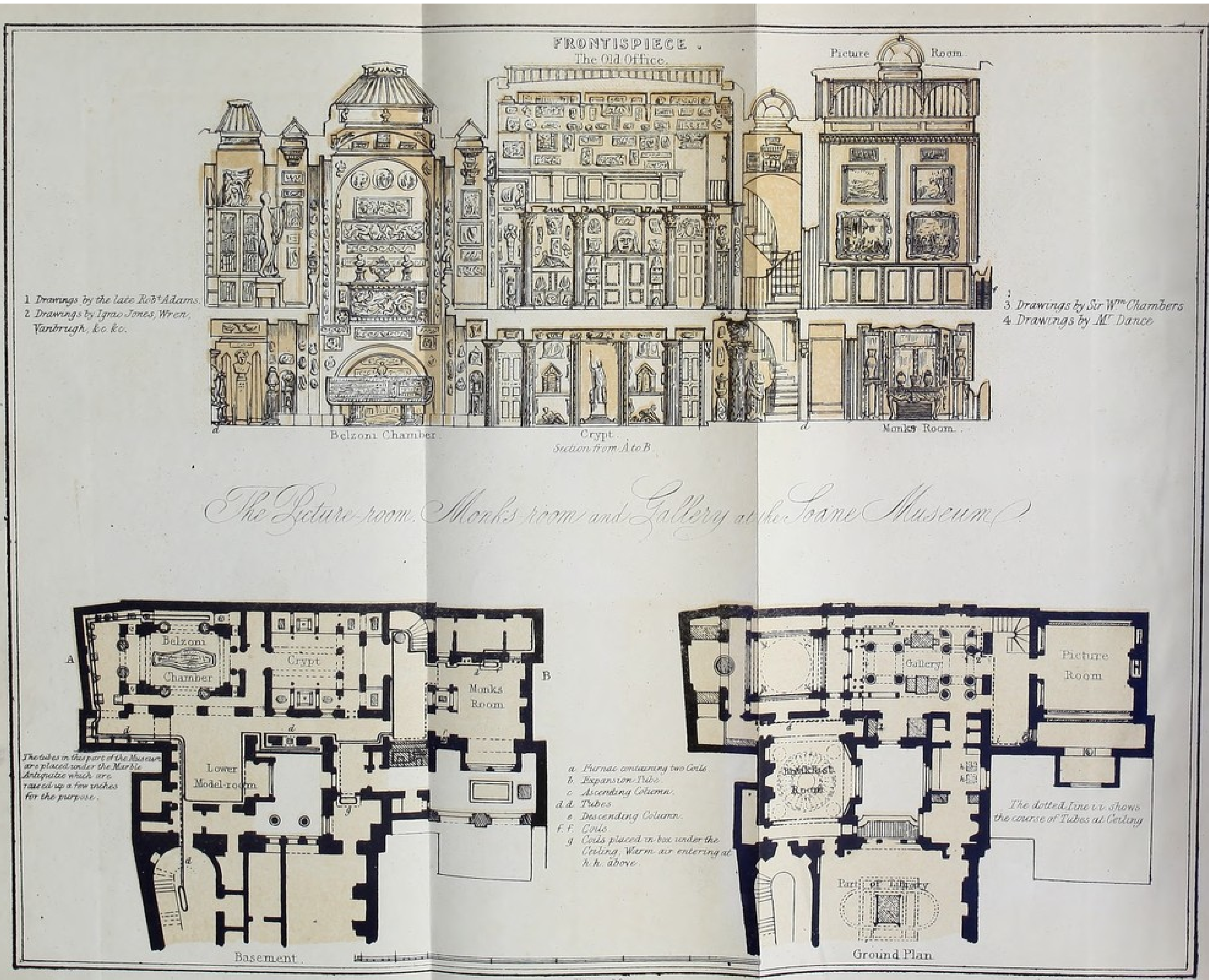


Plate 10.

Day & Son Lithrs to The Queen

With G. R. Ritchie 16 Hill S Edin Compts

A POPULAR TREATISE

ON THE

WARMING & VENTILATION

OF

BUILDINGS:

SHOWING THE

ADVANTAGE OF THE IMPROVED SYSTEM

OF

Heated Water Circulation.

BY

CHARLES JAMES RICHARDSON,

FELLOW OF THE ROYAL INSTITUTE OF BRITISH ARCHITECTS,
CONSULTING ENGINEER FOR WARMING AND VENTILATING BUILDINGS.

ILLUSTRATED WITH SEVENTEEN PLATES.

Third Edition.

LONDON:
JOHN WEALE, ARCHITECTURAL LIBRARY,
59, HIGH HOLBORN.
1856.

ADVERTISEMENT.

This small volume having run through two editions, the Author was induced to publish a third; first, from the considerable success which the system upon which he treated had met with, and secondly, to introduce Mr. Perkins's ingenious contrivance, by which the older system of heated-water circulation is combined or connected with his own. To describe this an additional chapter, with two plates, has been added. The rest of the volume has been carefully examined and corrected, and some few descriptions of apparatus, such as Bernhardt's and others, now no longer in use, omitted.

The Author has not entered into the details of expenditure, as they depend so much, in every instance, upon local circumstances, that he considered the engineer himself the most proper person to supply them. The Apparatus may always be seen in use at the Manufactory, No. 6, Francis Street, Regent Square, where full information on every point can doubtless be afforded.

34, *Kensington Square, Kensington.*

PRINTED BY
COX (BROS.) AND WYMAN, GREAT QUEEN STREET,
LINCOLN'S-INN FIELDS.

PREFACE.

It may seem on a cursory view an easy task to warm a room, or the several parts of a house, but to do so effectually and with due regard to economy, and still more to the health of the inhabitants, is a more difficult problem than our readers may at first sight suppose. There is more in the science of Warming and Ventilation than is generally considered. It is therefore much to be regretted, that persons desirous of realizing the advantages to be derived from efficient and suitable apparatus, do not, prior to incurring the outlay its purchase involves, more commonly avail themselves of the architect's knowledge and experience, rather than trust the selection and adaptation of the apparatus to tradesmen who may be altogether ignorant of the first principles of the science they profess to exercise. To the professional man the vaunted expensive patented apparatus is often the cause of considerable trouble ; he may not have been consulted on the subject, or his opinion asked, until a failure with it takes place ; and then, probably after making several abortive attempts to render it successful, he is obliged to advise its removal and the substitution of another on a better principle : often an apparatus only applicable to one particular situation is introduced in another where it is not suitable, or where it can render little service, and this without intent to deceive, the projector thinking it capable of every kind of adaptation. Our houses are cut about without any regard to the health of their occupiers; and they are frequently burnt down by fires originating in flues or from stoves, which a moment's inspection by a professional man, in the first instance, would have prevented being dangerously placed.

