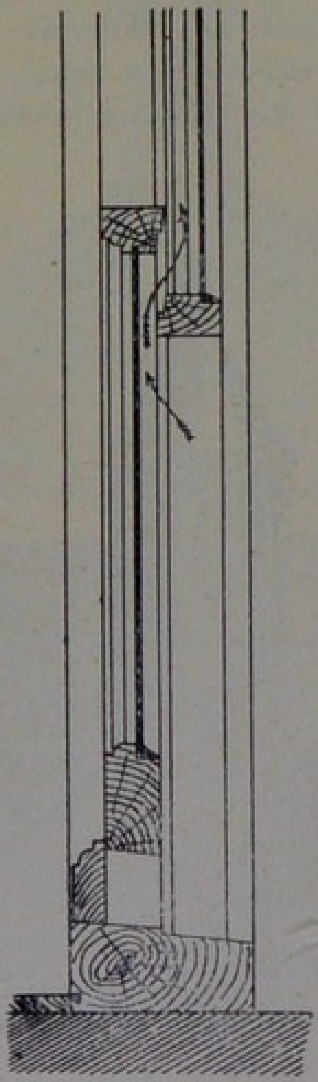


Fig 6.—Window Air Inlet.

behind each radiator. If the weather is suitable, the windows can be opened for additional air supply, and the only other thing necessary is a series of good-sized outlets at the ridge of the roof.

AIR OUTLETS.

It is frequently claimed by manufacturers of patent cowls that their particular make will produce strong extraction currents of air in all weathers. This is a claim I have never been able to substantiate, and in my experience the best roof ventilator is the one which allows the air to pass out with the least obstruction, and yet is weather tight. Years ago I assisted in testing some large Archimedian screw ventilators on the

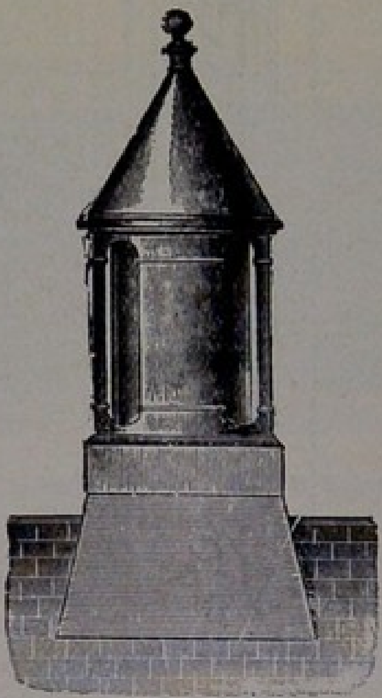


Fig 7.—Type of Automatic Ventilator not recommended.

roof of the Manchester Art Gallery. Some had rusted fast and would not revolve, while others whirled round merrily when any wind blew. We fixed anemometers under several, and found that the ventilators which were stationary allowed more air to pass out than the revolving ones, and Mr. Allison, the late City Surveyor, had them all fastened. Ventilators of the type shewn in Fig. 7 are not to be recommended, and a much better and simpler pattern is shewn in Fig. 8. The wooden louvred turret, as Fig, 9, is also a very effective outlet. From all these ventilators you will, however, get down-draughts under

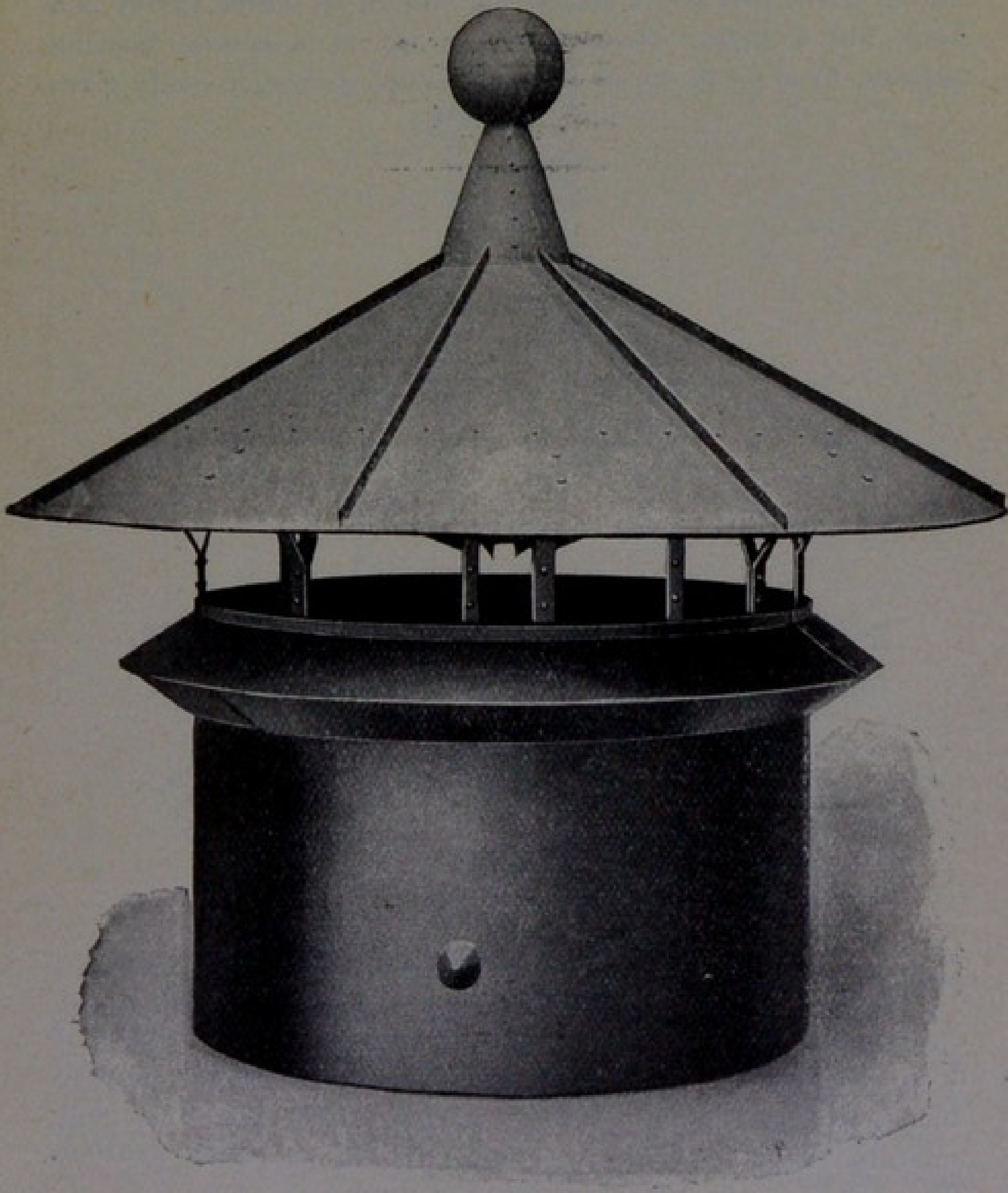


Fig. 8.—Type of Automatic Ventilator recommended.

certain conditions, and it is well to remember that they are only outlets for air, and not effective exhausters in the true sense of the term.

AN ACTIVE AIR OUTLET.

If a really effective automatic extractor is wanted, heat will have to be used in one form or another. A good-sized Bunsen burner fixed just above the ceiling line in an outlet turret is a help, but a better arrangement is to use a special heating battery, fixed as shewn in Fig. 10. Such an outlet really gives

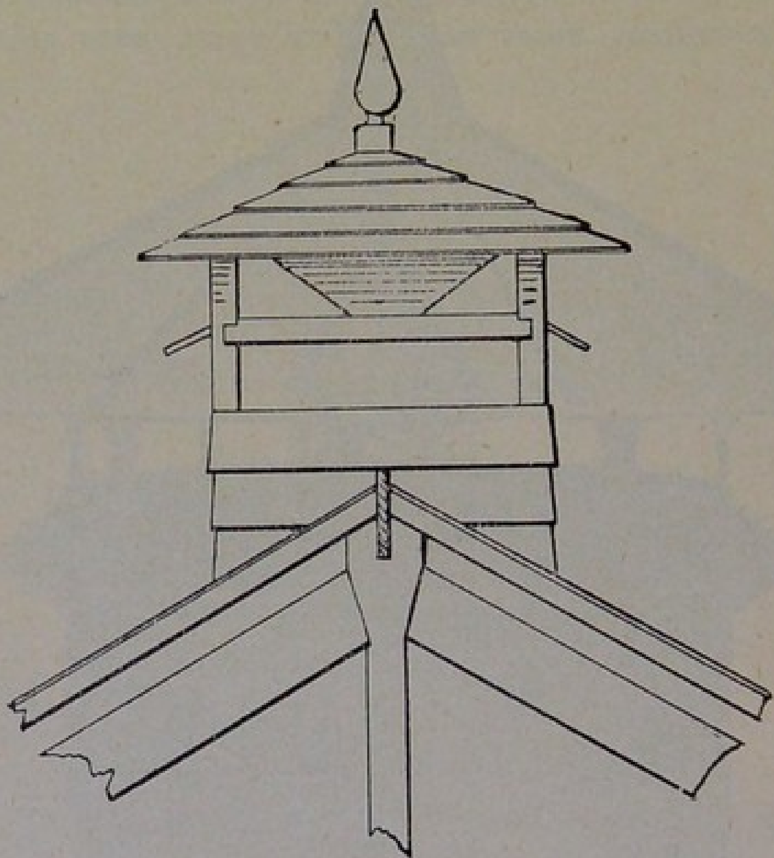


Fig. 9.—Louvred Turret Outlet.

extracting power, and with it there is no possible chance of a down-draught. I must warn you that it is not safe to heat such a battery from a hot water supply on account of the considerable danger of freezing and bursting in frosty weather. Steam is the only suitable heating medium.

HOT WATER OR STEAM HEATING?

This brings me rather sharply to the question of the advantages and disadvantages of steam and hot water for heating purposes. Personally, I prefer hot water radiators for private houses, offices, and other rooms that are not overcrowded, but are usually occupied by the same number of people. With hot water, however, larger heating surfaces are required to get

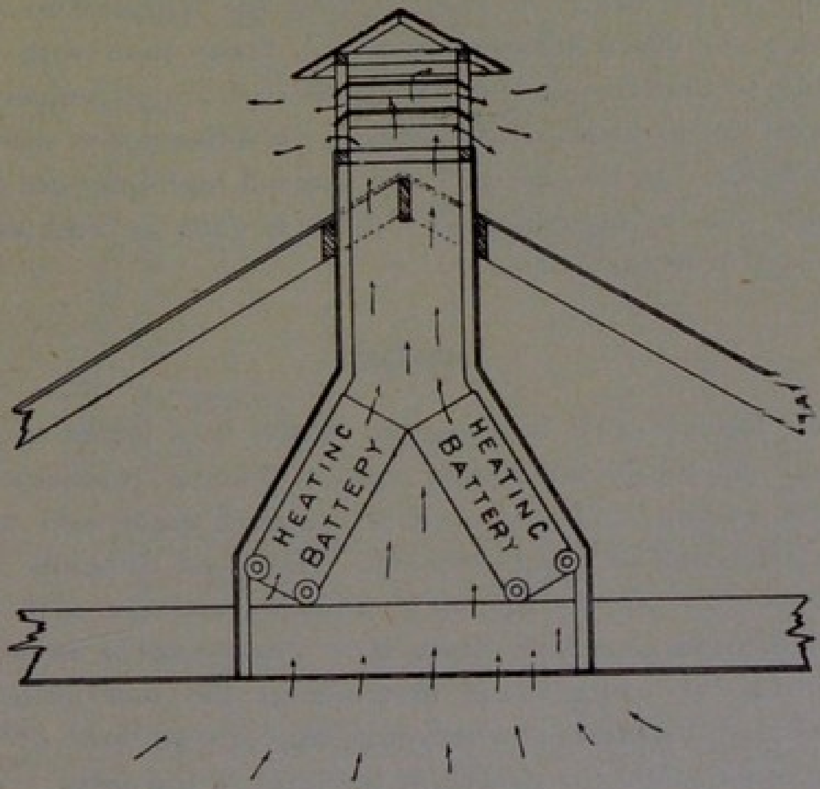


Fig. 10.—Air Outlet, with Heating Battery.

the same temperature effect, and also much larger pipes, while another disadvantage is that the heat is not so readily controllable. Using steam, you will have useful heat from the radiators inside an hour after lighting the boiler fire, whereas with hot water several hours usually elapse before any heat is available. There is also the corresponding drawback when you want to shut off the heat quickly. Directly the control valve is turned off, the heat disappears when steam is used, but in a hot water installation the heat remains a long time in the radiators, and the overheating may become serious. Where you have at one time a building crowded out, and at another time the same building less than half-full, it is essential to use low pressure steam, as it is so much more amenable, and you can raise or lower the temperature to suit the conditions in a few minutes. Then, again, in cold and frosty weather hot water pipes are liable to burst if the apparatus is out of use for a few days, whereas with steam this cannot happen. One advantage of hot water heating is, that the temperature of the radiators, or other heating surface, is lower than with steam heating, so that the air is not raised to such a high temperature, but with low-pressure steam heating the difference is comparatively little, In no case do I recommend high-pressure steam heating, and in my opinion 2 to 5lbs. is quite as high as it is necessary or desirable to go.

CHURCHES.

Churches are also buildings in which it is better to use a natural or automatic system rather than a mechanical or plenum system, and they can be warmed quite well on the lines laid down for small schools. The chief difficulty is the cooling of the air by the large windows and the roof, which causes considerable down-draughts. These can be avoided or minimized by using steam batteries in the roof outlets, as previously illustrated, and running one or two rows of small steam pipes round the church at the level of the eaves. If hot water is used for heating, it is a very simple matter to use also a small separate steam boiler specially for the ventilation. What one should particularly avoid in the heating of a church is the usual channels sunk into the floor, with steam pipes in them and gratings over. They are always foul receptacles for dust and dirt, and can never be properly cleaned.

I should have liked to have touched upon several other points in automatic ventilation, but will content myself by just a line in reference to the ventilation of lavatories and W.C.s.

The usual plan of opening the windows 'and allowing the foul air to blow through the door and all over the house is not to be recommended. A better plan is to have an air inlet in the bottom rail of the door, or, failing this, have the door shortened, so that there is a clear air space under the door for its full width and 1½in, deep. Then take the outlet through the wall at the highest point opposite the door. On the

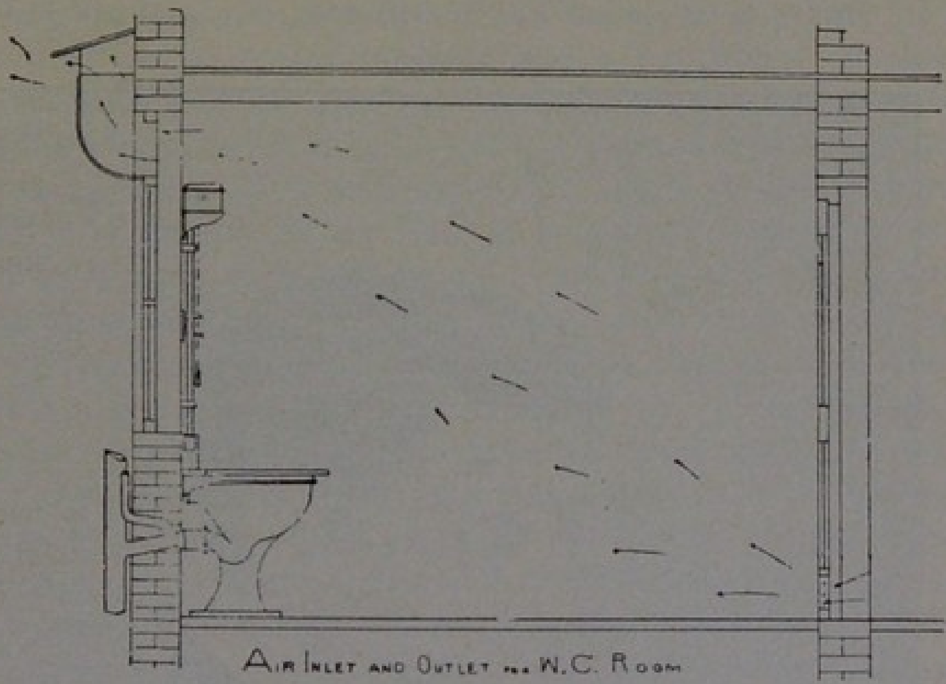


Fig. 11.—Air Inlet and Outlet for W.C.'s.

outside of the outlet have a protecting cover, as shewn in Fig 11. Of course, in a new building an outlet flue should be built in the wall and carried up to the roof.

MECHANICAL VENTILATION.

Many of the difficulties that are met with in automatic ventilation disappear when fans are used. The necessary amount of air is obtained by simply choosing the right style and size of fan, and driving it at the proper speed, The only problem—a serious one, I grant—then lies in the correct distribution of the air.

AIR DISTRIBUTING.