The Author had early opportunities of testing the capabilities of the different systems of Warming, applied to a building which presented considerable difficulties to their introduction;—that which eventually succeeded, and which has now been employed there for twenty years, is the system chosen for more especial illustration in the present volume.

For facilitating reference, the subject has been subdivided as follows:—the first portion of the work is more particularly devoted to an explanation of this system, which is one for the circulation of hot water through inch iron tubes, as applied to merely the warming of buildings; in the second are pointed out the means for its advantageous combination with the older plan of open or large pipes; and finally is considered the subject of Warming and Ventilation combined. The object of the Writer has been to give some proved general principles of the science, and some practical aids to carrying them out. The approbation expressed for the two former editions has led him to publish a third, which he trusts will be found more complete and useful than the foregoing.

34, *Kensington Square, Kensington.*

LIST OF PLATES.

ON

WARMING AND VENTILATION.

CHAPTER I.

ON THE WARMING AND VENTILATION OF BUILDINGS.

THE capricious nature of the climate of this country, and the deleterious influence of a cold and damp atmosphere during a greater portion of the year, render the capability of obtaining a pure and equable warmth in our dwelling-houses most desirable.

In public and private buildings (more particularly the latter) the best means of insuring this essential requisite should be a primary consideration with the architect, the builder, and the inhabitant. On a subject so closely connected with the welfare of the country, the statesman and the individual are alike called upon to consider and investigate; for health is the greatest blessing we can enjoy on earth, and of course its preservation or restoration an object of the highest interest as it regards ourselves, and a paramount duty in our consideration for others.

Dr. Arnott informs us * that "Consumption is the disease which carries off a fifth or more of the persons born in Britain; owing, in part, no doubt, to the changeableness of the external climate, but much more to the faulty modes of warming and ventilating houses."

With this opinion many of our first medical men have concurred, and the assertion is most unhappily borne out by documents supplied by every bill of mortality.

If to this register of death were added the sufferers from asthma, rheumatism, and ague, we must shudder at the effects of cold and humidity, and look anxiously around for the means of escape from their inflictions.

In the more northern countries of Europe, where the intensity of cold has compelled the inhabitants to greater activity in seeking the means of relief, much has been done to obtain warmth, consistent with that economy of fuel so necessary to be observed in a country where wood alone is burned.

By the proper construction of their buildings to this end, the warmth of one fire is diffused through several rooms and passages; and although this is done on the bad principle of impregnating air with heat in close stoves, composed either of masses of brickwork, or in the well-known iron German stoves,

* Elements of Physics, page 433.

such means are more calculated to produce comfort and preserve health to the inmates of dwellings thus circumstanced, than those adopted in English houses. Here, the effect of a single fire in a sitting-room is counteracted by cold vestibules, long passages, staircases, and sleeping-apartments; and the extremes necessarily experienced cannot fail to be prejudicial to the most robust, whilst to the delicate, every breeze thus "visiting them too roughly" foretells disease and death.

The deficient attention to this important consideration for many ages past, is a singular omission in the history of a people so enlightened, industrious, and wealthy as the inhabitants of Great Britain have long been; since the mutability of their atmosphere must make its frequent changes injurious even to the highest classes, and an especial love for comfort has always formed a species of national taste and pride even in the lowest.

At a time when the utmost skill and science were displayed in the construction of our sacred edifices—when our progressively improving architecture, in due time, produced the magnificent structures of St. Stephen's and King's College Chapel, the Minster at York, and many other splendid buildings, that important improvement and finish, the art of warming, and thereby preserving alike their beauty and usefulness, was utterly neglected. The finest labours of the chisel, the delicate enrichments of the chaser, were exposed to all the effects of close damps, which the climate, joined with bad ventilation, naturally engendered.

The scientific skill in construction displayed in these buildings was not carried to the hearth of private life : the warming to be found there, continued of the rudest description, and the fire-place, even on the same rude construction of the Anglo-Normans, was not introduced to any extent until the universal decline of our national architecture.

Along with deficiency as to the means of imparting necessary warmth, ran the parallel error of neglecting, or rather preventing, ventilation, not only in private dwellings, but in the erection of towns, where attention to the general wants of a large body of people is most imperatively called for. Their buildings, composed of timber frames, filled with brick and plaister, decorated and enriched with devices, gilt or painted, were externally imposing; but their interior presented insuperable impediments to warmth and air; the rooms were low and ill-contrived, the windows small, the passages and staircases dark, narrow, and consequently unwholesome.

In the towns the streets were crooked, irregular, and incommodious; one story above another, jutting out until the inhabitants could shake hands with their opposite neighbours; of course, the free circulation of air was effectually obstructed, and the stagnant and corrupt state of that element rendered it liable to become the medium of every species of infection.

We have few left of the better class of these half-timbered houses (in which the decorative labour of our ancestors was most conspicuous) remaining in our towns and cities; but in Edinburgh, York, Chester, and Newcastle,* there are still a sufficient number of specimens to prove the truth of these remarks. In the towns of Normandy and the Netherlands, numerous buildings, and indeed whole streets, may be seen, which still exhibit the perfect counterpart of our own old Cheapside before the great fire. Troyes, the capital of Champagne, still retains its ancient buildings; and the chestnut timber houses of Caen, which were raised, or restored, during that period in the fifteenth century when it was in the hands of the English, show us precisely what our own cities once were, and, of course, the extent of our improvements.

If, from such survey, we see how much remains to be effected of which we are still capable, we shall gain a very valuable lesson.

The deficiencies of ventilation, as exhibited in the construction of their towns, renders the mode by which our forefathers communicated warmth to

* This part of Newcastle suffered most from the visitation of the Cholera in 1834.

their dwellings less surprising. It is probable that during the period when the southern part of the island was a Roman colony, that polished and luxurious people found the country very poor; in consequence of which, their own elegant but expensive means of warming apartments by suspended floors (as applied in the caldarium of their baths), was not introduced to a sufficient extent by them in Britain, to be understood or adapted by the inhabitants they left behind.