The movements of air currents have not been sufficiently studied, and I think sometimes it is a misfortune they are not visible. If fresh air were coloured blue, and when it became foul it blushed a delicate pink, we should be able to deal with it better. I know a great many halls, schools, and other rooms where there would be a good deal of blushing. At present, unfortunately, we know very little of the behaviour of air, and if we could only see it, many things which now puzzle us would

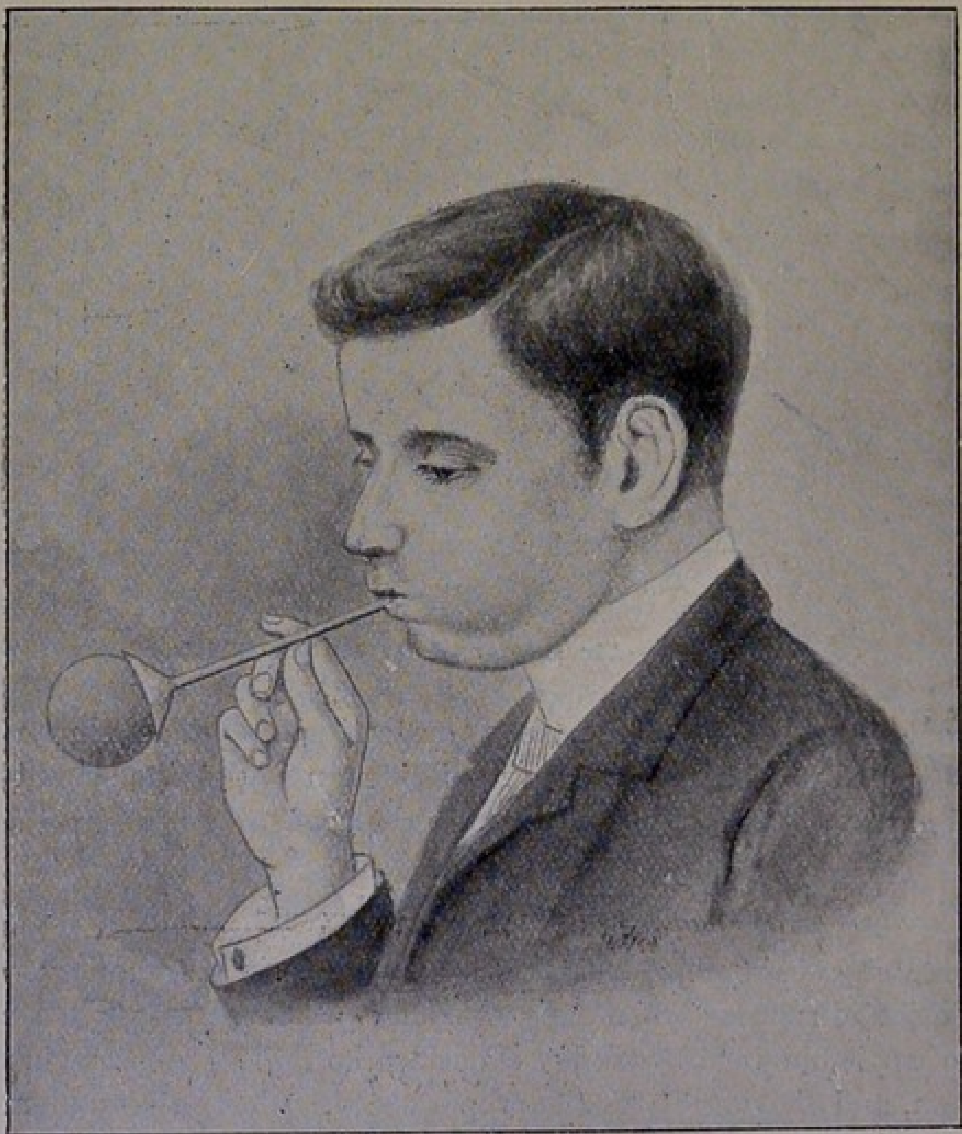


Fig. 12.—Toy Illustrating Air Movements.

be made clear. As illustrating this point a small toy, Fig. 13, is worth attention. It consists of a tin tube about 6in. long and ¼in. diameter, with one end of the tube opened out funnel-wise. If you were told that by blowing through this tube you could support a wooden ball 1in. in diameter, and that the harder you blew the tighter the ball would hold, you would probably be disposed to discredit the statement. Yet it is a fact, and you shall have an opportunity of trying the toy later, when you may give your idea of how the air must behave for a "blast" to be turned suddenly into a "suction." Another remarkable point is, that just beyond the ball a light may be blown out. The difficulty with all air currents is in controlling their direction. For instance, if you admit air into a room, say, on a side wall at six feet six inches from the floor, and direct it upwards to the ceiling, what happens? Well, that will depend on the temperature of the incoming air in relation to the air in the room, and will constantly alter as the temperature and velocity vary. If the air enters at considerably higher temperature than that in the room the warmer air will go to the ceiling and probably diffuse itself there, travelling along to the opposite wall and then cooling and coming down, or passing out at any opening that may be provided. If the admitted air should be colder than that in the room it will probably never reach the ceiling, and will certainly not cross the room unless a fan pulls it, and even then it may travel along the floor. Of course, any intermediate stages of warmth will give intermediate stages of direction and velocity.

VELOCITY OF AIR CURRENTS AT INLETS.

The velocity of air coming into a room has a great deal to do with the comfort of the occupants. Ventilating engineers generally say that if the velocity does not exceed five feet per second there is no perceptible draught. This needs qualifying, as a great deal depends on the occupants. A thin, spare man who takes little out-door exercise can feel a draught where a healthy man feels none, and until some device of enveloping each man in his own particular temperature and in his own pet air current is introduced, it will be difficult to suit everybody. With all systems of automatic ventilation there is the difficulty of keeping the velocity of air constant. If a strong wind is blowing on one side of the building the air enters the inlets on that side at a much more rapid rate than it does on the leeward side or on a still day.

I remember discussing some ventilating plans of a new technical school with an architect, who told me he had decided to adopt a certain scheme because the ducts and air inlets were so much smaller than in any of the other plans. He instanced a room for twenty pupils with an inlet only six inches square and pointed to the difference between this and another plan where the inlet was 18 inches square for the same room. I told him that if 3,000 cubic feet of air per hour per pupil were supplied the velocity at the inlet would be 66·6 feet per second, whereas with 18 inches square it would only be 7·4 feet per second. On the other hand if the velocity were to be kept down to four feet per second each poor pupil would only get 180 cubic feet per hour, whilst with the larger inlet they would each get 1,620 cubic feet per hour. Many ventilating contracts have no doubt been given out for similar reasons, but no architect is likely to make such a serious mistake more than once.

THEATRES AND SIMILAR PUBLIC BUILDINGS.

Theatres and public buildings have frequently no windows in the auditorium, they are surrounded by corridors and other rooms, they have several tiers or galleries, and no system of ventilation but the plenum is of any use. In the balconies and circles of theatres the cubic space allowed to each person is so limited that unless a large quantity of air is positively forced into them they become foul in a very short time. There are many theatres where the height between the floor and ceiling of the circles is less than seven feet, whilst the space from back to back of the seats is barely two feet six inches, and each seat only occupies one foot six inches in width. This practically means that each person is in a cubicle containing only 27 cubic feet, and it requires no stretch of the imagination to see how rapidly the air in such a small space becomes impure. Another difficulty is that the pittites are fully dressed and often wearing their overcoats, whilst the occupants of the stalls on the same level are very scantily clothed. It therefore follows that what is a comfortable temperature for one is a disagreeable one for the other and the stalls may always with advantage be five or six degrees higher in temperature than the pit proper.

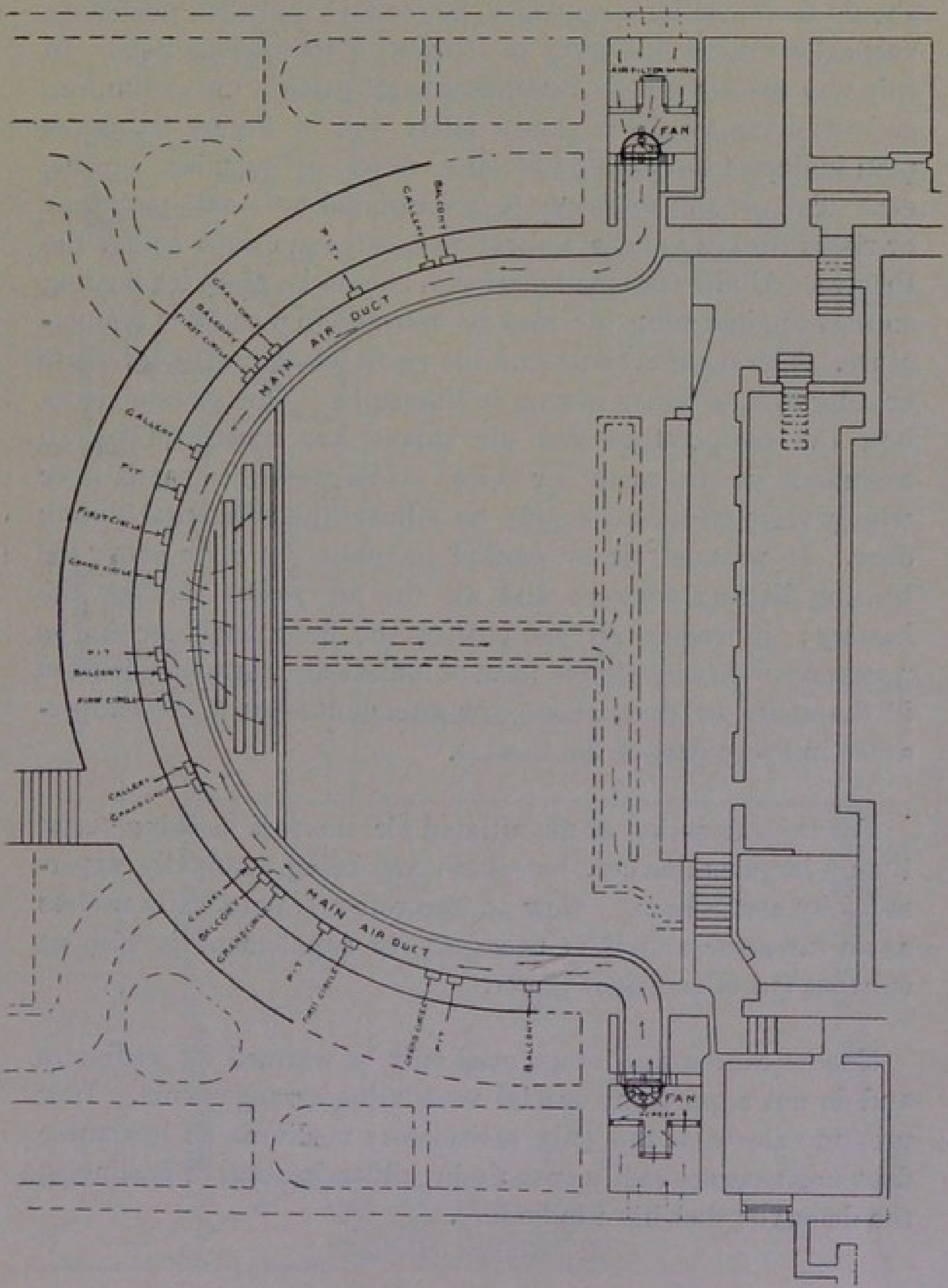


Fig. 13.—Plan of Theatre, showing Fans and Air Ducts.

My own idea of ventilating a theatre is to have an underground main air duct say 6 feet high and 3 feet 6 inches wide all round the auditorium wall. Into this duct fresh air should be forced by means of a fan or fans and then five or six vertical air ducts led from it to each of the various tiers. In this way the air will be distributed to all parts of the auditorium and the arrangement is shewn fairly well in Figure 13, as the plan indicates the position of fans, fresh air supplies, screens, etc. The pit and stalls are best ventilated by small platforms or risers running under several rows of seats right across the theatre. Under the small platforms should be pipes for heating so that the incoming air may be warmed to a suitable temperature. The main air duct and the small platforms under seats are shewn to a larger section in Figure 14. This section shews how the temperature and air supply are controlled by an attendant in the main air duct. If he wishes to partially or wholly close off the air supply he adjusts the horizontal sliding door. If warmer air is wanted he pulls the door above the heating battery forward and all the air passes through the battery; if cooler air he pushes the door back as far as necessary. A very simple form of indicating thermometer fixed in the main air duct shews the attendant what is the temperature in every part of the theatre.

For the extraction of the vitiated air there is nothing better than a large sunburner, but these are being gradually superseded by electroliers. Now an electrolier is practically useless as an extractor and it is necessary to supplement it with an exhaust fan of sufficient power.

The entrances and stage need only be warmed by radiators and do not require any special ventilating arrangements. Low pressure steam is the only satisfactory medium, as hot water does not answer readily enough in either heating or cooling to the demands that have to be met.

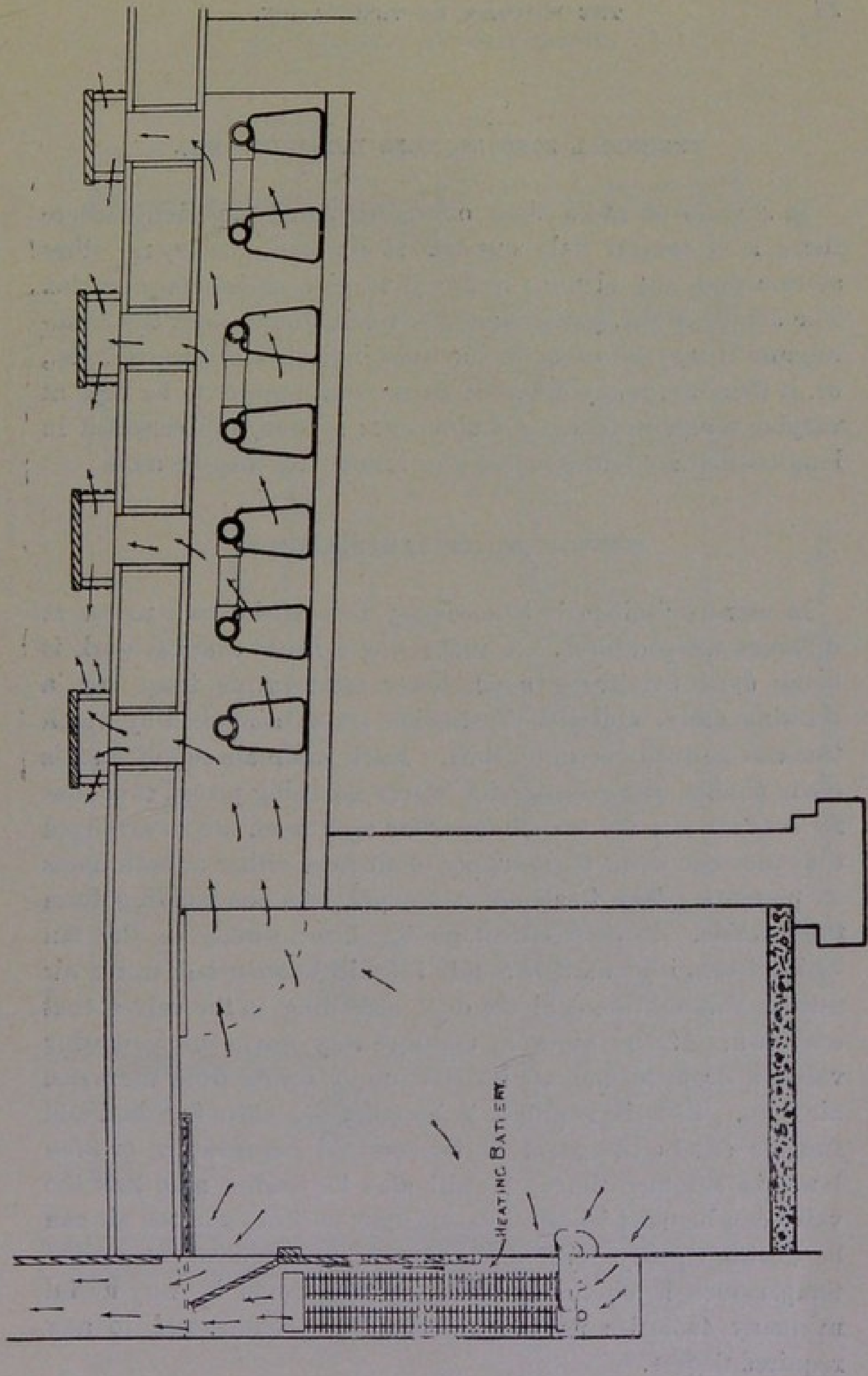


Fig. 14.—Section of Heating Chamber and Risers for Seats in Pit.

TECHNICAL SCHOOLS, FREE LIBRARIES, ETC.

In schools of more than one storey, and especially where there is a central hall surrounded by class rooms, no other system than the plenum is likely to give satisfactory results. The details of the system must be worked out to suit the building and it may be either on the lines indicated for theatres, etc., or, if there are many different rooms that require to be kept at varying temperatures the double duct system, as illustrated in longitudinal and cross sections in Figure 15, may be used.

CONTROLLING OF TEMPERATURES.

In many buildings it is necessary to have different rooms at different temperatures. A room where heavy manual work is being done requires a much lower temperature than, say, a drawing office, and the illustration shows a method by which this can be easily accomplished. Each main air supply duct is made double, the passage for warm air being placed over that for cold air and the branch ducts for each room are so arranged that they can draw their supply of air from either or both ducts at pleasure. The fresh air is brought into the building from the outside. It passes through the filter screen to the fan which forces it forward through the air warmer and warm air duct or through the cold air duct according to the valves that are open. If the room is required very warm the regulating valve is dropped and all the air supply comes from the warm air duct. If it is required to be cold, the valve is raised and the air enters the room at the normal temperature or even lower in summer time. It will also be readily seen that the valve can be fixed in any intermediate position and the air can be drawn equally from both ducts or mixed until the desired temperature is obtained. This system would be very useful in many factories as the air could be conditioned to any required degree.

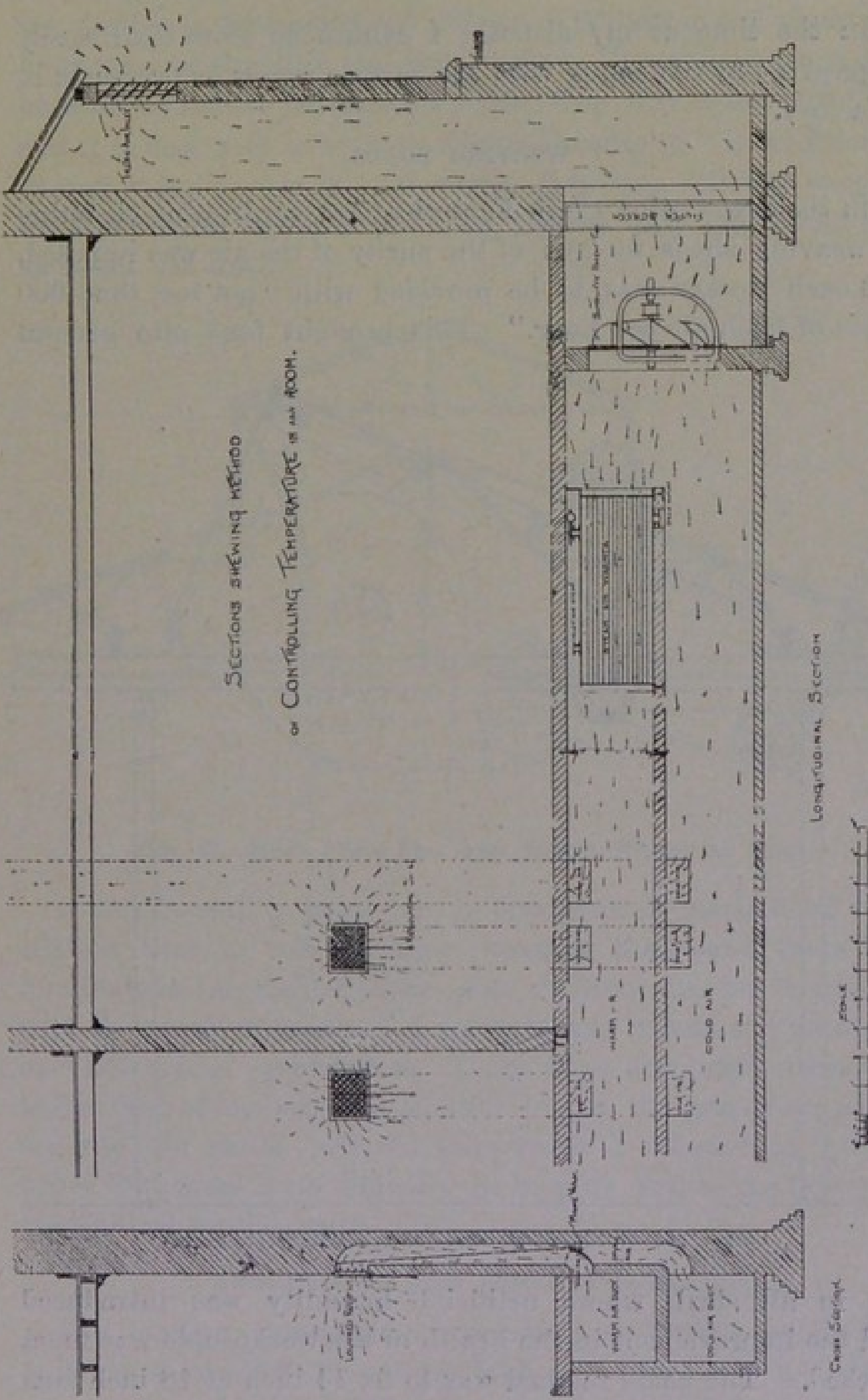


Fig. 15.—Section of Double Duct System.

FACTORY VENTILATION.

In the time at my disposal I cannot do more than barely suggest a way of dealing with the various rooms or processes in a factory.

WEAVING SHEDS.

In the first Cotton Cloth Factories Act controlling steaming in weaving sheds no test of the purity of the air was imposed, but each worker was to be provided with "not less than 600 cubic of fresh air per hour." This brought fans into general

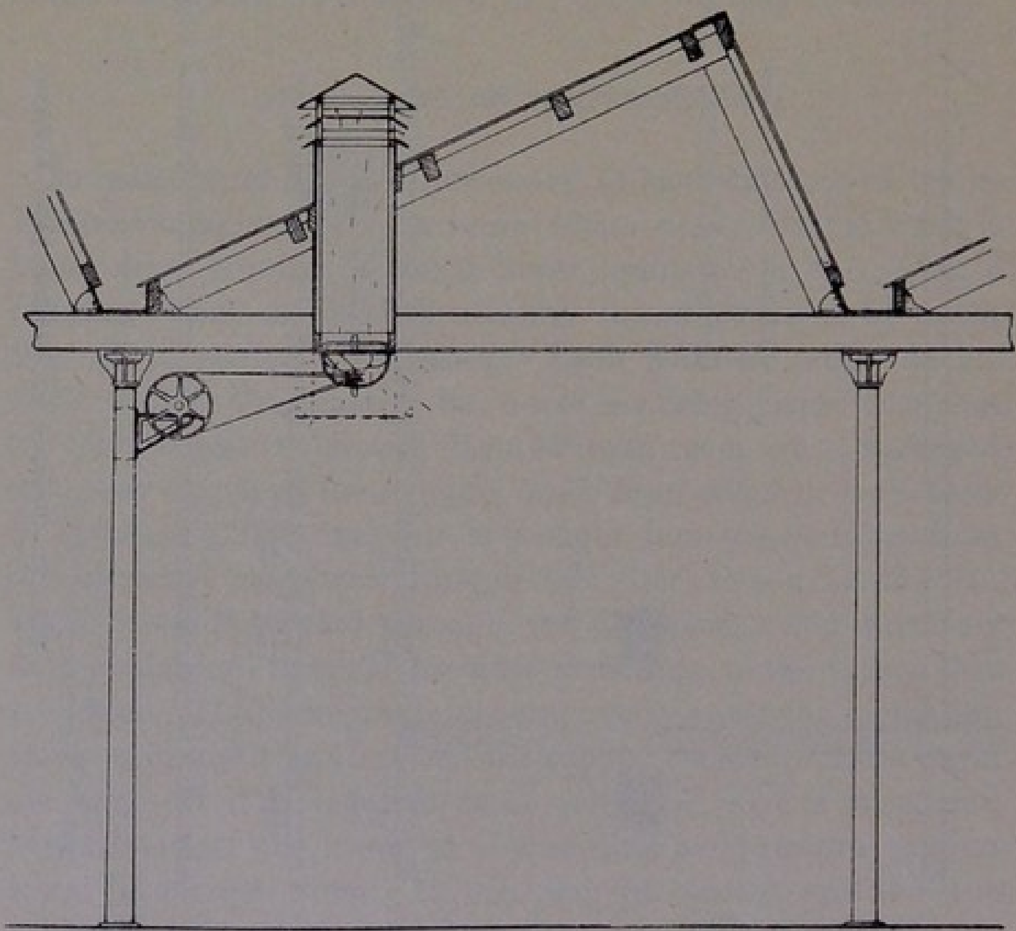


Fig. 16.—Section of Weaving Shed with Fan.

use in all sheds where artificial humidity was introduced and the improvement in the health of the workpeople was most marked. The usual method was to fix 14 inch or 18 inch fans as Figure 16, exhausting from the shed and to provide fresh air inlets round the walls where possible.

In the most recent Cotton Cloth Factories Act the standard of purity of the air is fixed and as stated previously if this standard is to be maintained at least 2,000 cubic feet of air per hour must be supplied for each worker. By experience it has been found that to fix fans for exhausting only is not sufficient and it is necessary to arrange fans "blowing in" in addition if success is to be assured. Of course, it is very different supplying 2,000 cubic feet each per hour, against only 600 cubic feet as in the old Act.

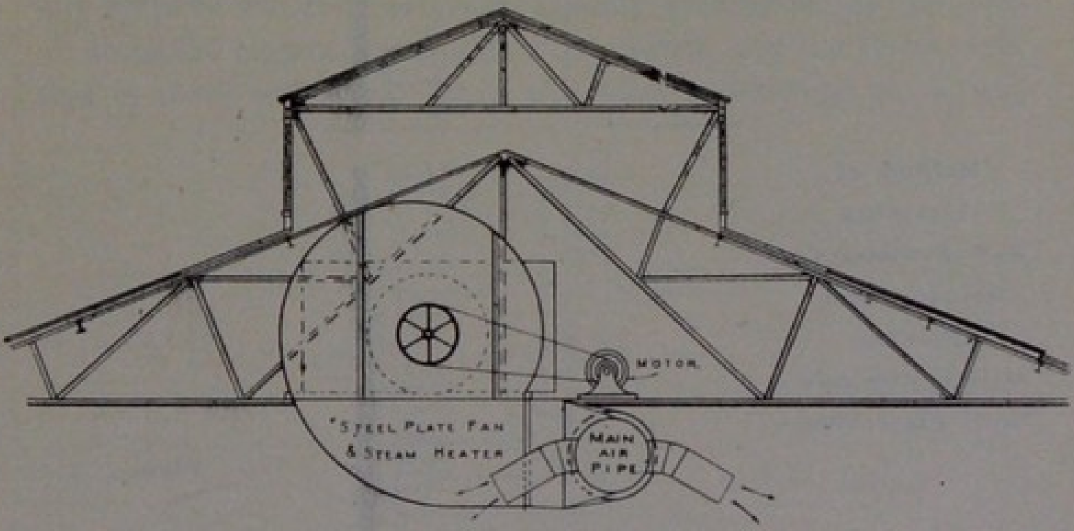


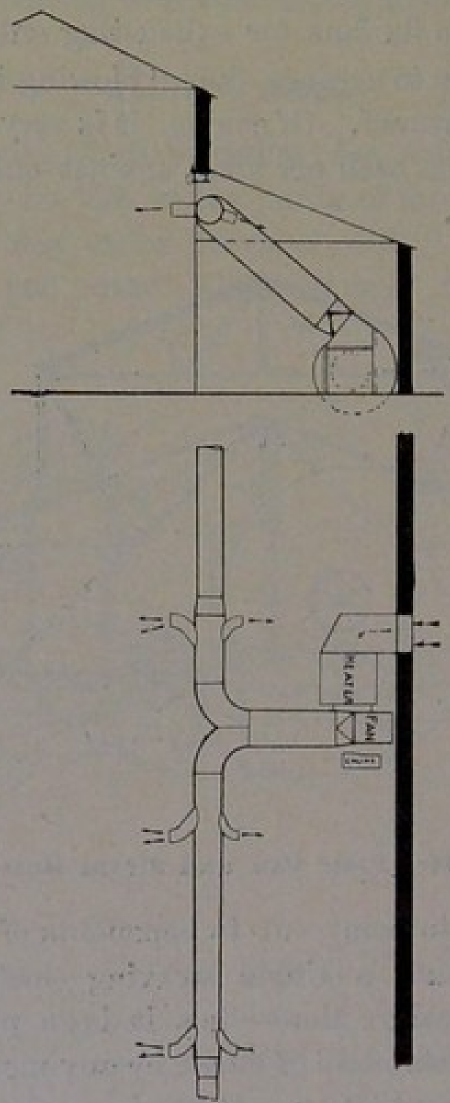
Fig. 17.—Steel Plate Fan and Steam Heater in roof.

It may be well to point out to opponents of mechanical ventilation that in not a single weaving shed—and there are hundreds in Lancashire alone—has it been possible to comply with the required standard of purity by any means of "natural" or "automatic" ventilation. It has been absolutely necessary to use fans of one type or another to get the proper supply of air into the sheds, and the tests which I referred to earlier prove that there is no difficulty in keeping within the law with mechanical ventilation.

ENGINEERING AND PRINTING WORKS.

The modern engineering, printing and similar works are built, as a rule, only one storey high. They cover a great deal of ground, and it is not possible to keep the air fresh and sweet in the centre of the rooms with ordinary air inlets in the walls.

Frequently there are travelling cranes overhead, and steam pipes and air ducts must be kept clear of these and can only run parallel with the cranes and not across their path.



Section.

Method of Warming and Ventilating Single storey Factory with Heater and Steel Plate Fan.

Plan.

Fg. 18.

In such cases it is necessary to fix any heating and ventilating plant well clear of the cranes, shafts and belts, and sometimes the fan and heating battery are placed in the roof as shown in Figure 17, where they cannot cause any obstruction. More frequently, however, the fan and heater are fixed on the floor, as Figure 18, and the distributing air ducts or pipes are carried in the most convenient positions for supplying the whole of the works with fresh air warmed to suit almost any conditions of temperature that may be required.

One incidental advantage of this system of heating is, that when the works are being warmed up on a cold morning and before work is started the inlet for fresh air from the outside to the fan may be shut off, and the fan can draw its air actually from the room it is heating. This circulating of warm air greatly reduces the time taken to heat up the works to the required temperature.

VENTILATION OF FACTORY W.C.'s.

It is always a serious matter to fix a fan exhausting from any room to which closets are directly connected, as the foul air from the closets is certain to be drawn into the room, and this is more noticeable when the wind is blowing in at the

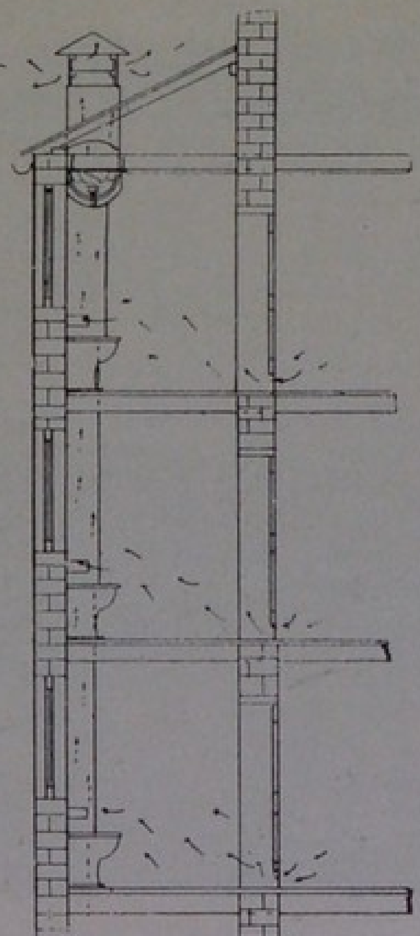


Fig. 19.—Section through three W.C's.

closets. If there are a series, one above the other, as Figure 19, it is a good plan to fix an exhaust fan on the ceiling at the top and connect all of them by means of a wooden tube. The foul air should be extracted at the level of the closet seat and the fresh air admitted by cutting three inches from the bottom of each door. The illustration shows the arrangement clearly, and you will see that by adopting this plan, you ventilate each room into the closet, which is much better than ventilating the closets into the rooms.

DUST REMOVING.

"General" ventilation in factories is certainly a benefit, but where dust, fumes, or especially foul air are to be removed the ventilation should be "local." It is a mistake to fill the air of a room with dust, steam or other impurities and then exhaust with a fan. Much better practice is to hood in the source of trouble and exhaust the limited space of the hood.

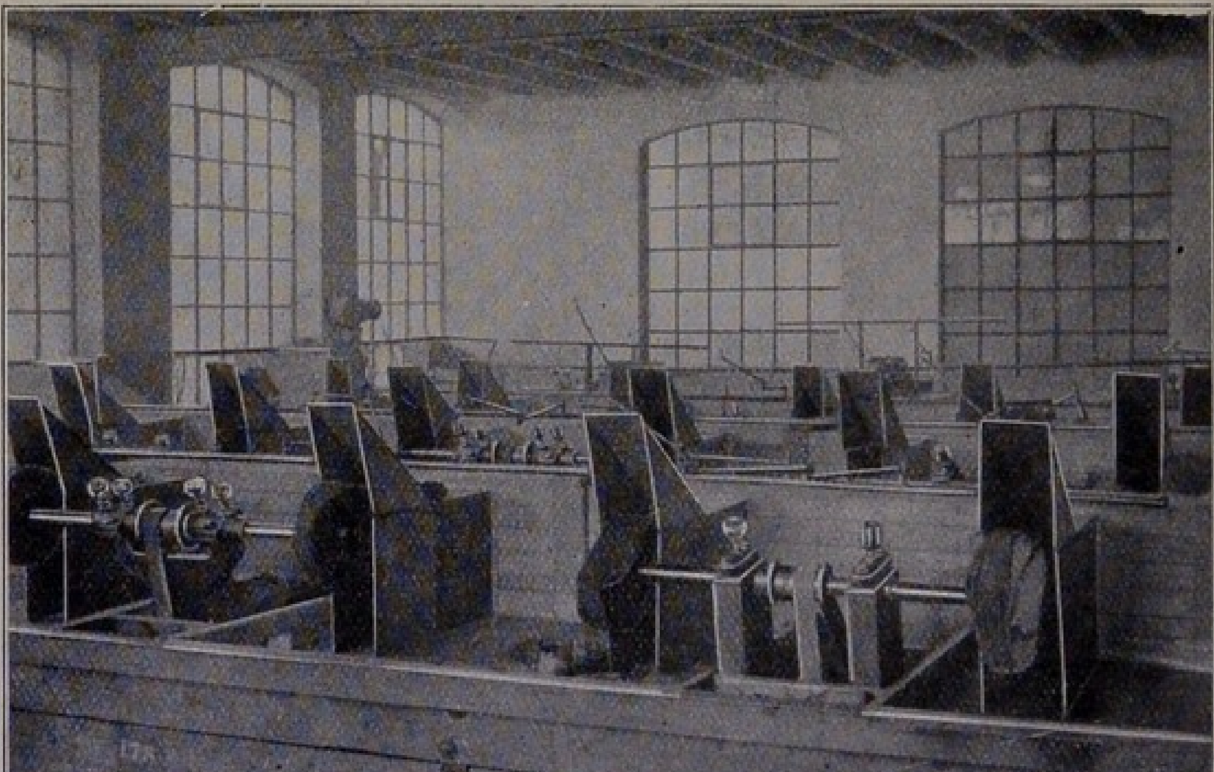


Fig. 20.—Dust Removing from Polishing Shop.

LOCAL VENTILATION FOR DUST REMOVING.

Figure 20 is an illustration of a polishing shop in an engineering works. There are four benches, and each bench accommodates six workers. Eighteen-inch diam. extracting fans are fixed at the ends of the benches in the windows, and a main duct is led right along the back of each bench and connected to the fans. Small branch ducts with hoods lead from each "bob" or grinding wheel to the main duct and the dust never enters the rooms, but is drawn away as fast as it is given off. This and the next illustration, Figure 21, are good examples of "local" ventilation where dust and fumes have to be dealt

Fig. 21.—Dust Removing in Pottery Works.

with. Figure 21 has a special interest because it was designed to remove the lead dust from the workers in the pottery trade, and hundreds of fans have been fitted on the lines shewn. The girl cleans the ware or puts on the colour dust under the glass hood, and any floating dust is immediately carried away through the opening at the back of the hood and down through the bench to the fan. A velocity of air of 500 feet per minute is necessary to ensure the removal of all the dust.

GENERAL VENTILATION FOR DUST REMOVING.

It is impossible to use a hood in some cases, and greater care is then necessary in selecting the best position of the fan. The upper left-hand illustration in Figure 22 shows how a fan should

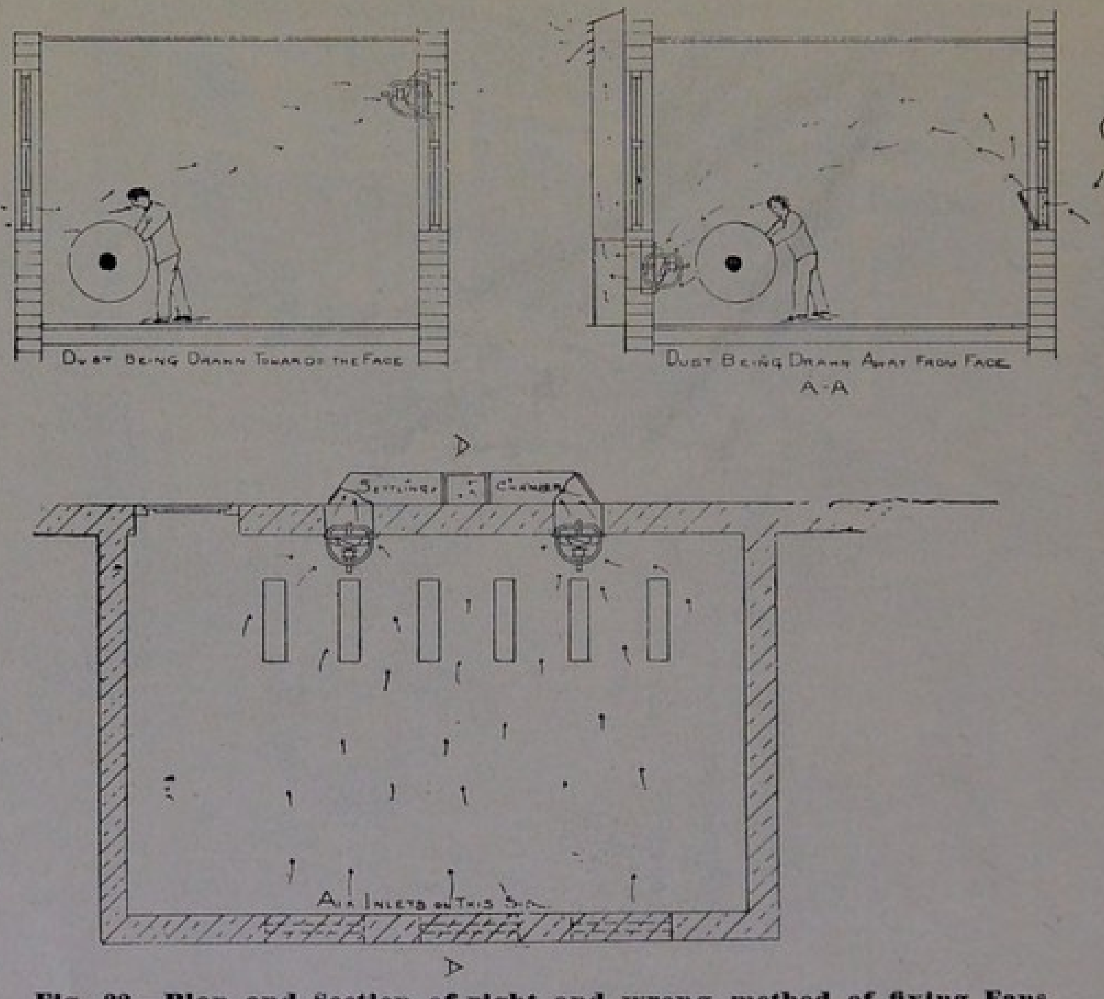


Fig. 22.—Plan and Section of right and wrong method of fixing Fans.

not be arranged. You will see that the fan is fixed behind the man and, consequently, any dust that may be drawn by the fan must pass over the man's face. This is entirely wrong, as the fan should always be fixed in such a position that the particles of dust are carried away from the face of the operative, and the principle is properly illustrated in the other section and plan of Figure 22.