The wars and internal confusion of the country after their departure, likewise prevented such elegant models as those at Northleigh, in Oxfordshire, and Bath, from being copied. That they introducd the brazier, or fire-pan, in this country, we cannot doubt; and we find it mentioned so late as the reign of Henry the Eighth; and as it may be applied (and frequently is at the present day) greatly to the advantage of new houses, this alone may be deemed a valuable, as well as lasting, acquisition to a barbarous people.

The earliest fire-places, or recesses in the wall for cooking, similar to those seen in the conventual kitchens of Glastonbury and Durham, had no chimnies. In the former, which is octangular, and provided with three of these recesses sunk in the walls, the roof is groined with stone, and provided with an open-worked turret in the centre, for the exit of steam and smoke. This turret became afterwards a highly decorative part on the roofs of our ancient halls, and in this situation remained for a considerable period in use, being placed about the middle of the building. A large wood fire was kindled exactly underneath, and the smoke permitted to find its way through the splendid tracery and imagery which ornamented the dwellings of the great and wealthy, in the many convolutions which fail not to "leave a trace behind."

In private dwellings the same principle necessarily obtained, the fire being kindled against the wall, and louver tiles provided, to facilitate the escape of the smoke.

The nuisance occasioned by wood-smoke thus allowed to permeate through the apartments and burthen the lungs of our ancestors, led to the introduction of those beautiful proofs of their architectural taste, the stone screens, which were used as a means of shelter from the powerful currents of air created by fires of this description. The national love for the habits and customs of their predecessors long retarded those improvements in the formation of the chimney, which the general amelioration of society and its more refined habits naturally called for; but at length (about the middle of the fourteenth century), evidences of increased knowledge and comfort are to be found. Crosby Hall, built in 1466, has an angular fire-place with a chimney, and several of our ancient castles, of a still earlier date, were similarly provided. Leland, in his Itinerary, of the time of Henry VIII., observes: "One thing I much notid in the haulle of Bolton [Yorkshire], how chimnies were conveyed by tunnels made in the side of the walles, betwyxt lights [windows] in the haulle; and by this means, and by no louvers, is the smoke of the hearthe in the haulle strangely conveyed."

So slowly did this important innovation proceed, that it was not until the latter end of the sixteenth century, chimney-pieces at all resembling the present came into very general use. The national characteristic, the boasted English fireside, with its projecting chimney breasts, large enough to contain within their capacious circle the whole family of the domicile, provided with a flue so large, that we have instances on record of a culverin being employed to cleanse it, was still an important feature in every mansion.

The great quantity of fuel consumed in these huge fire-places drew the cold air from all parts of the room, and through the cracks and crevices of the building, in direct currents towards the blazing embers; these cold draughts, while they caused a rapid consumption of the fuel, obliged the inmates (in order to procure the warmth they sought) to enter the very chimney breasts. Such seats became those of consideration as well as comfort, and were not only the cosy corners to which the elders of the family pressed, but places offered to the guest most honoured. In front, the high-backed settle was the necessary protection from the cold currents of air rushing towards the embers; and if our reader's imagination can place a group of weary travellers thus seated, with a glowing fire before them and the stars of heaven peering down upon them, on a clear frosty night, he will enjoy a vivid picture of that fireside, around which the genius of Scott has scattered charms belonging alike to reality and romance.

Many specimens of this fire-place, provided with fire-dogs or cradles, for the support of wood billets, are to be found in Surrey, and other parts of the country where coal is scarce, and peat or wood is generally consumed.

Dr. Franklin, who first drew the public attention to this subject, ascertained that only one-fiftieth part of the heat generated in these fire-places, where the consumption of fuel is so great, became of actual use in the apartment: therefore, the necessity of carrying off the smoke, and diffusing the benefit of warmth by a more philosophic and economic medium, must be apparent even to the most careless or prejudiced person. Wherever coal was used (and it then had become the sole fuel of the Metropolis), bars of iron were substituted for hand-irons, a transition of evident utility, and which by degrees gave rise to various and beautiful constructions in metal; which, in their classic elegance, splendid effect, and convenient form, appear at this time to have realised everything the eye of taste can desire, in an object of such primary importance as a fire-place in a northern country must always be.

But it is not by graceful forms, nor even improved adaptations, that health can be benefited, or sensation satisfied; the truths asserted by Franklin, and the many improvements developed by Count Rumford, still leave us in a predicament requiring the further aid of practical science. The principle on which our fire-places and stoves are made, not admitting any change, a current of cold air is still necessary to carry off the smoke; and when the room does not supply it, the doors or windows, the hall or passage, or the external air, must. Register stoves may lessen the inconvenience in some degree, and they are certainly better fitted for the improved construction of modern buildings than any which preceded them; yet from the superiority of our present workmanship, the tightness with which doors and windows now close, the general use of carpets, and the careful exclusion of all external draughts, the balance is so nearly adjusted, that the most delicate obstruction may destroy it, and cause the smoke to descend and fill the room.

Thus the fire-place remains evidently inadequate to the production of an equalized temperature in a building, or even an apartment; and however sociable and companionable the sight of a glowing fire in a polished stove may be to our habits and feelings, we in fact obtain from them little actual heat.

That genial warmth, alike pleasant and salubrious, ascends the flue, and the smoke which bears it serves afterwards to vitiate the atmosphere and blacken the surfaces of our buildings.

Mr. Brande, who has made many interesting calculations on this subject, supposes, " that of every chaldron of coals consumed in our ordinary fires, about one-eighth part is lost in the character of soot, smoke, and other unconsumed matters; that in London only, upwards of one hundred thousand chaldrons of coals are thus unprofitably applied to the contamination of our atmosphere, which smoke, by improved methods of combustion or burning, might be turned to profitable account."