In these illustrations a form of settling chamber is shewn which is useful when the dust is valuable, or even when it would be a nuisance if allowed to blow about the premises. Many settling chambers are rendered useless by contracting the outlet, which should be at least equal to the area of the fan or fans.

CARDING ROOMS.

It is rarely possible to use local ventilation in card rooms as the hoods would generally interfere with the machines and

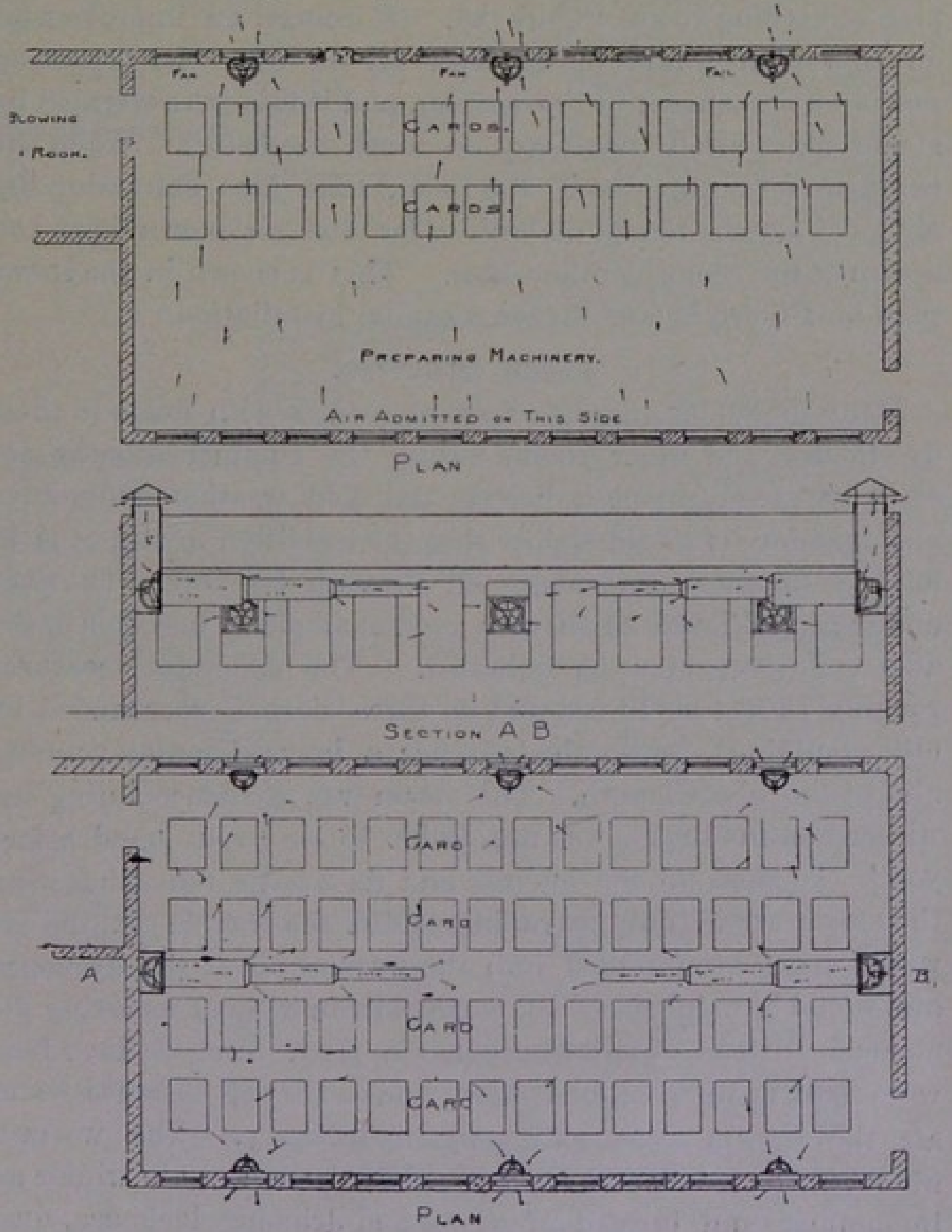


Fig. 23.—Plans and Section of Cotton Carding Room.

obstruct the light. If the carding machines are down one side of the room only it is a simple job to remove the bulk of the floating dust. The best arrangement is to fix small fans, say 24 inch diam., in every third window on the same side as the cards. The height from floor to bottom side of fan should be 7 feet 6 inches to 8 feet. The air should be admitted at the windows on the opposite side of the room to the fans so that it travels over the preparing machinery and then forward over the cards to the fans. This is shewn clearly in the top plan of carding room, Figure 23. Of course, an improvement on this plan would be to blow air in over the preparing machinery as shewn in the section, and if this were warmed by steam pipes when necessary so much the better. When the cards are on both sides of the room, then fans extracting the air must also be placed on both sides and air blown down the centre of the room by other fans. This is shewn in the lower plan on Figure 23 and makes a capital installation.

STEAM REMOVING.

Many manufacturers who have no trouble with steam in their dye houses and other rooms during the summer months are seriously inconvenienced directly the cold weather commences and therefore it would appear that the condition to aim at is to have a summer atmosphere all through the year. The plan and section Figure 24 shews a good example of how this desirable condition may be obtained. The dyehouse measures roughly 75 feet by 40 feet and on three sides is surrounded by other buildings, while the roof has a louvred outlet running almost the whole length. The steam was so dense during the winter months that it was impossible to see 'your hand before you.' To close up the louvres and fix a large fan exhausting the steam would only have intensified the trouble as cold air would have been pulled into the warmer air of the dyehouse and would have increased the condensation without removing the steam. Instead of following such a plan, three 24 inch fans were fixed in the positions shewn and as they all obtained warm air the results were extremely satisfactory. The warmth absorbed the steam and now the place is as clear in winter as in summer and instead of a wet and dripping dyehouse, dust may be seen on the roof beams.

In some dye, bleach works and wash-houses, it is not easy or possible to get suitable warm air from any adjoining room and recourse should then be had to a steam heating battery for

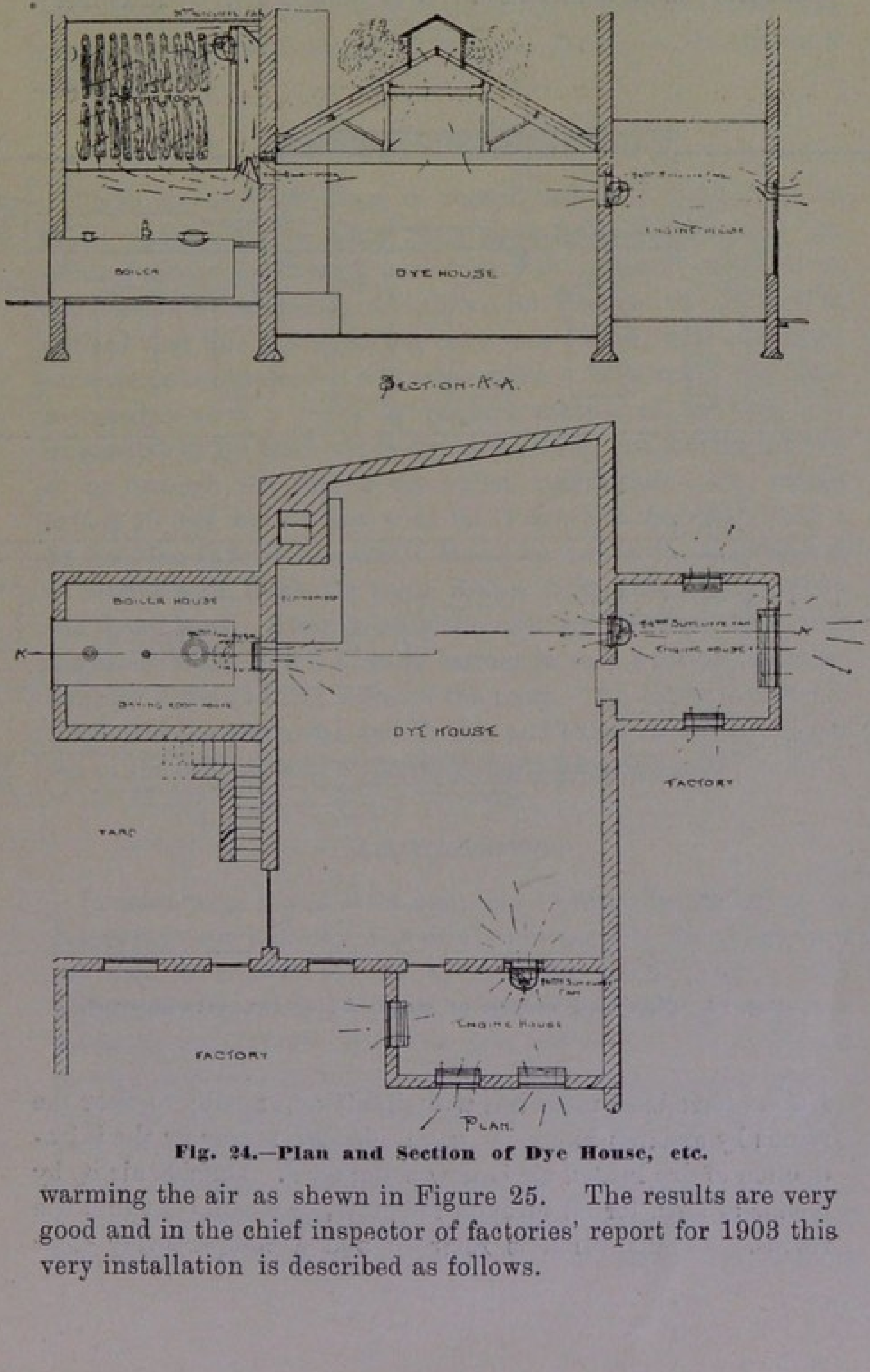


Fig. 24.—Plan and Section of Dye House, etc.

warming the air as shewn in Figure 25. The results are very good and in the chief inspector of factories' report for 1903 this very installation is described as follows.

"The amount of free steam in different departments in bleach and dye-works, hat works, laundries and other works, is frequently a serious menace to health, and as vision is often obstructed there is increased risk of being caught by machinery.

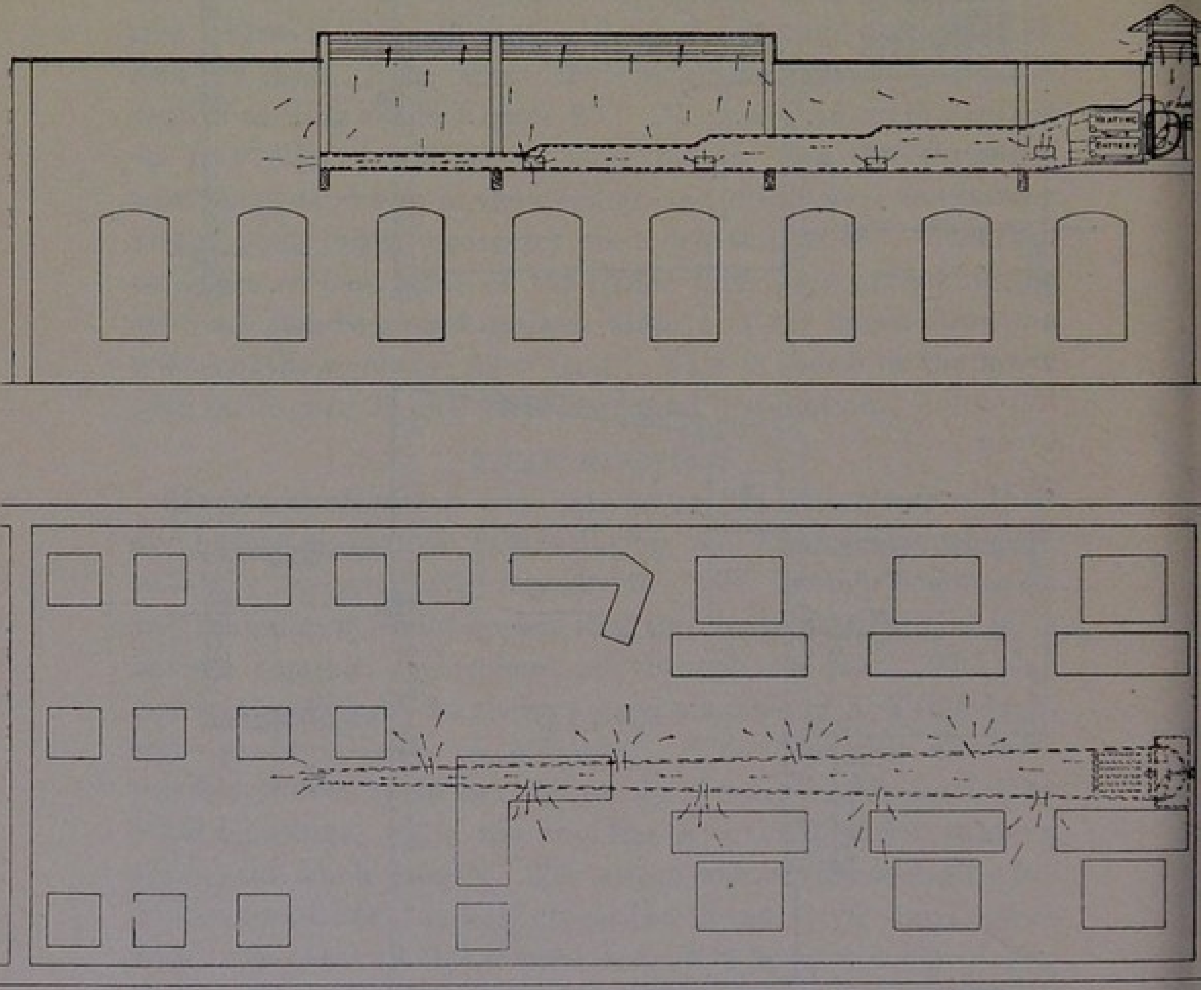


Fig. 25.—Plan and Section of Steam Absorbing Arrangement.

Efforts have been made but with indifferent results to clear the rooms by exhaust fans. A more efficient means by the introduction of dry heated air is now being tried. Outside air is, by means of fans, forced through radiators, or steam coils into the rooms. Condensation is retarded and a comparitively clear atmosphere secured. I visited the works on March 5th, when at my request the "radiator" was allowed to get quite cool after I had observed the condition of the room. The contrast was most marked and with no hot air the atmosphere was heavily charged with steam, so much so that I could only see a few feet."

BASEMENTS AND CAFÉS.

These are another class of rooms that can frequently be better dealt with by using fans than by any automatic or natural means, and I wish particularly to call your attention to the plan of a basement café shewn in Figure 26. It will be noticed that this basement has only one outside wall and fresh air cannot be obtained at any other point. How could one hope to ventilate such a room by natural means, as not only is it impossible to get fresh air in round the sides, but it is impossible to go through the ceiling for outlet ventilation. The actual café is 70 feet by 30 feet wide by 11 feet 3 inches high, and a 24 inch fan is fixed in a small basement under the only length of outside wall, fresh air being drawn downwards from above the street level. After passing through an air filter screen the fan forces it through a heating battery in cold weather, and distributes it round three sides of the room. An extracting fan is fixed over the lavatories and W.C.'s and exhausts all the smoke out of the café, as well as keeping the lavatories sweet.

AIR FILTRATION.

In most large towns it is desirable to filter the air before it passes into any building, but this is not easy to do unless fans are used to compel the air to pass through the filter. Thin layers of cotton wool have been tried in Tobin tubes, but even a thickness of half inch across the tube will reduce the air supply by 90%, and frequently stop it altogether. Fine wire or perforated zinc over an inlet will lessen the velocity by 50% or more, and, in fact, any kind of screen or filter will stop the supply of air to a greater or less extent unless mechanical means are adopted. Many experiments have been made with cotton and jute cloths, matting, etc., but none of these seem to approach in

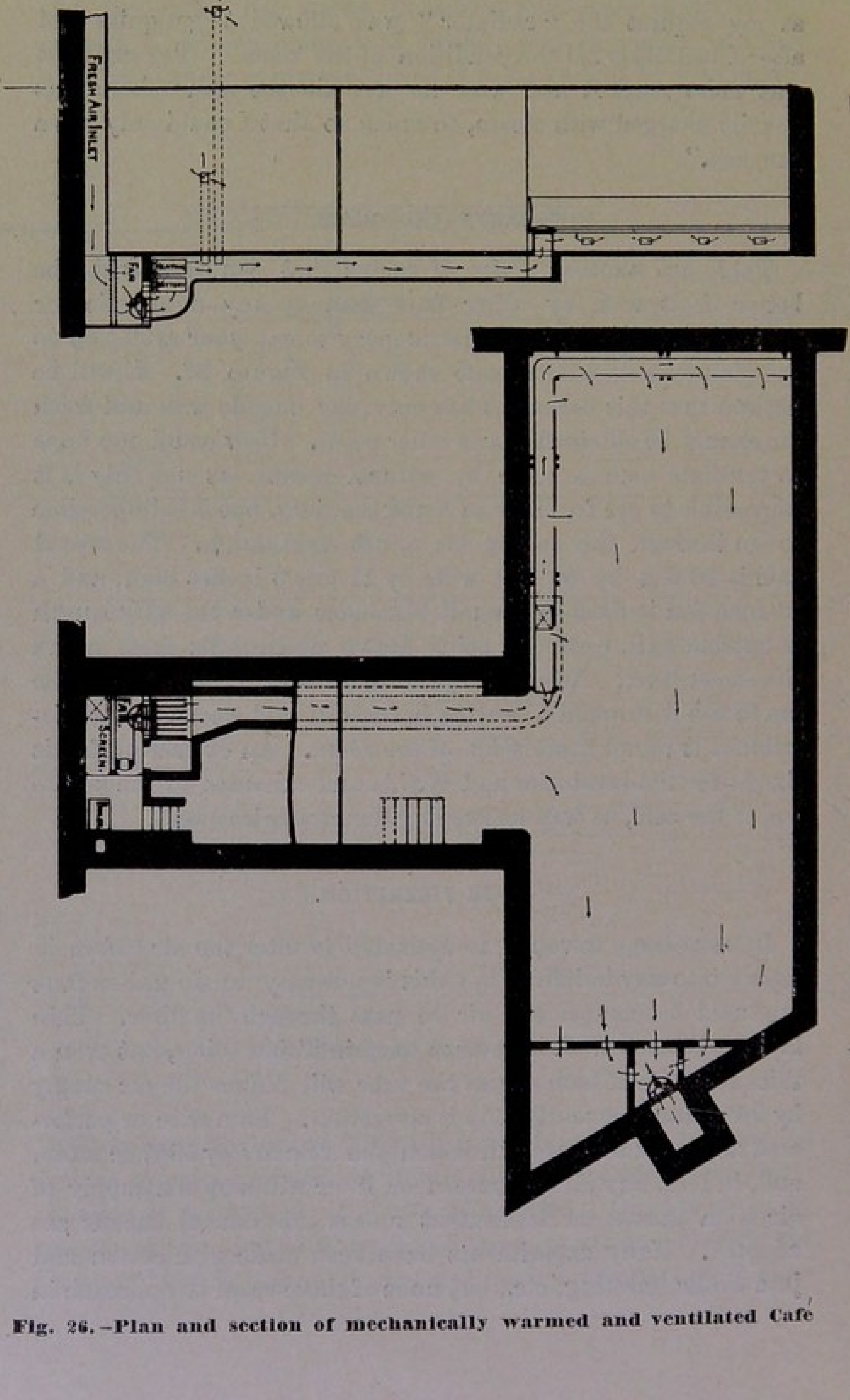


Fig. 26.—Plan and section of mechanically warmed and ventilated Cafe

efficiency the coke screen seen in the illustration, Figure 27. Two frames of strong wire netting are securely attached to a wooden support about five inches thick. The netting should be of about three-quarter inch mesh and made from wire of 16's to 18's guage. On the side furthest away from the fan a door is constructed at the top for filling with coke, and a door at the bottom for emptying. The screen should have a superficial area of at least equal to six times the area of the fan used.