The principle of the common English fire-place is thus forcibly illustrated by Dr. Arnott :—

" In England, the apartments, with their open chimneys, may be compared to great air funnels, constantly pouring out their warm contents through a large opening, and constantly requiring to be replenished. They thus waste fuel exceedingly, because the chimney being large enough to allow a whole room-full of air to pass away in two or three minutes, the air of the room has to be warmed, not once in the course of the day, but very many times. The temperature in them is made to fluctuate by the slightest causes, as the opening a door, the omitting to stir the fire, &c. The heat is very unequal in different parts of the room, rendering it necessary in general for the company to sit near the fire; where they must often submit to be almost scorched on one side, while they are chilled on the other. There is generally a warm stratum of air above the level of the chimney-piece, surrounding, therefore, the upper part of the bodies of persons in the room, while a cold stratum below envelopes the sensitive feet and legs. As a very rapid current is constantly ascending in the chimney, a corresponding supply must be entering somewhere; and it can only enter by the crevices and defects in the doors, windows, floors, &c.; now there is nothing more dangerous to health than to sit near such inlets."

In construction, fire-places and chimney-flues are a fertile source of difficulty. Serious professional attention should always be given, not only to the form of the flue, but the position of the chimney-breast, with the relative situations of doors and windows. It will be generally admitted by architects, that no part of their professional practice is more annoying than the necessity of curing the defects which so constantly recur in this essential part of building; and I will add, that no claim on their attention can be more urgent than that of guarding against the evil by the adoption of other and better means of warming.

The numerous unsightly appendages in the form of cowls, turncaps, and wind-guards, which appear alike on our houses, churches, and palaces; whilst they exhibit the ingenuity of our builders and workmen, in remedying the trouble of smoky chimneys, demonstrate also the frequency of the misfortune. There are, in fact, few occurrences in domestic life productive of more vexatious, expensive, and alarming accidents, than those of smoky chimneys.

Professional and scientific men have paid due attention to the subject, and various patents have been granted for the better construction of every part of the fire-place, from the patent chimney bar to the patent flue and chimney pot: many of the latter inventions are deserving of the highest credit; some have been extensively acted upon, and proved their right to be esteemed *improvements* in the fullest sense of the word: yet, nevertheless, inconveniences still arise from the principle of the fire-place being unchangeable; and the danger attending defective construction is such, that we find from an authorised statement lately published, there are no less than from 120 to 150 fires in chimneys in London per month. Fires are, in fact, more frequent and destructive in our metropolis than any other in Europe, although our supplies of water and number of engines, managed by clever and courageous men, are more abundant than in any other city.

The known impossibility of discovering a complete remedy, by better construction, for the deficiencies enumerated in our flues and fire-places, together with the increasing demand made by our medical practitioners, for a temperature suited alike to the climate and the wants of the delicate and the aged, have, within the present century, occasioned great attention to be given to the subject, by scientific and mechanical men. At a period when knowledge and intelligence are so universally diffused (and the acquisitions obtained through them are on all sides evident), it may be presumed that, if the result of their labours is really found to be efficient, and a system of warming houses, generally or partially, can be adopted at an easy expense, no blind prejudice in favour of our old habits will prevent its adoption.

In point of fact, the plan of warming houses which we are now going to examine, and to which the foregoing remarks are prefatory, is not intended to *supersede* the use of the English fire-place, which we have long deemed the favoured spot where

> "Social mirth
> Exults, and glows before the blazing hearth,"

but rather to *superadd* to its pleasant features the valuable properties in which it is deficient.

The science of warming and ventilating our buildings (if the labours of our professional men justify the term), so as effectually to counteract the evils of our climate, increase our domestic comforts, and be provided at an easy expense, has been productive of different systems. Those now in use are the following:—

Atmospheric air, heated by hot iron plates in stoves.

Ditto, ditto, by the circulation of steam in iron pipes.

Ditto, ditto, by the circulation of hot water in iron pipes.

To enter fully into the merits and demerits of each of these several systems would fill a folio volume, and demand the exercise of learned investigation and philosophical experience, very distinct from the character of a tract like this, intended to be popular and desiring to be plain and obvious to every capacity. Every person is interested in the subject; therefore, it must be evident that abstruse reasoning and technical description should be studiously avoided, and those simple facts alone be offered to the reader, from which experience and good sense will draw the necessary deductions.

To this it may be added, that these pages are intended to illustrate that apparatus only (of the warm-water system), which an experience now of upwards of twenty-five years has proved can be introduced with the best effect, both into our public and private architecture. Therefore, a detailed description of the different apparatus required by other systems will not be attempted; but the principle, and more especially the practical introduction of the several systems in buildings, will be slightly examined.

It may previously be necessary to observe, that the atmospheric air, under all these various contrivances, is made the vehicle for supplying warmth; and the manner of suffusing or saturating this important fluid, with the heat required to effect its purpose with safety and facility, is the first object for investigation.

We find the atmospheric air to be principally composed of two elementary substances, forming a thin, elastic, and perfectly invisible fluid. In chymical analysis it is a mixture of nitrogen and oxygen gases, in fixed and uniform proportions, with a small adventitious mixture of carbonic acid gas, and a variable quantity of aqueous vapour generally held in solution.

The oxygen, or vital principle, constitutes a little more than one-fifth of the whole mass, and is the most essential part. The air which is breathed once only, is rendered unfit for future respiration at the time, and it is supposed that a man requires about a gallon every minute. Air is likewise the principal supporter of combustion, by which bodies burn; a fact which is proved by the increased brilliancy with which fires burn in fine, frosty weather, when the atmosphere contains a greater quantity of oxygen. If a glass jar is placed over a lighted candle, that candle will only burn until the oxygen contained in the air within it is consumed; when that ceases, the flame will immediately expire.

The important end the oxygen, or vivifying spirit, is destined to fill in the animal economy, as the means of respiration, renders the necessity of our being supplied with this support of life in its due and uniform proportion, very apparent. Its deterioration, by flame, causes us to feel a sense of great oppression and suffocation, and we could not survive in an atmosphere deprived of it. The exhilaration of our spirits on a fine frosty day, when the air is cool, fresh, pure, and invigorating, over one that is humid and moist, proves that there exists a greater quantity of oxygen in the atmosphere of the first than that of the other. Our health is generally most perfect by the sea-side, where the oxygen abounds in the greatest purity.

Thus, however desirable it may be, that we should be surrounded by a warm temperature in our apartments, it is, at least, equally necessary that the air so heated should be pure and wholesome, every way fitted for the purposes of respiration. Any system that has a tendency to vitiate the air must be highly prejudicial to the health of every person within its influence. The great difference of principle between the various systems of hot air, and all those by steam and warm water circulation, consists in this circumstance: in the first, the air passes into the apartments direct from the hot chambers of a furnace, and thus is too much heated, while, in the other instances, it is warmed by the simple radiation of caloric from the tubes, containing the hot water or steam, placed in the apartments.

The difference is very essential; for by the latter method, the air is not so highly heated, and therefore it cannot be deteriorated; whereas by the pernicious hot-air stove, the air, in passing through circuitous flues, and coming in contact with iron plates nearly, if not quite, red hot, has all the extraneous substances floating in it burnt and decomposed; the carbonic acid gas, the result of such decomposition, is, of course, disseminated through all the apartments by means of the hot-air passages: thus the remedy becomes more injurious than the evil it was intended to remove.

Without a double apparatus for procuring ventilation in conjunction with warming, it is impossible to regulate the temperature of rooms warmed by this method. The objections, indeed, without this improvement, are so great, that they appear insuperable. With hot-air stoves the current is produced solely by the difference of temperature between the highly rarefied state of the air in them, and the colder atmosphere of the room into which it ascends. Of course, it enters at such an elevated temperature that it proceeds in a rapid direction towards the ceiling, making that part of the room where it enters uncomfortably warm and insalubrious, while the more remote parts are still left cold and uncheered.

By ventilation, when the air is drawn out of a room, and the warm air is forced to mix more intimately with its colder atmosphere (this I shall treat of more at large in the third chapter), the consequences are not so prejudicial; but this method, with hot-air systems, causes a complicated collection of flues in a building, as a separate one for each room must tend towards the ventilating power. These hot-air flues, passing in every direction near timbers, wall-plates, lintels, &c., in the small confined walls of a private house are most dangerous; the least crack in an iron plate in the furnace, or the smoke-pipe, would carry flames into every room as from a centre. Several of our largest public buildings have been completely destroyed by their use, even where the flues have been constructed in the soundest manner, without reference to expense.

This system of warming our rooms, which was in the first instance copied from the close and unwholesome stoves in use upon the Continent, cannot therefore be considered an improvement. Insufficient as the national feature of our domestic architecture may be deemed in many essential points, it is yet infinitely superior to the baneful effects of air heated by stoves, cockles, &c. Neither is the system of hot-air applicable to any extent in domestic architecture; the flues, either in brickwork or copper, being too large, and interfering too much with the construction of a building to allow of their general introduction.

The apparatus adopted for warming houses by the circulation of steam, exhibited a principle very superior to the one above mentioned, being in many respects similar to the system of later introduction —the circulation of hot water. Till this last system appeared, the steam apparatus, as it did not vitiate the air in any way, and was not attended with danger in construction, was the best adapted for introduction into buildings. Numerous excellent contrivances were introduced in this system, the acknowledged power of steam being supposed applicable to every want and emergency ; but in this particular the expense of the apparatus defeated the hopes of its general utility. To the rich it proved an expensive, though most desirable luxury. To those in the middle ranks of life it was a forbidden one ; since it demanded, in addition to the first expense, a constant and intelligent attendant.

The pernicious system of warm air from stoves, and the costly and therefore unattainable one of steam, have been superseded in a great measure by the more simple and less expensive method of a circulation of hot water through iron tubes.

The principle on which this system operates in transmitting heat to any given point, is the property possessed by water, of *motion* among its particles upon the admission of *caloric*.

In this system, the rarefaction produced by the heat in an ascending column of water occasions a difference of weight between it and the water in a descending column ; the first ascends by its greater lightness, the other descends at the same moment, and passes through the fire, receives its supply of caloric, to ascend and return as before ; thus establishing a perpetual circulation, and performing the object of carrying warmth wherever it may be desired.

It has been frequently and aptly compared with the circulation of the blood in the human frame. The water in the tubes has the same constant movement with the blood in the veins; it ascends from the furnace or boiler as the blood flows from the heart; it circulates through the house, ascends or descends rapidly, and returns to the fire to re-charge itself with caloric; as the blood circulates and passes again into the lungs to regain a new portion of oxygen, thus constantly renewing the power of that function whereby it carries heat to extremities of the body.

The efficacy of this simple principle depends (as may be supposed) upon the apparatus by which it is applied to the building it is intended to benefit. The Marquis de Chabannes, one of the earliest introducers of the system into this country, placed a boiler at the bottom of the house, communicating with two cisterns at the top; one of these was for the hot water, which ascended from the boiler, and then on its return or descent branched through the different rooms required to be warmed. The other cistern was for cold water, to supply the first by means of a ball-cock.

Since the time of the marquis, various improvements have been made in the form of the boiler, the pipes, and the pedestals; but where alterations have been made in the general disposition of the parts, it has been done with bad effect: the lower the supply-cistern, the more inefficient and unsatisfactory the result. In some modern apparatuses, strange as it may appear, the larger the fire in the furnace the less the heat obtainable from the pipes, the hot water being rapidly driven out, and the cold water entering to supply its place.

The architect has to contend with many disadvantages in the introduction of the old system into private buildings. The water it contains is seldom raised to a higher temperature than one hundred and eighty degrees. Indeed, when it exceeds this heat, the water in the supply-cistern very frequently overflows from the pressure of the steam in the boiler. Cases have occurred where the water has been forced right out of the apparatus, and the boiler consequently became red hot ; when in this state, if water, either hot or cold, is imprudently supplied, the boiler will immediately burst. From the low temperature of the water, it is obvious the pipes cannot be introduced as the substitute of an open fire-place, without requiring such a quantity of surface as must materially injure the appearance of the room or building.

The pipes through which the water circulates are generally three to four inches in diameter, when circular; large flat pipes, of different dimensions, are used. They necessarily contain a large quantity of water, sometimes many hundred gallons, and are applicable only to the lower rooms of a building.

From these circumstances, warming by the ordinary, or old system of heated water, has never obtained to any extent in domestic architecture.

It may readily be imagined that such a formidable apparatus assimilated nearly with those of steam, in forming, from the expense, a luxury appropriated only to the rich. In procuring the ventilation of a building, the tubes of this system are of little use, as they cannot be carried to any great height, and are besides of too low a temperature.