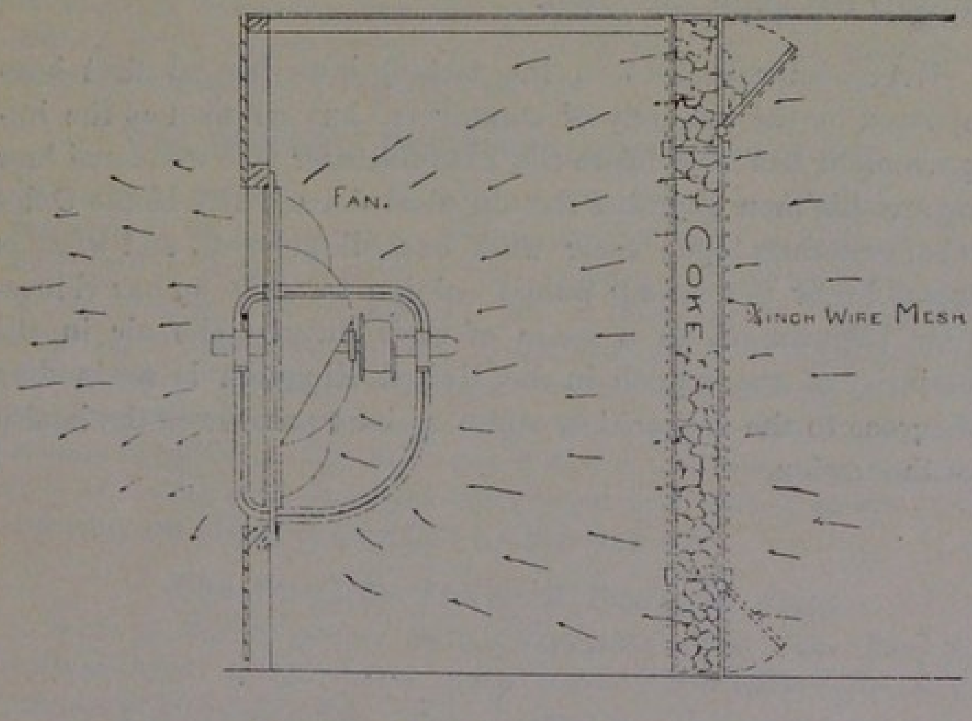


Fig. 27.—Fan and Coke Air Filter.

The coke before it is placed in the screen, should be carefully washed and passed through a 1½ inch mesh, as the best size for the coke is about two inch diameter. For cooling in summer water can be sprayed against the screen and it can be washed down at any time with a hose pipe without disturbing the coke. All smuts and dust will be filtered out of the air, and even fog is very sensibly reduced by passing through the screen.

CONCLUSION.

Although I have only been able to touch the fringe of my subject, I trust the few examples I have given will be useful, and especially that my remarks about the open window will bear some fruit. I strongly believe that it pays the manufacturer to have his workshop and factory as healthy and cleanly as possible. Fresh air is as necessary as good food if the best is to be obtained from any man, and many manufacturers already recognise this truth.

Every improvement in the factory laws has at first been opposed by the majority of employers, but as soon as the improvement has been made the manufacturer has wondered how he and his men tolerated the old conditions. The Home Office have generally done their work exceedingly well, and what is wanted now is a strong public opinion to wake up our Education Department to a sense of their duty! The air in the majority of the schools in the United Kingdom is a standing disgrace to the authorities, and a serious menace to the health of the nation.

How to Choose a Fan!

The type of Fan is of the utmost importance to fan users if the best results are to be obtained. The nature of the work the Fan has to do, the volume of air to be moved, its velocity and pressure should all be carefully considered, and the following description of different types of Fans and their application will be found useful.

The Sutcliffe Ventilating Fan

is of the well-known propellor type, and is shown and described on ps. 53-55. It is the most suitable Fan for moving large volumes of air againt very small resistance, general ventilation, removing floating steam or dust, and is generally belt driven, but can be equally well coupled direct to an electric motor or steam engine as shewn on page 55. See page 54 for sizes, speeds, capacities, horse-powers, etc.

The Sutcliffe Ventilating Steel Plate Fan

Is shown on page 42. It is designed for blowing or exhausting large volumes of air at a moderate pressure through ducts or other channels where the air passage is more or less restricted. It can be run at high speeds to give a water-gauge of 5in. or more, but is most suitably employed at pressures of from ½in. to 3in. water-gauge. This Steel Plate Fan is made with casing to completely enclose the Fan wheel, called Full Housing Pattern as shewn on page 45, and also with three-quarter housing as page 46. The latter type is mostly used where the discharge is to be underground or height is important. A table of speeds, sizes, capacities and horse-powers will be found on page 47.

The Sutcliffe Induced Draught Fan]

is built on the same lines as the Ventilating Steel Plate Fan, but made stronger. It is illustrated on page 48, and a description of the salient points is given on page 43.

The Sutcliffe P.M. Fan

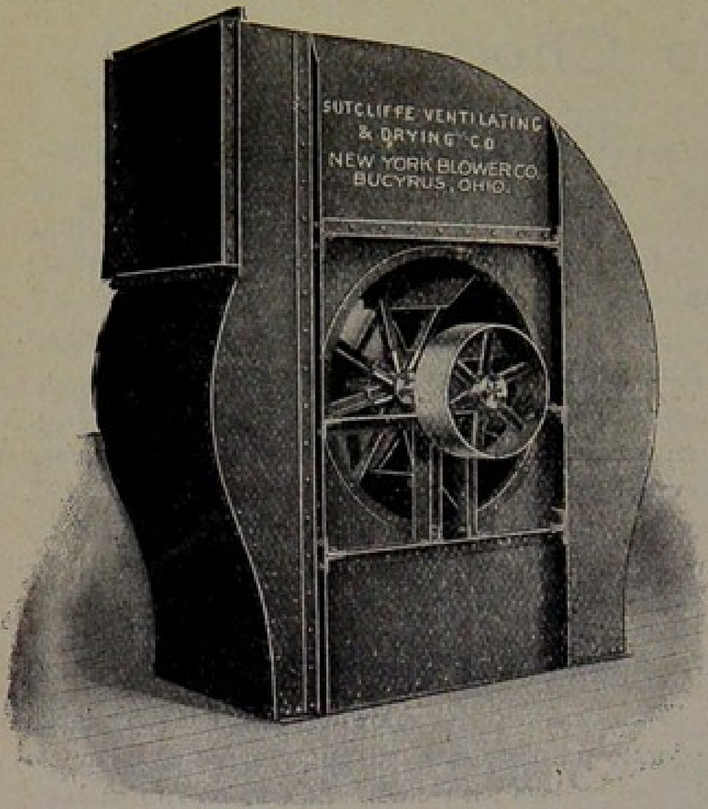
Or Planing Mill Exhauster, on page 49, is the Fan to use for exhausting and conveying dust, shavings, chips, wool, &c., where high pressures are required. It will give a pressure up to 20in. water-gauge, and the sizes, &c. will be found on page 50.

The Sutcliffe Peerless Fans

Are designed for blowing Cupolas, Smiths' Fires, and other work where high pressures are wanted, without a large volume of air being moved. The sizes are the same as the diameter of the inlet and outlet, but for any size above a No. 14, the P.M. Fan is usually preferable. The pressure of air delivered can be varied according to the speed from 1in. to 20in. water-gauge, and the general sizes, speeds and capacities are given on page 52.

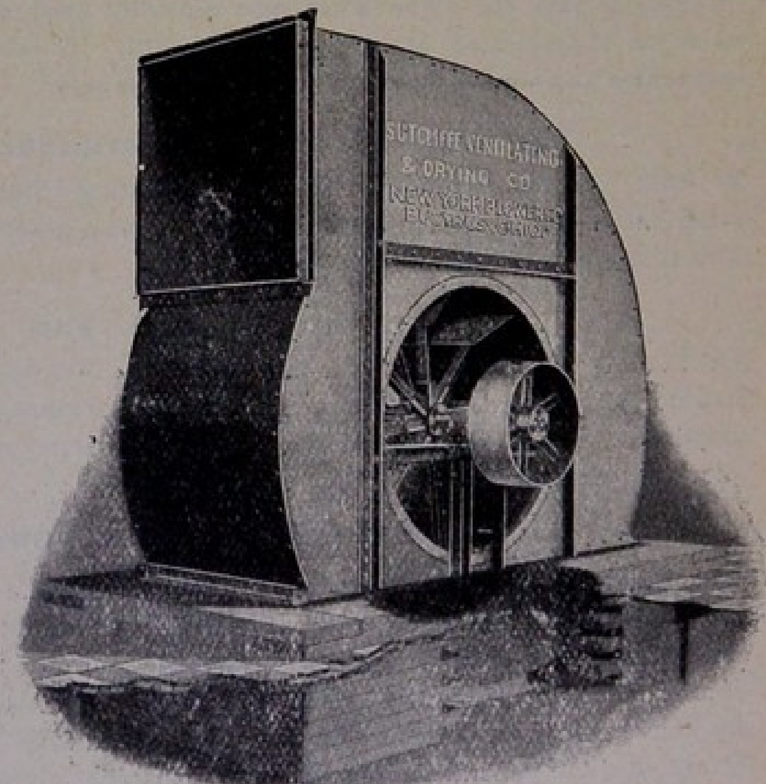
SUTCLIFFE STEEL PLATE VENTILATING FANS.

BELT-DRIVEN FANS.



Right Hand Top Horizontal Discharge Full Housing Type Fan, with Overhung Pulley.

Our Three-quarter Housed Fans are constructed on the same lines and principles as our Full Housed Fans. They are mostly used in positions where the height is insufficient for a Full Housed Fan and are necessary with under-ground ducts where the discharge is directly into the ducts.



Right-hand Top Horizontal Discharge Three-quarter Housing Type Fan, with Overhung Pulley.

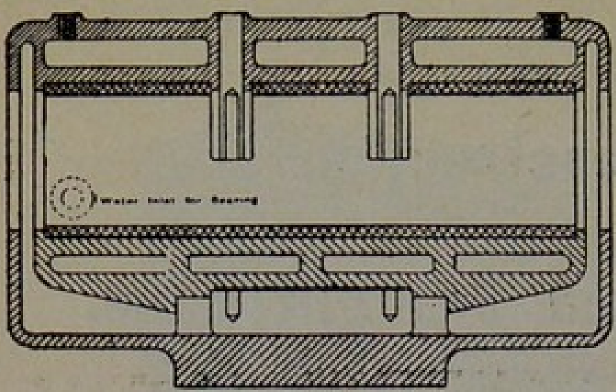
The Construction
OF
Sutcliffe Induced Draught Fans.

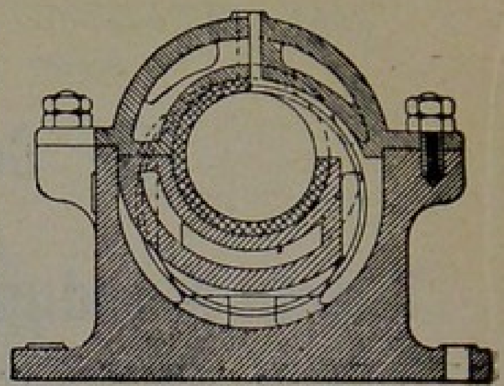
The handling of gases at high temperatures requires fans that are stronger and more durable than fans handling hot air heated by steam coils. It has been our constant endeavour to construct a fan that in every respect will meet the requirements that are demanded in a fan handling gases from boilers and kilns. We use heavier gauge steel, heavier angle iron, and double the number of rivets as compared to an ordinary fan.

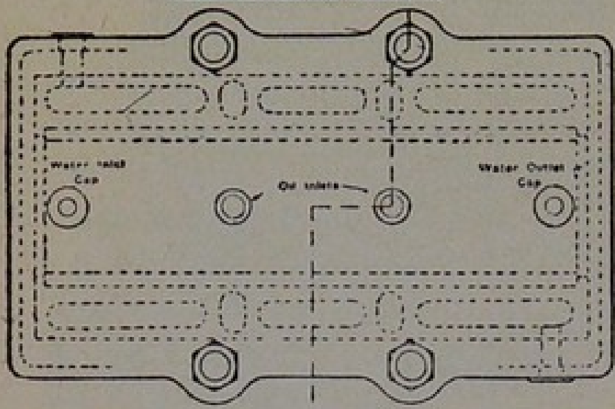
One of the strong points of our Induced Draught Fan is the water-cooled bearing, illustrated on page 44. This bearing consists of a heavy sole plate, which rests on the grillage. The pedestal contains the oil chambers and the lower water-jacketed bearing with the water-jacketed cap above. Water is introduced by pipes into the cap and lower bearing, giving a constant circulation of water entirely around the shaft. This keeps the temperature of the shaft down, and absolutely prevents heating of the bearing. These boxes are double ring-oiling, the oil being contained in chambers in the pedestal. The rings passing through this oil and revolving on the shaft, maintain a perfect lubrication of the bearing. This is the best constructed and most durable water-cooled box manufactured, and is an essential to the successful working of an Induced Draught Fan.

When purchasing a fan for induced draught the fact should be taken into consideration that the fan is running day and night, and is practically in constant operation from one year's end to the other.

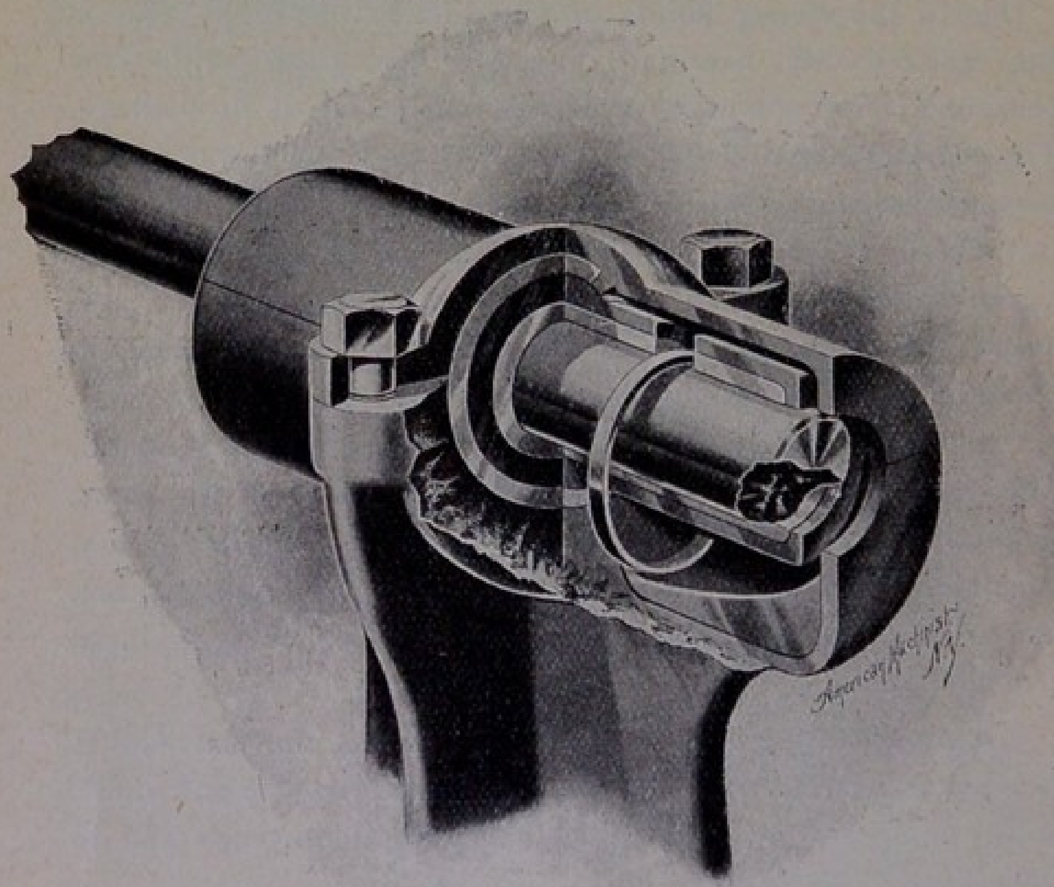
For this kind of service the best is none too good, and you will make no mistake in installing one of our fans. They have stood the test, and will not fail at the critical time.







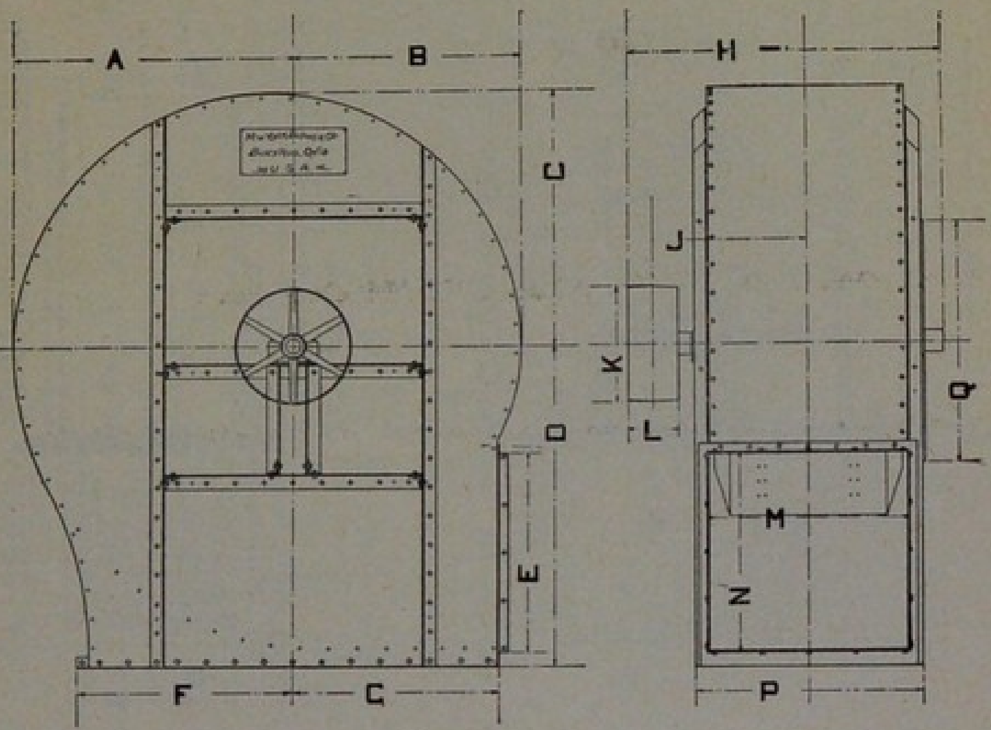
Plan and Section of
Water-cooled Bearing as described
on page 43.



This Journal Box is our Standard Ring oiling Ball and Socket Type; it consists of an internal sleeve mounted in a substantial casting. The alignment is absolutely perfect, and as the sleeve is protected by the outer casing, it is impossible to accidentally disturb the adjustment.

The outer casing is utilised as an oil-reservoir. The oil is fed from this reservoir to the shaft by the ring.

Wherever conditions make it advisable we furnish a water-jacketed bearing. This is especially desirable where fans are used for handling hot gases from cooling kilns and in mechanical draught plants.

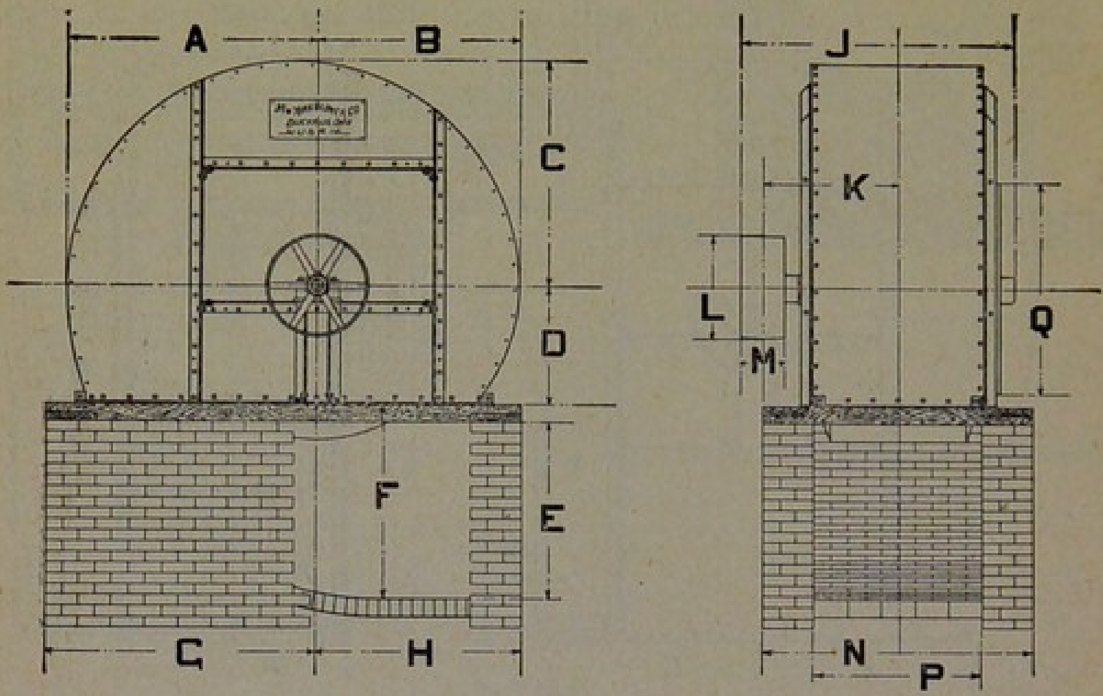


Full Housing Type, Bottom Horizontal Discharge Steel Plate Exhausters with Overhung Pulleys.

Table of Principal Dimensions.

Size	A	B	C	D	E	F	G	H	J	K	L	M	N	P	Q
40	18½	15½	17	23	12½	16 7/16	14½	25⅛	12 3/16	8	4½	12½	12½	17½	18
45	20¾	17¼	19	25½	14	18	16¼	26⅜	12 13/16	9	4½	14	14	19	20
50	23½	19½	21½	28½	15½	20 7/16	18	29¼	14 3/16	10	5½	15½	15½	20½	22
55	25¾	21¼	23½	31	17	21 11/16	19	30⅝	14 13/16	11	5½	17	17	22	24
60	28½	23½	26	34	20½	23⅝	21½	34 7/16	16 11/16	12	6½	20½	20½	25½	26
70	33½	27½	30½	39½	24	27¼	25	40¼	19 9/16	14	6½	24	24	29	30
80	38½	31½	35	45	27½	30⅞	28½	44¼	21 5/16	16	6½	27½	27½	32½	34
90	43½	35½	39½	50½	31	34 7/16	32	51⅛	24 13/16	18	8½	31	31	36	38
100	48½	39½	44	56	34½	38 1/16	35½	54⅜	26 11/16	20	8½	34½	34½	39½	42
110	53½	43½	48½	61½	38	41⅝	39	60¾	29 13/16	22	8½	38	38	43	46
120	58½	47½	53	67	41½	45¼	42½	65¾	32 1/16	24	10½	41½	41½	46½	50
130	63½	51½	57½	73	45	49 13/16	46	70⅝	34 7/16	26	10½	44½	45	51½	54
140	68½	55½	62	78½	48½	53⅝	49½	73⅝	35 11/16	28	10½	47	48½	54	58
150	73½	59½	66½	84	52	57	53	77 9/16	37 13/16	30	10½	49½	52	56½	62
160	78½	63½	71	89½	55½	60 9/16	56½	80 9/16	39 5/16	32	10½	52½	55½	59½	66
170	83½	67½	75½	95	59	64 3/16	60	83 9/16	40 13/16	34	10½	55½	59	62½	70
180	88½	71½	80	100½	62½	67¾	63½	86 1/16	42 1/16	36	10½	58	62½	65	74
190	93½	75½	84½	106	66	71⅜	67	90⅛	44 3/16	38	10½	60½	66	67½	78
200	98½	¶9½	89	112½	69½	75⅞	70½	93⅛	45 11/16	40	10½	63½	69½	72½	82
220	108½	87½	98	123½	76½	82⅝	77½	100⅛	48 13/16	44	12½	69	76½	78	90
240	118½	95½	107	131½	83½	90¼	84½	108⅜	53⅛	48	12½	74½	83½	83½	98
260	128½	103½	116	145½	90½	97 7/16	91½	113⅞	55⅞	52	12½	80	90½	89	106
280	138½	111½	125	156½	97½	104 11/16	98½			56	14½	85½	97½	94½	114
300	148½	119½	134	167½	104½	111⅞	105½			60	14½	91	104½	100	122
320	158½	127½	143	178½	111½	119 1/16	112½			64	14½	96½	111½	105½	130

Note.—All Dimensions are in inches. Dimensions of inlet and outlet are outside measurements.



Three-quarter Housing Type, Bottom Horizontal Discharge Steel Plate Exhausters with Overhung Pulleys.

Table of Principal Dimensions.

Size	A	B	C	D	E	F	G	H	J	K	L	M	N	P	Q
40	18 1/2	15 1/2	17	12	12 1/2	16 1/2	25 5/16	23 13/16	25 1/4	12 3/16	8	4 1/2	36	12 1/2	18
45	20 3/4	17 1/4	19	13	14	18	27 13/16	25 1/4	26 1/4	12 13/16	9	4 1/2	37 1/2	14	20
50	23 1/2	19 1/2	21 1/2	14	15 1/2	19 1/2	30 1/4	27 3/16	29 1/4	14 3/16	10	5 1/2	39	15 1/2	22
55	25 3/4	21 1/4	23 1/2	15	17	21	32 5/16	28 5/16	30 5/8	14 13/16	11	5 1/2	40 1/2	17	24
60	28 1/2	23 1/2	26	16	20 1/2	24 1/2	35 1/4	30 5/16	34 3/16	16 13/16	12	6 1/2	44	20 1/2	26
70	33 1/2	27 1/2	30 1/2	18	24	28	39 7/8	34	40 1/4	19 5/16	14	6 1/2	47 1/2	24	30
80	38 1/2	31 1/2	35	20	27 1/2	31 1/2	44 5/16	37 3/8	44 1/4	21 5/16	16	6 1/2	51	27 1/2	34
90	43 1/2	35 1/2	39 1/2	22	31	35	49 3/8	40 3/8	51 1/8	24 13/16	18	8 1/2	54 1/2	31	38
100	48 1/2	39 1/2	44	24	34 1/2	38 1/2	53 7/8	44 1/8	54 5/8	26 13/16	20	8 1/2	58	34 1/2	42
110	53 1/2	43 1/2	48 1/2	26	38	42	58 1/8	47 1/2	60 3/4	29 13/16	22	8 1/2	61 1/2	38	46
120	58 1/2	47 1/2	53	28	41 1/2	45 1/2	63 3/16	50 7/8	65 3/4	32 1/16	24	10 1/2	65	41 1/2	50
130	63 1/2	51 1/2	57 1/2	30 1/2	45	49	67 5/8	54 1/4	70 5/8	34 7/16	26	10 1/2	68	44 1/2	54
140	68 1/2	55 1/2	62	32 1/2	48 1/2	52 1/2	72 1/4	57 5/8	73 1/8	35 13/16	28	10 1/2	70 1/2	47	58
150	73 1/2	59 1/2	66 1/2	34 1/2	52	56	76 13/16	61	77 5/16	37 13/16	30	10 1/2	73	49 1/2	62
160	78 1/2	63 1/2	71	36 1/2	55 1/2	59 1/2	81 5/16	64 3/8	80 5/16	39 5/16	32	10 1/2	76	52 1/2	66
170	83 1/2	67 1/2	75 1/2	38 1/2	59	63	86 3/16	68 1/8	83 5/16	40 13/16	34	10 1/2	79	55 1/2	70
180	88 1/2	71 1/2	80	40 1/2	62 1/2	66 1/2	90 13/16	71 1/2	86 3/16	42 3/16	36	10 1/2	81 1/2	58	74
190	93 1/2	75 1/2	84 1/2	42 1/2	66	70	95 7/16	75 5/16	90 1/8	44 5/16	38	10 1/2	84	60 1/2	78
200	98 1/2	79 1/2	89	45 1/2	69 1/2	73 1/2	99 3/8	78 1/4	93 1/8	45 13/16	40	10 1/2	87	63 1/2	82
220	108 1/2	87 1/2	98	49 1/2	76 1/2	80 1/2	109	85	100 1/8	48 13/16	44	12 3/8	92 1/2	69	90
240	118 1/2	95 1/2	107	53 1/2	83 1/2	87 1/2	118 1/4	91 3/4	108 5/8	53 1/8	48	12 1/2	98	74 1/2	98
260	128 1/2	103 1/2	116	57 1/2	90 1/2	94 1/2	127 1/4	98 1/2	113 7/8	55 7/8	52	12 1/2	103 1/2	80 1/2	106
280	138 1/2	111 1/2	125	61 1/2	97 1/2	101 1/2	136 3/4	105 1/4			56	14 1/2	109	85 1/2	114
300	148 1/2	119 1/2	134	65 1/2	104 1/2	108 1/2	146	112			60	14 1/2	114 1/2	91	122
350	158 1/2	127 1/2	143	69 1/2	111 1/2	115 1/2	155 1/4	118 13/16			64	14 1/2	120	96 1/2	130

Note.—All Dimensions are in inches. Dimensions of inlet and outlet are outside measurements.

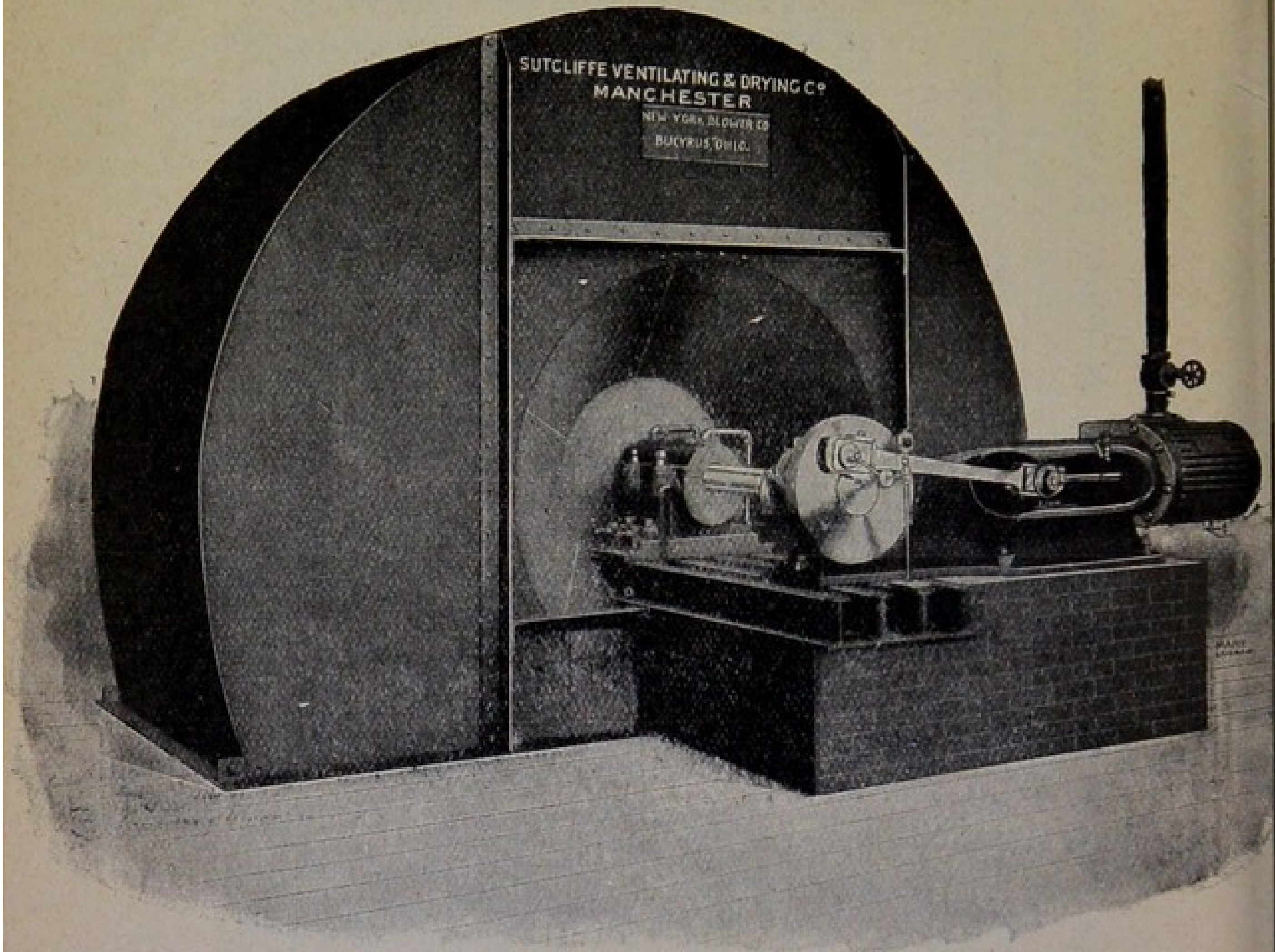
Sizes, Speed Capacities and Horse Power of "Sutcliffe" Steel Plate Exhausters.