The difference of principle between the old warm system and the one introduced by Mr. Perkins is, that a moderate pressure is placed on the water within the apparatus, which is either wholly a close one, or a cistern with valves is added, which, upon a certain pressure or volume being obtained by the water, allows it to escape or flow into it. The pipes, which form a continuous or endless tube, are reduced in size; a very small quantity of water is required, which, circulating with great rapidity, effectually takes up the heat from the furnace, and transmits it to any height in a building, or in any direction, to a considerable distance—the furnace being placed in any convenient spot, either within or without the structure.

The apparatus thus combines, before all other, the great requisites of compactness, utility, and frugality, and possesses the power of adaptation to all situations, interfering in no respect with any architectural arrangements.

The apparatus has now been in use twenty-two years, and during that time has been introduced most extensively into buildings of every description with great success. In the hands of the architect, it is capable of being adopted in any building, in consequence of the small space it requires; and from the rapid circulation sustained in the pipes, it is capable of warming even the largest building very efficiently.

The selections of plans given in this volume, made from the different buildings in which it has been applied, will elucidate the subject much more effectually than words can do, and prove that it acts upon a principle at once simple and efficient, and equally applicable to the smallest parlour, or the largest public room.

Dr. Combe, in his justly popular work on the "Principles of Physiology applied to the Preservation of Health," thus renders his testimony to the excellence of Mr. Perkins's apparatus.

"The efficacy, economy, safety, and agreeableness of warming by the above plan can scarcely be overrated, particularly in hospitals, large buildings, and places liable to fire. The pipes may be conveyed through rooms full of paper or other inflammable products, without the possibility of accident; and the apparatus being once fitted up, lobbies and every part of a house can be comfortably heated, as well as a single room."

The superiority of Mr. Perkins's apparatus consists in his having availed himself to the utmost of the great advantages presented by water as a circulating medium for transmitting heat, and which, until his system appeared, had only been, as before seen, very insufficiently and imperfectly applied.

In its simplest form, the apparatus consists of a continuous or endless tube, closed in all parts and filled with water ; about one eleventh part of which tube, being coiled in any suitable form, is placed in the furnace, and the other ten elevenths are heated by the circulation of the hot water which flows from the top of the coil, and cooling in its progress through the building, returns into the bottom of the coil to be re-heated.

The procuring a circulation of water through such small tubes is obtained by the extreme expansibility of water, which is much greater than any other fluid. We have only to consider the relative specific gravities which two columns of water must bear to each other, one column having been rendered lighter by the application of heat, which expands it, and fills it with minute bubbles of steam, which rise rapidly to the upper part of the tube, and becoming there condensed into water again, and then forming another column of water, which, from having no bubbles of steam in it, must necessarily descend in proportion to the expansion of water in the ascending column. Knowing steam to be 1,800 times lighter than water, it may easily be conceived how readily a small stream of water may be kept in constant circulating motion;—and when combined with its power of absorbing heat, it is not surprising that it should extend through a considerable length of pipe before it cools so as to be inefficient.

A tube, called an expansion-tube, is placed above the highest level of the small tubes led through the various apartments of the building. The filling-tube of the apparatus is placed on a level with the bottom of this tube, so as to perfectly fill all the small tubes, and yet prevent the possibility of filling the expansion-tube itself. This tube is generally of larger diameter than those which are used as heating surfaces, and its length is proportioned to the quantity of tube to which it is attached, and being thus left empty, allows the water, as it becomes heated, to expand without endangering the bursting of the smaller tubes.

Water, when heated from forty degrees to two hundred and twelve degrees, expands about five per cent., and it is known that it requires 28,000lbs. to the square inch to compress water five per cent.; hence the necessity of allowing sufficient expansion for the water.

Practice has proved that fifteen to twenty per cent. of expansion-space is ample for the greatest heat which can be attained by hot water.

The natural tendency to ascend of the column of heated water is aided as much as possible by so placing the furnace in the building that the tube proceeding from the top of the coil can be carried straight up at once to the highest level where the water has to circulate, and where the expansion-tube is placed; from this point, two or more descending columns can be formed, it being only necessary to connect them in one tube before entering the furnace.

Fig. 1, plate 1, will explain this arrangement; *a*, is the ascending column; *b*, the expansion-tube; *c*, descending columns; *d*, the coil in the furnace.

The coils *e*, *e*, are formed by these descending columns, and not by the ascending ones.

The heat is communicated to the atmosphere of the building from the external surface of the tubes, which are either coiled up and placed in pedestals ranged round the room behind skirting boards with open trellis-work in front, sunk in stone floors, or placed in any manner most convenient.

A screw pipe is inserted in the upper part of the expansion-tube, which being opened while the apparatus is filling with water, permits the air in the pipes to escape; the filling-tube being connected