Size.	Wheel Dia. Ft.	Wheel Wd. P In.	Width inside Housing	Outlet H	Outlet W	Round Pipe to fit Outlet	No. of Fives in Pipe.	·43in. ¼oz. R.P.M.	·43in. ¼oz. Cu.Ft.	·43in. ¼oz. H.P.	·859 in. ½ oz. R.P.M.	·859 in. ½ oz. Cu.Ft.	·859 in. ½ oz. H.P.	1·075 in. ⅝ oz. R.P.M.	1·075 in. ⅝ oz. Cu.Ft.	1·075 in. ⅝ oz. H.P.
40	2	8	12	12½	12½	14	13	415	1148	·22	580	1624	·5	650	1815	·61
45	2¼	9¾	13½	14	14	16	18	365	1575	·33	515	2226	·7	580	2848	·9
50	2½	10½	15	15½	15½	18	24	330	1885	·4	465	2663	·92	520	2979	1·1
55	2¾	11¾	16½	17	17	20	32	290	2321	·5	425	3280	1·08	475	3666	1·38
60	3	16	20	20½	20½	22	41	275	3446	·75	390	3869	1·56	435	5445	2
70	3½	18¾	23½	24	24	26	62	235	4712	1·03	335	6660	2·15	380	7444	2·75
80	4	21½	27	27½	27½	30	88	205	6174	1·4	290	8727	2·9	325	9756	3·7
90	4½	24¼	30½	31	31	34	120	185	7835	1·7	260	11072	3·6	290	12379	4·6
100	5	27	34	34½	34½	38	158	165	9693	2·2	235	13700	4·5	260	15315	5·7
110	5½	29¾	37½	38	38	42	205	150	11747	2·6	215	16604	5·5	235	18994	6·9
120	6	32½	41	41½	41½	46	255	140	14001	3·1	195	19690	6·6	215	22121	8·3
130	6½	35	44	45	44½	50	313	130	16334	3·8	180	23086	8	200	25808	10·1
140	7	37	46½	48½	47	54	384	120	18596	4·3	165	26283	9	190	29381	11
150	7½	38¾	49	52	49½	57	435	110	20848	4·4	155	29466	9·1	175	32939	11·4
160	8	41¼	52	55½	52½	60	499	105	23693	5	145	33488	11·2	165	37435	14·5
170	8½	43	55	59	55½	64	581	95	26242	5·8	135	37090	13	155	41463	16·8
180	9	45	57½	62½	58	68	676	90	29079	6·9	130	41090	14·8	145	46050	18·1
190	9½	47½	60	66	60½	72	780	80	32409	7·2	125	45790	15·1	135	51190	20
200	10	49¾	63	69½	63½	76	893	80	35541	7·9	120	50230	17	130	56154	21·4
220	11	53¾	68½	76½	69	80	1002	75	42451	9	106	60000	19·2	120	67071	24·8
240	12	58	74	83½	74½	88	1288	70	49972	10·8	100	70790	22·6	110	78955	28·8
260	13	62	79½	90½	80	96	1600	65	57871	13	90	81800	26·8	100	91434	34
280	14	66	85	97½	85½	100	1772	60	66341	15	85	93770	30·6	95	104820	39
300	15	70	90½	104½	91	106	2050	55	75390	16·9	75	106550	35	85	119390	44·5
320	16	74	96	111½	96½	112	2352	50	85020	19·2	70	120150	40	80	134310	51

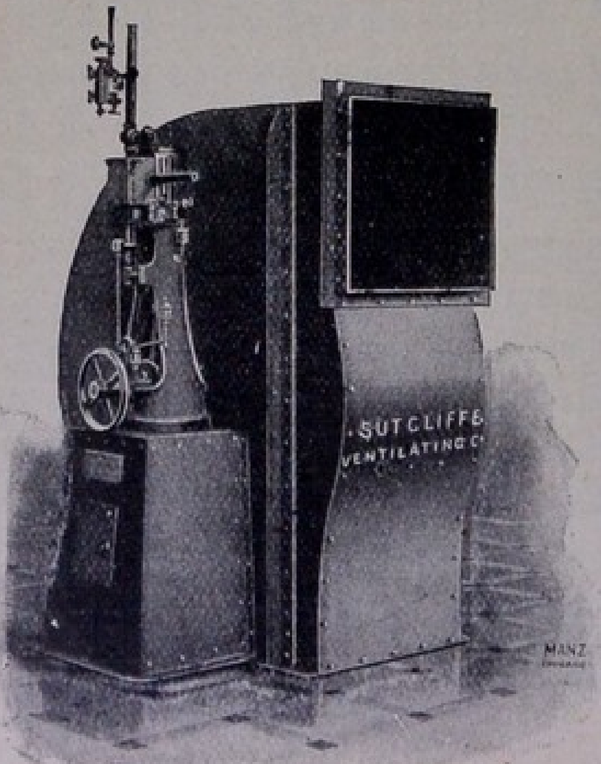
Size.	1·29 in. ¾ oz. R.P.M.	1·29 in. ¾ oz. Cu.Ft.	1·29 in. ¾ oz. H.P.	1·721 in. 1 oz. R.P.M.	1·721 in. 1 oz. Cu.Ft.	1·721 in. 1 oz. H.P.	2·15 in. 1¼ oz. R.P.M.	2·15 in. 1¼ oz. Cu.Ft.	2·15 in. 1¼ oz. H.P.	2·58 in. 1½ oz. R.P.M.	2·58 in. 1½ oz. Cu.Ft.	2·58 in. 1½ oz. H.P.	3·44 in. 2 oz. R.P.M.	3·44 in. 2 oz. Cu.Ft.	3·44 in. 2 oz. H.P.	5·15 in. 3 oz. R.P.M.	5·15 in. 3 oz. Cu.Ft.	5·15 in. 3 oz. H.P.
40	710	1988	·75	820	2294	1·06	920	2563	1·4	1005	2815	1·76	1160	3237	2·65	1420	3957	4·8
45	630	2726	1·1	730	3146	1·55	820	3515	1·46	895	3860	2·45	1030	4439	3·62	1281	5926	6·6
50	510	3261	1·34	660	3764	1·84	735	4205	2·4	805	4619	2·98	930	5311	4·34	1135	6492	7·95
55	520	4015	1·7	600	4634	2·35	670	5178	3·03	730	5687	3·72	845	6539	5·32	1030	7998	9·8
60	475	5964	2·44	550	6883	3·36	610	7691	4·3	670	8445	5·35	775	9173	7·82	945	11871	14·5
70	405	8153	3·34	470	9411	4·6	525	10516	5·9	575	11550	5·9	660	13280	10·8	810	16230	19·6
80	335	10690	4·5	415	12333	6·3	460	13781	8·2	505	16133	10·3	580	17703	14·8	710	21269	26·3
90	315	13560	5·6	365	15648	7·7	410	17486	9·8	450	19203	12·3	515	22820	18	630	26389	33·4
100	285	16810	6·9	330	19359	9·5	365	21632	12·2	400	23756	15·1	465	27318	22	560	33388	43
110	260	20330	8·4	300	23470	11·5	335	26221	14·4	365	28793	18·2	420	33111	26·7	515	40468	49·6
120	240	24230	10	275	27962	13·7	305	31246	17·6	335	34314	21·8	385	39459	32	470	48116	61
130	220	28270	12·3	255	32624	16·6	280	36454	21	310	40033	25·8	355	46036	37·2	435	56265	70·6
140	205	32180	14	235	37140	17·9	260	41502	23	285	45577	29·2	330	52411	42·5	405	64056	80
150	190	36080	15·2	220	41640	19	245	46528	25	265	51095	32	310	58486	48	380	71813	88
160	180	41000	17·4	205	47320	24	230	52879	30·8	250	58070	37·8	290	66468	55	355	81615	101
170	170	45410	20·8	190	52410	28·2	215	58567	35·8	235	64314	44	275	73630	62	335	90896	111
180	160	50320	22·1	185	58080	30	205	64899	37·9	230	71270	46·9	255	81612	67	315	100170	124
190	150	56060	25	180	64710	33·8	195	72708	43	210	79407	53	245	90893	75·5	300	111610	137
200	145	61500	26·3	165	70980	36·2	185	79720	46	200	87106	57	230	99705	82	285	122430	151
220	130	73460	30·3	150	84790	41·1	165	94742	53	185	104040	66	210	119900	97	260	146280	181
240	120	86470	35	140	99810	48·4	155	111530	63	170	122480	79	195	140190	116	235	172140	223
260	110	100140	41·6	135	115580	57	140	129120	73·2	155	141830	91	180	162350	133	220	199340	248
280	100	114800	47·8	115	126550	65·3	130	148050	84	145	162590	104	170	190450	153	200	228520	280
300	95	130450	54·2	110	150560	74·7	120	168250	95·5	135	187700	118	160	211490	173	190	259690	318
320	90	147100	61·7	105	167100	84	115	189720	107·5	130	208350	134	145	238480	198	175	292330	360

SUTCLIFFE INDUCED DRAUGHT FAN.

FANS DIRECT COUPLED TO STEAM ENGINES.



Three-quarter Housing Type, with Water-cooling Bearing and Special Grillage for Over-hung Fan Wheel and Direct-coupled Engine.
All our Fans are fitted with Ring-oiling Ball and Socket Bearings.

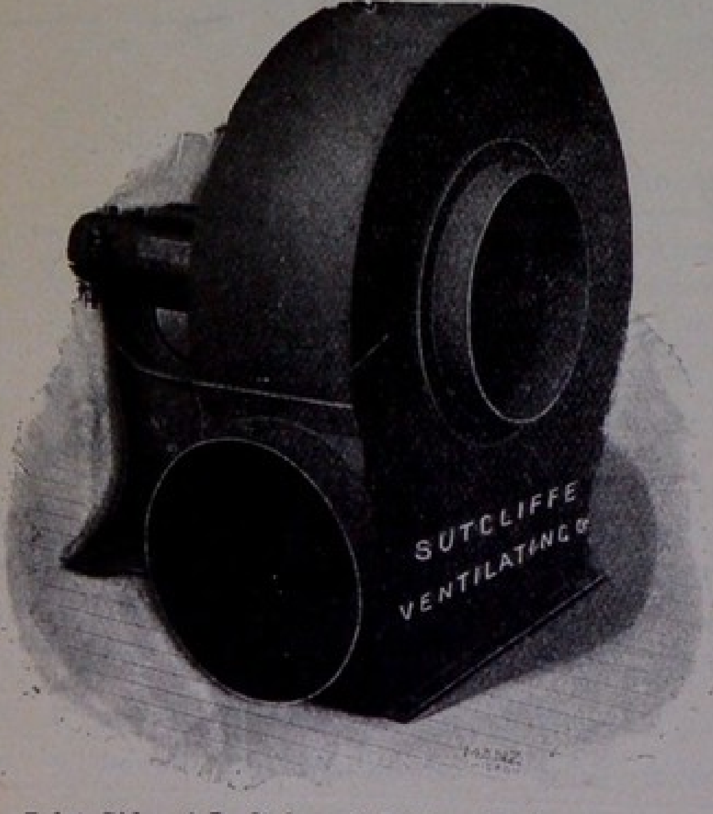


In application and usage our Steam-driven Fans are identical with our Pulley Fans. The direct-connected Engine makes them independent, and variation in speed is easily attainable. Fans can be run with Horizontal or Vertical Engines, or with Electric Motors as preferred.

Sutcliffe P.M. Exhausters.

For circulating large volumes of Air for Induced Draught, Heating and Ventilating, Drying, and any purpose where a moderate pressure only is required, users cannot do better than order one of the Fans illustrated on the preceding pages. We make them in all the sizes shown, and they will move from 1,200 to 300,000 cubic feet of air per minute at pressures from ¼oz. to 3oz.

The Removal of Shavings and Sawdust from Wood-working Shops, Dust and Trimmings from Tanneries, Dust from Emery and Polishing Wheels, the Conveying of Cotton, Wool, &c., demands a higher pressure, and for this purpose we recommend our Steel Plate P.M. Exhauster as illustrated below. This Exhauster, with the exception of the cast-iron base plate, inlet and outlet rings, and the heavy pedestal, is made throughout of steel plate reinforced by substantial wrought-iron frame. This construction enables the Exhauster to sustain the sudden strain caused by blocks, &c., passing through it, and which would quickly wreck an ordinary cast-iron Exhauster. It is made in the sizes given on the opposite page, and will give any water gauge up to 8oz.



Inlet Side of **Left-hand** Bottom Horizontal Discharge Exhauster.

These Steel Plate Exhausters are regularly built to discharge horizontally or vertically, at the top or bottom, and are carried in stock with the inlet on either side. Customers should be particular to specify the *Discharge* and *Hand* of Exhauster they desire.

Table of Dimensions of
Bottom Horizontal Discharge Steel Plate P.M. Exhausters.

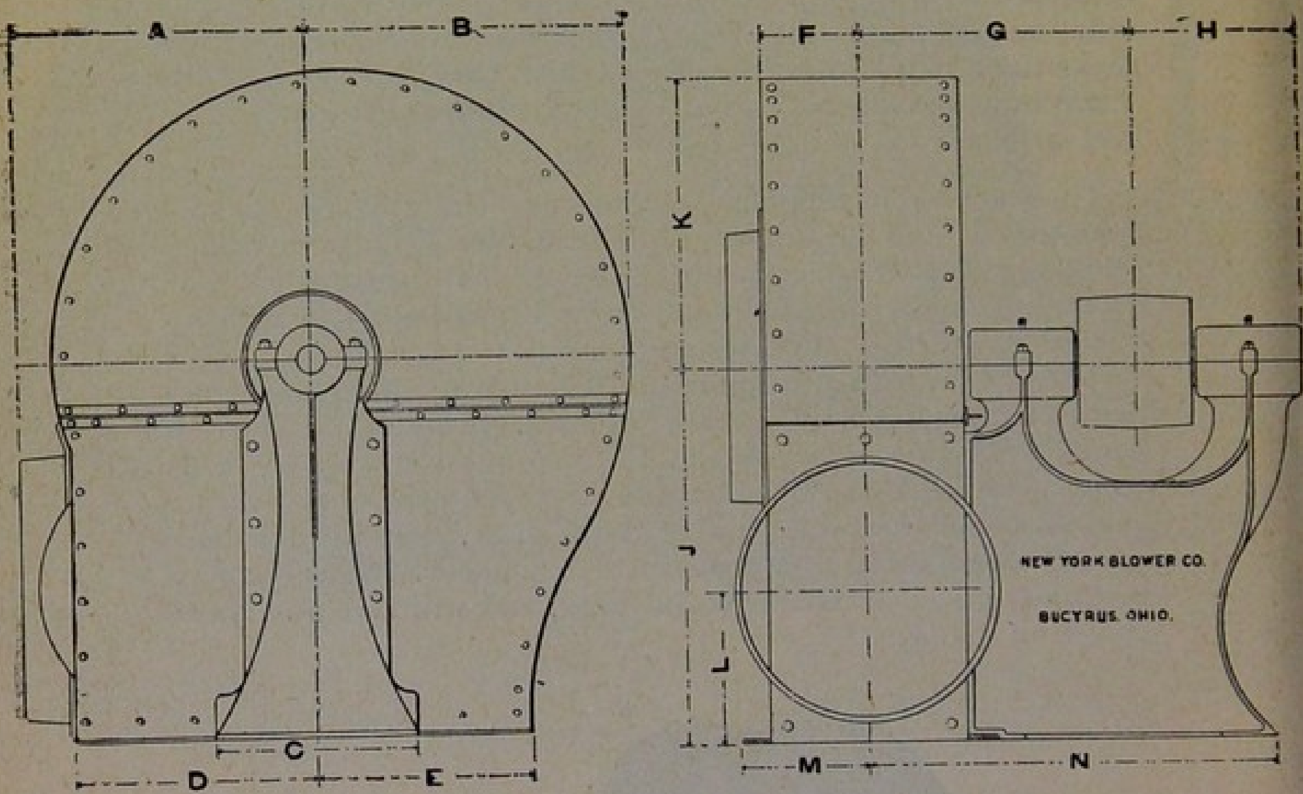


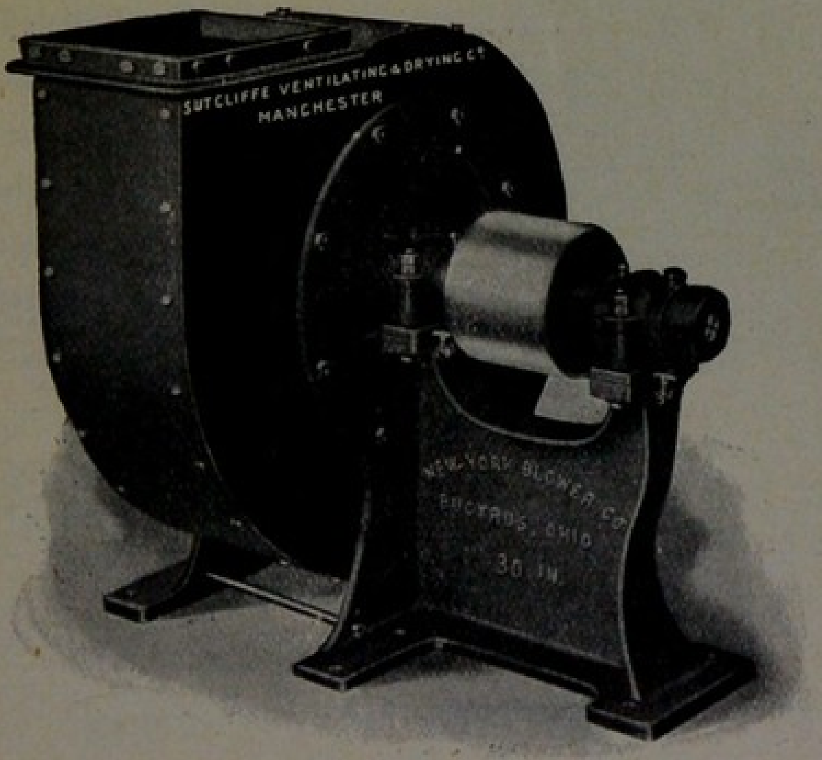
Table of Principal Dimensions,

Size	A	B	C	D	E	F	G	H	J	K	L	M	N	Diameter of Pipe Fitting Inlet.	Size of Pipe Fitting Outlet.	PULLEY D	PULLEY F
25	11 3/4	12 1/8	7 1/2	9 1/4	7 3/4	3 3/4	13 1/4	9 5/8	14	11	6	5 1/2	21 1/4	10 Diam.	10 Diam.	5	5
30	13 3/8	14 5/8	9	10 3/4	9 1/4	4 1/2	14 1/8	9 3/4	17	13	7	6 1/4	22 1/2	12 ,,	12 ,,	6	5 1/2
35	15 5/8	16 1/2	10 1/2	12 3/8	11 5/8	5 1/4	16 1/2	11	20	15	8 1/4	7	25 1/2	14 ,,	14 ,,	7	6
40	18 1/4	19 1/4	12	14 3/4	12 1/4	6	17 1/2	11 1/4	22 1/2	17 1/2	9 1/4	7 3/4	26 3/4	16 ,,	16 ,,	8	6 1/2
45	18 11/16	22	13 1/2	16 15/16	18 1/16	6 3/4	19 7/8	12 3/4	25	20	10 3/8	8 3/4	30 5/8	18 ,,	18 ,,	9	7 1/2
50	22 11/16	24 1/4	15	8 7/16	15 9/16	7 1/2	21 1/8	13 1/4	28	22	11 1/2	9 1/2	31 1/4	20 ,,	20 ,,	10	8 1/2
55	24 1/2	26 1/2	16 1/2	20	17	8 1/4	23 1/4	14 3/4	31	24	12 1/2	10 1/4	35 3/4	22 ,,	22 ,,	11	9 1/2
60	26 3/8	28 3/4	18	21 3/4	19 1/4	9	24 3/4	15 1/4	34	26	14	11	37 1/2	24 ,,	24 ,,	12	10 1/2
70	28 7/8	33 1/4	21	26	22	10 1/2	28 5/8	17 1/2	40	30	16 1/2	12 1/2	41 1/2	28 ,,	29 3/8 × 21 3/8	14	12 1/2
80	33 7/8	38 5/8	24	31	23	12	31	18 1/2	45	35	18 3/4	14 1/4	46 3/4	32 ,,	33 7/8 × 24 3/8	16	14 1/2

Note.—All dimensions are in inches. Inlet and Outlet dimensions are outside measurements.

SUTCLIFFE

Reversible Steel Plate P.M. Fan.



The Sutcliffe Reversible Steel Plate P.M. Fan is built on the same lines as our Standard P.M. Exhauster, except that the Fan casing may be turned so that the outlet points in any direction.