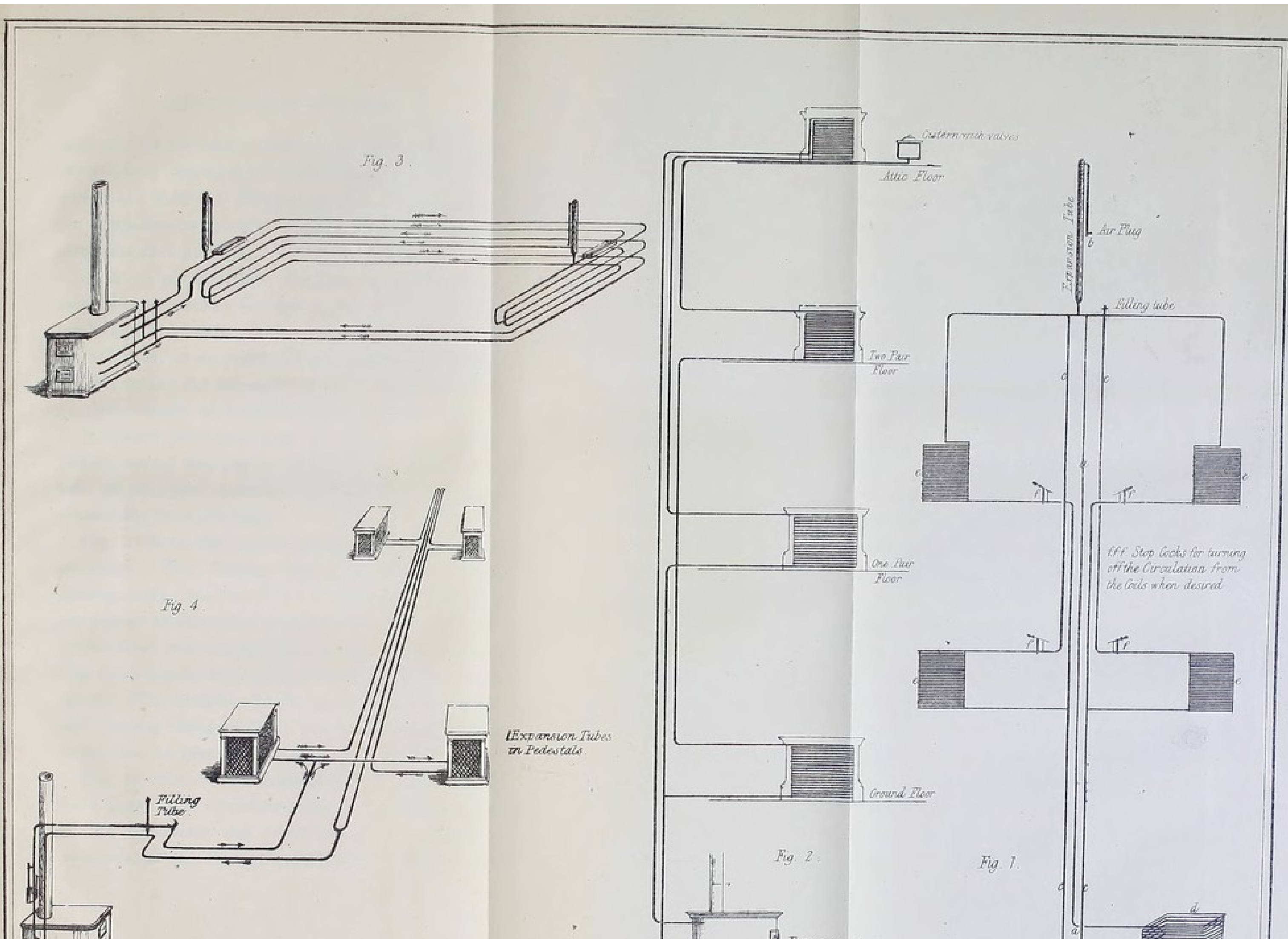


Plate 1.

Day & Son Lith^rs to the Queen

with the lowest line of tubing, the water, as it rises in the pipes, drives the air out before it; when the whole are full, the filling-pipe and the opening of the expansion-tube must be carefully closed with the plugs for that purpose.

In fig. 2, plate 1, the ascending and descending columns are placed in the angle of the chimney-jamb, and the coils placed either in the fire-places of each floor, or on pedestals, all flues being stopped. In this figure, the expansion-tube is dispensed with, an open cistern with valves being used instead.

It is very important that the air should be expelled out of the pipes; and it is usual to effect this, in the first instance, by pumping the water repeatedly through them.

Fig. 3 shows the pipes arranged to warm a conservatory. The furnace has a double coil, and, consequently, two flow and return pipes: the latter are placed at the back, or highest part of the room, in the floor, and the six pipes at the lowest end, so that the warmth may spread itself over the whole space. The troughs placed in each circulation, the pipe passing through them, are intended to contain water, and to generate moisture by evaporation.

Fig. 4 shows the arrangement of pipes proper for a great hall or public room. As the furnace is in the basement, the pipes rising are placed in channels in the floor: these are covered with perforated iron-work; the pipes, leaving the channels at intervals, form coils, which, together with the expansion-tubes, are covered with open pedestals.

The temperature of Mr. Perkins's tubes can be made to vary from 150 degrees to 300 degrees; in rooms where great heat is desired, such as drying-houses, &c., a temperature from 300 degrees to 400 degrees can easily be obtained.

Thus a convenient surface, of a temperature sufficient to warm rooms to any extent, is obtained; the small diameter of the tubes adapts them to almost every situation; they are readily carried into the different parts or apartments of the place to be warmed, and there accumulated in sufficient quantity to produce any required degree of heat; and this can be done without injuring the appearance of the room in any way.

Before proceeding further, it is desirable to examine minutely the construction of the apparatus, in order to show that the advantages already mentioned are obtained without any sacrifice of strength, and in what way it is rendered sufficiently strong to bear, not merely the low pressure it sustains when moderately worked, but even the highest it can be subjected to, when great heat is required.

The tubes which contain the heated water, forming the principal feature in Mr. Perkins's apparatus, deserve our first attention. The inch-pipes, those most commonly used, are of wrought iron, and are one quarter of an inch thick. They are manufactured by Messrs. Russell and Co., of Wednesbury, in Staffordshire.

Their mode of making this patent tubing being a great improvement on that article, it deserves a more particular description, as without this improvement the introduction of wrought-iron tubing for warming purposes would have been very limited.

The iron of which the tube is to be made is first rolled into sheets of the requisite width and thickness. The edges are then brought nearly together the whole length of the iron, which is generally about twelve feet. In this state it is placed in a hollow brick furnace, and heated to a proper welding heat. One end is then grasped by an instrument which is firmly attached to an endless chain, made to revolve by steam power. At the same instant, a man applies a pair of circular nippers, which, when closed, press the tube into the size required, and which he holds firmly while the tube is drawn through them by the engine. The edges are thus brought into perfect contact, and are so completely welded, after passing two or three times through the nippers, that a conical piece of iron driven into the end of the tube would not open it at the joining sooner than at any other part.

The tubes are afterwards screwed at each end, and proved by hydraulic power to support an internal pressure of three thousand pounds to the square inch. In this state they are sent to London, where (from the purity and ductility of the iron) they are with the utmost facility bent while cold into coils of different sizes and shapes, and adapted to any form or situation where they may be required for heating purposes.

When the tubes are arranged and completely fixed in the building to be warmed, the whole apparatus is filled with water by a force pump, and subjected to a considerable pressure before lighting the fire. This is done to prove the joints, and the pressure is continued till the apparatus has been perfectly proved, and found to be without either faulty pipes or leaky joints.

One of the greatest inconveniences that has been found to attend the use of warm water for heating purposes, is the liability to frequent leakages, from the great difficulty of making perfect joints. In the large pipes which have hitherto been used, iron cement has been found most convenient for securing the joints; but, owing to the unequal expansion and contraction of the pipes, it too often proves ineffectual. The larger the diameter of the tubes, the greater difficulty they present in joining them.