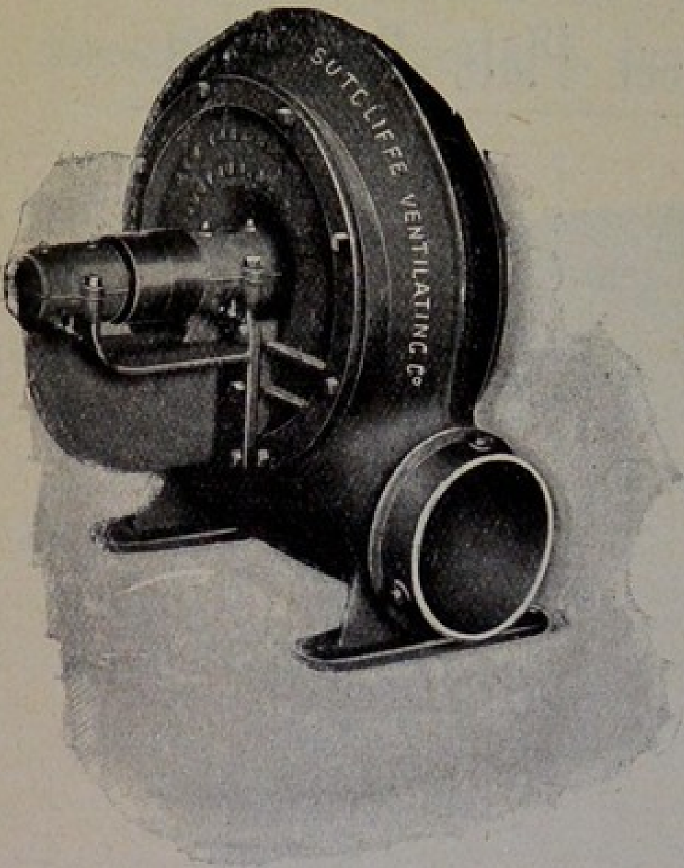
The wheel is of special design and construction, the back of the wheel being coned and the blades built up without rivets. There is no opportunity for stringy materials to lodge in the Fan, and it is specially suitable for handling long fibres of all kinds.

The casing on the pulley side is concave, allowing the Journal to come well inside the casing and reducing the overhang by 50 %. The bearings are double-ring oiling and universal in their adjustment.

The standard sizes range from 30in. to 60in. at intervals of 5in., but larger Fans are furnished for special conveying plants, &c.

PRICES ON APPLICATION.

PEERLESS FANS.



Peerless Fan, Bottom Horizontal Discharge Type.

The Peerless Fans are specially designed to move air at high pressure, and are suitable for Cupola, Smiths' Fires, and similar work where a high pressure but only a moderate volume of air is required,

This Fan is also arianged with Double Inlet for Blowing Smiths' Fires, &c.

Table of Speeds, Capacities, and Horse Power of "Peerless" Fans.

Size		¼ oz.	½ oz.	1 oz.	1½ oz.	2 oz.	2½ oz.	3 oz.	4 oz.	5 oz.	6 oz.	8 oz.
4	R.P.M.	1319	1864	2633	3222	3716	4151	4542	5234	5839	6383	7340
	Cu. Ft.	104	127	179	219	253	283	309	365	397	435	500
	H.P.	·02	·04	·09	·19	·25	·33	·41	·63	·91	1·81	2 75
5	R P.M.	1063	1502	2122	2535	2995	3345	3661	4218	4776	5144	5977
	Cu. Ft.	138	195	276	338	390	435	476	549	612	669	769
	H.P.	·03	·06	·13	·28	·41	·53	·75	1·16	1·50	2·06	3·34
6	R.P.M.	898	1268	1792	2193	2529	2825	3091	3502	3974	4344	4996
	Cu. Ft.	198	279	394	483	557	622	680	784	874	956	1099
	H.P.	·04	·09	·20	·44	·63	·88	1·13	1·69	2·34	3·06	4·69
7	R.P.M.	734	1094	1545	1891	2181	2436	2665	3003	3429	3746	4308
	Cu. Ft.	267	378	533	652	752	840	919	1059	1182	1282	1486
	H.P.	·0.5	·13	·29	·56	·81	1·13	1 50	2 25	3·13	4·75	6·38
8	R.P.M.	682	964	1362	1666	1922	2146	2349	2707	3020	3301	3736
	Cu. Ft.	347	490	693	879	978	1092	1195	1378	1536	1680	1931
	H.P.	·08	·16	·39	·72	1·06	1·54	1·94	2·94	3·94	5·38	8·38
9	R.P.M.	608	860	1214	1485	1714	1914	2015	2414	2693	2344	3385
	Cu. Ft.	437	618	873	1058	1231	1375	1505	1733	1934	2115	2432
	H.P.	·09	·21	·47	·94	1·57	1·84	2·88	3·75	5·95	6·81	10·28
10	R.P.M.	549	776	1096	1341	1547	1688	1890	2.78	2420	2656	3055
	Cu. Ft.	529	771	1076	1316	1518	1695	1855	2137	2384	2607	2998
	H.P.	·11	·34	·59	1·13	1·72	2·25	2·92	4·57	6·38	8·50	15·21

The Sutcliffe Fan

As illustrated on page 54, is the most SIMPLE, powerful, and effective means of REMOVING STEAM, COOLING heated Work-rooms, REMOVING NOXIOUS FUMES AND DUST, and for the RAPID DRYING of all classes of goods. It is easy to fix, noiseless, needs no attention, and will run in any position.

EFFICIENCY

We guarantee the SUTCLIFFE Fan to move more Air than any other for the same power, and we are willing to send a Fan (Carriage paid) on approval for one month. If not satisfactory, it may be returned carriage forward.

We have applied the Sutcliffe Fan to the following purposes with highly successful results :—

VENTILATING AND COOLING

WOOL COMBING ROOMS, SPINNING and WEAVING SHEDS, CLOTHING FACTORIES, DYNAMO and ENGINE ROOMS, IRONING ROOMS in Laundries, &c.

REMOVING STEAM AND MOISTURE

From DYE HOUSES, SIZING MACHINES, WOOL WASHING MACHINES, FINISHING ROOMS, JAM WORKS, STEAM LAUNDRIES, PAPER MILLS, SOAP WORKS, BREWERIES, &c.

NOXIOUS FUMES

From GASSING ROOMS in COTTON and SILK FACTORIES, CHEMICAL WORKS, BLEACH WORKS, &c.

REMOVING AND COLLECTING DUST

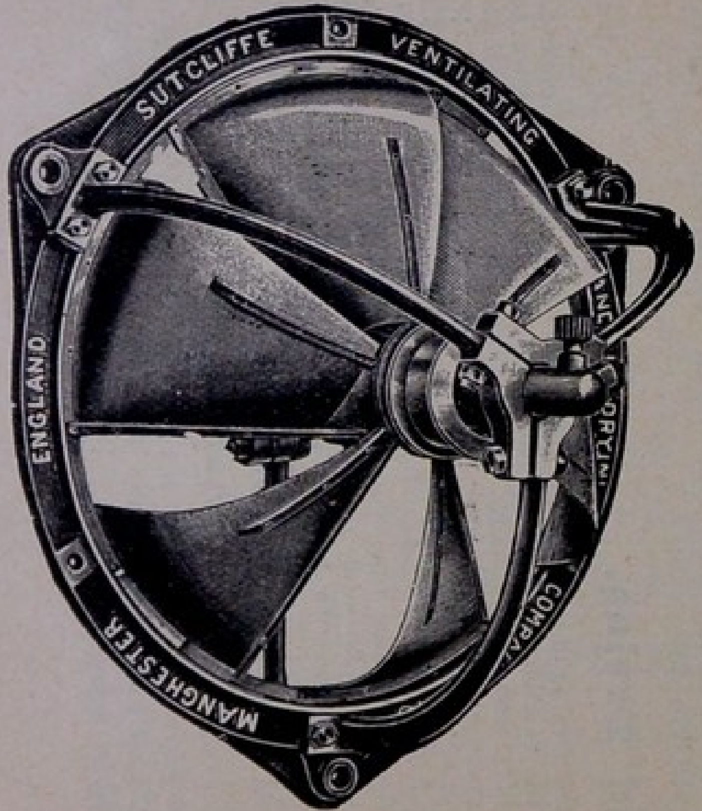
From WOOL SORTING BOARDS, CARDING ROOMS, and WILLEYING MACHINES, CARPET BEATING MACHINES, CHINA and EARTHENWARE FACTORIES, GRINDING SHOPS, &c.

Rapid Drying.

In the Drying of many Materials, we can, by a judicious application of the Sutcliffe Fan, cut the time occupied in Drying down to one half, and this is done without injury or deterioration to the material dried. We have successful installations Drying WOOL, YARN, CLOTHES in LAUNDRIES, LEATHER, GLUE, SOAP, COLOURS, CHEMICALS, TIMBER, BRICKS, &c. We issue and will send on request circulars showing the general method of application of the SUTCLIFFE FAN in connection with our STEAM AIR WARMERS, which are designed for the purpose of Warming large volumes of fresh air, by either EXHAUST or LIVE Steam.

ADVICE FREE.

Write for Circulars, or for a call from one of our Engineers, who will show you how to apply our Fans for any of the above purposes with assured success.



PRICE LIST OF SUTCLIFFE FANS.

With Sizes, Capacities, &c.

PRICE £ s. d.	Diameter of Fan in Inches.	Revolutions per minute.	Diameter of Pulley in Inches.	Width of Belt in Inches.	Cubic Feet of Air moved per minute.	Actual Horse Power required.	Area of Fan in Feet
2 10 0	14	900 to 1,600	2¼	1	1,100 to 1,800	⅛ to ¼	1 . 0
4 0 0	18	700 ,, 1,300	3	1½	2,200 ,, 3,600	¼ ,, ½	1 . 7
6 0 0	24	500 ,, 900	4	2	4,500 ,, 8,000	¼ ,, ¾	3 . 1
8 0 0	30	450 ,, 800	5	2½	5,800 ,, 10,500	⅜ ,, 1⅛	4 . 9
10 0 0	36	400 ,, 700	6	2½	9,000 ,, 16,000	½ ,, 1¼	7 . 0
13 0 0	42	350 ,, 600	7	3	14,000 ,, 23,000	¾ ,, 1½	9 . 5
16 0 0	48	300 ,, 550	8	3	16,000 ,, 34,000	1 ,, 2	12 . 5
26 0 0	60	250 ,, 420	10	4	23,000 ,, 50,000	1½ ,, 3	19 . 6
40 0 0	72	200 ,, 350	14	6	30,000 ,, 65,000	2 ,, 5	28 · 2

Note.—All these Fans can be combined with our Electric Motor, and are very convenient to fix wherever electric current is available.

Conditions.—These prices include packing and delivery at any Railway Station in the United Kingdom or f.o.b. at any British Port. We do not charge for Crates or Cases, and do not allow for them if returned.

Further particulars &c., from

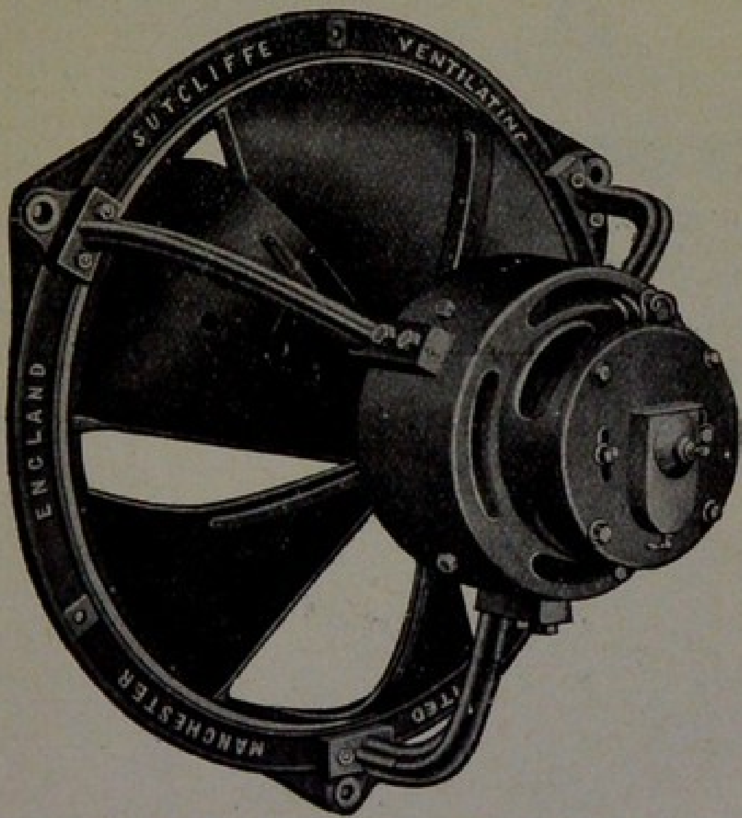
SUTCLIFFE VENTILATING AND DRYING Co. Ltd.,

Cathedral Corner,
Fennel Street, **MANCHESTER.**

Telegrams:
"Ventilabro, Manchester."
Telephone: **No. 3920.**

SUTCLIFFE ELECTRIC FAN.

The best and quietest Electric Fan on the market, and therefore



the most suitable for Ventilating Offices, Smoke Rooms, Restaurants, &c.

These combined Fans and Motors are made in all sizes from 14in. to 72in. diameter, and for any continuous current voltage up to 440. They can be fixed in any window, ceiling, or suitable opening, and are then ready for the electric wires connecting to the terminals on motor.

SPECIFICATION OF SUTCLIFFE ELECTRIC FAN MOTORS.

GENERAL. These Motors are of the circular type, the yokes being constructed of steel into which wrought iron pole pieces containing field magnet coils are securely fixed. All sizes up to 36in. diameter are of the bi-polar type, larger sizes having four poles.

ARMATURE. The armature is built up of highest permeability charcoal sheet-iron stampings, slotted to contain armature coils.

COMMUTATOR. The commutator is built from hard drawn 100% conductivity bare copper strip, held together by strongly constructed driving bushes, the whole thoroughly insulated with prepared mica.

BRUSH GEAR. The brush gear in all cases consists of carbon brushes of ample proportions fitted to special carbon brush-holders of our own design.

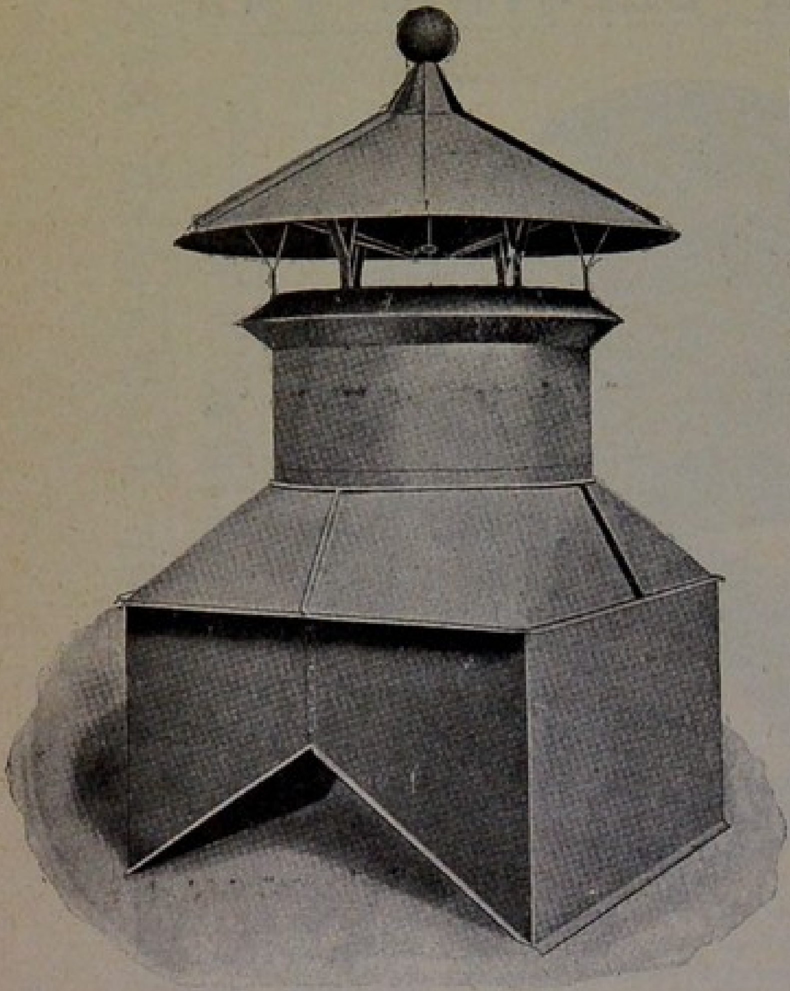
BEARINGS. All Fans are constructed with two bearings only. Sizes above 24in. diameter are supplied with automatic ring oilers; smaller sizes having Stauffer lubricators. Whenever it is desired to fix the Fan with vertical spindle Stauffer lubricators are fitted.

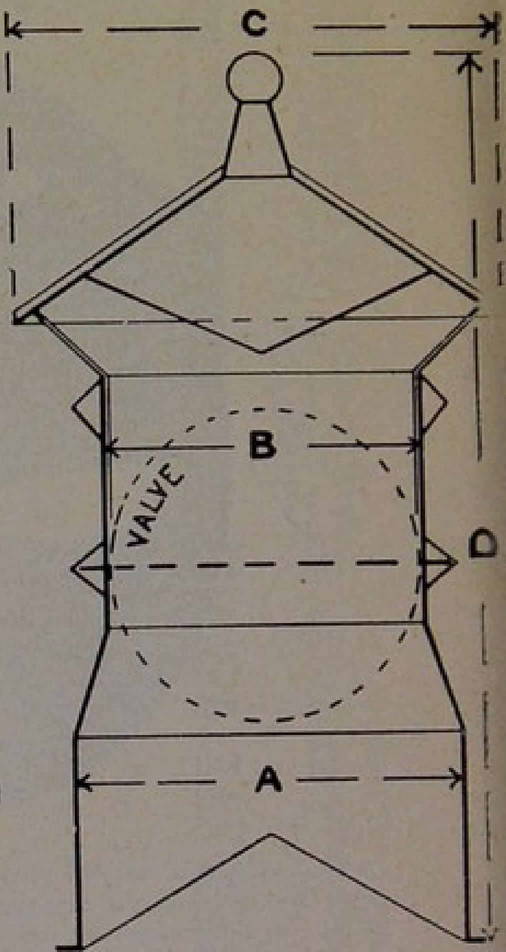
TESTING. Before despatch all Fans are carefully balanced and tested for insulation, and also for running and general efficiency.

CONNECTIONS. Unless otherwise specified all Motors are series-wound, the two leads projecting through two insulated holes provided in upper side of motor shell.

SWITCHES. Starting switches can be supplied, single or double automatic type, for starting and regulating the Motor as may be desired.

Peerless Automatic Ventilator.





STANDARD SIZES.

Size No.	A	B	C	D
	Inches	Inches	Inches	Inches
18	18	14	21	38
24	24	18	28	50
30	30	23	35	64
36	36	27	42	78

Prices with or without Valve on application.

The Peerless Ventilator is a simple form of Automatic Outlet Ventilator. It can be fixed over a Fan or used alone. When air is being blown into a building by Fans no more suitable outlet than the "Peerless" can be used. It is built up in strong galvanised iron and is made with valve for closing at night, or it can be furnished without valve.

SUTCLIFFE VENTILATING & DRYING Co. Ltd.,

Specialists in
Warming, Ventilating,
Drying, and
Induced Draught,

Cathedral Corner,
Fennel Street,

MANCHESTER.

T.A. "Ventilabro." T.N. 3920.