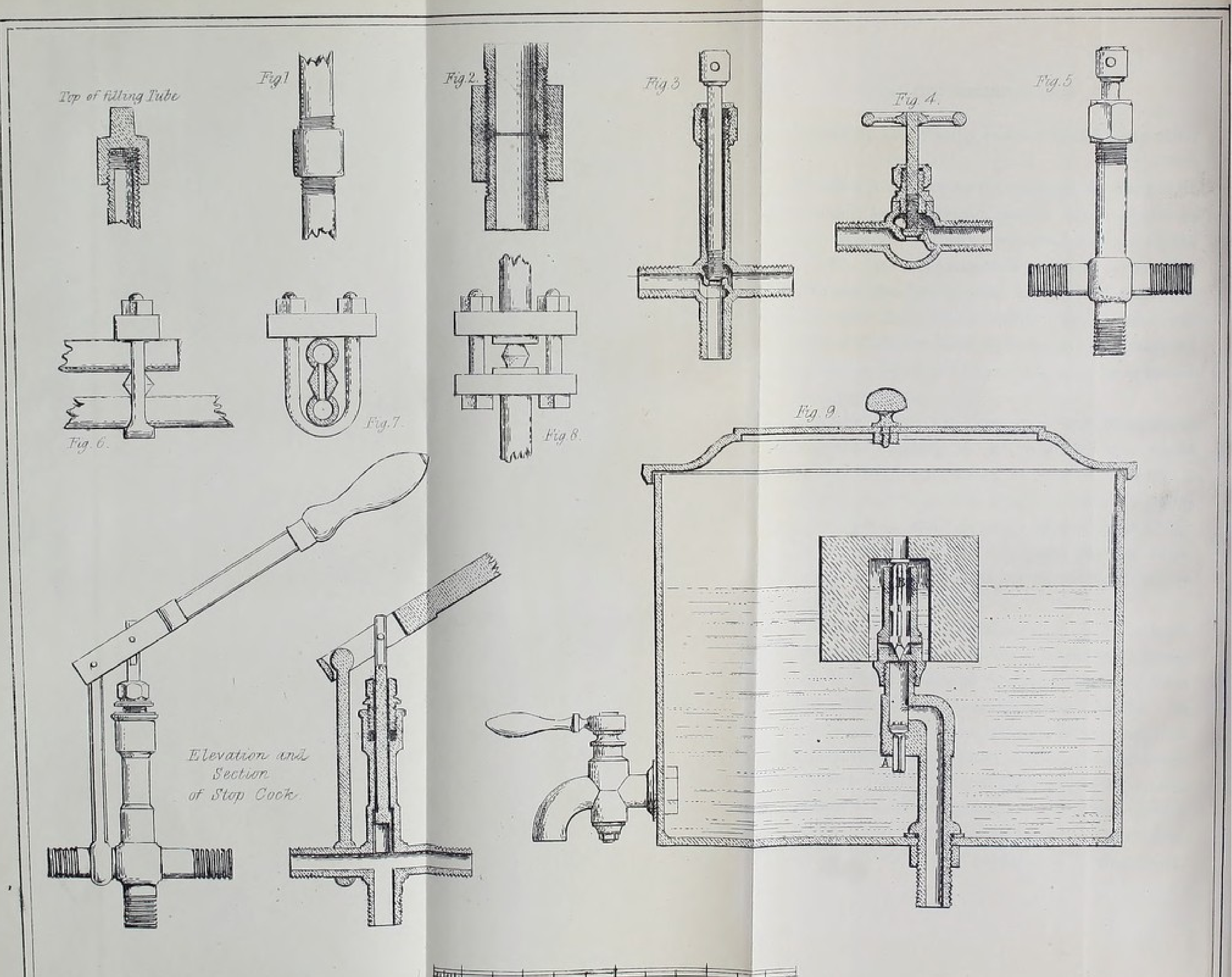


Plate 2.

Day & Son, Lith.rs to The Queen

In this respect, the small size of the pipes renders the mode by Mr. Perkins particularly secure and effectual.

When two tubes are to be joined, the ends are placed within a socket forming a right and left-hand screw, the edge of one tube having been flattened and the other sharpened; they are then screwed so tight that the sharpened edge of one pipe is indented in the flattened surface of the other; thus a perfectly tight joint is formed, capable of sustaining a pressure equal to the pipes themselves.*

Plate 1, Fig. 1, shows an elevation of this joint. Fig. 2 is a section of the joint half full size. Fig. 3, a section of a screw stop-cock; the screw, falling into a conical seat, stops the waterway of one circulation. No. 4 is a similar screw stop-cock, made more compact; this is used to stop the circulation in any particular length of pipe: both these stop-cocks serve for connecting a pump to the apparatus when required. Fig. 5 is an elevation of Fig. 3. Figs. 6, 7, and 8, are cone joints; the first shows the connection of two longitudinal pipes together; the second is a section of the same; the third shows the connection of two pipes together at their ends,

* This joint, invented by Mr. Perkins, is now extensively used in several other departments of engineering; the pipes of hydraulic presses, and all steam-pipes of small diameter, being joined by it.

by means of a cone. Fig. 9 is a cistern containing the feed and expansion valves. This can be used instead of an expansion-tube, where objection is made to the apparatus being completely closed. The feed-valve, *a*, in this cistern, opens inward;—when the pipes require water, the pressure of the atmosphere and weight of water above the valve lift it, and the water runs in. The expansion-valve, *b*, opens outwards, and is weighted to the pressure required. When the apparatus is full of water, and the fire is lighted in the furnace, the water expands, and lifts the weighted valve, *b*, allowing all the water due to expansion to escape, and no more;—the apparatus is then full of heated water, circulating rapidly, and it will continue to do so, until the heat goes down, when the tubes become cool, and the water contracting to its original bulk, that previously thrown out is forced in again by the pressure of the atmosphere acting on the valve *a*, as before stated.

The advantage of this cistern is, that it can be applied to any part of the apparatus most convenient, and when connected with another cistern, by means of a ball-cock in the usual way, it requires less attention than is needful for an expansion-tube.

By the side of the cistern in the plate, is an elevation and section of the stop-cock used either for cutting off one circulation or for pumping the apparatus through.

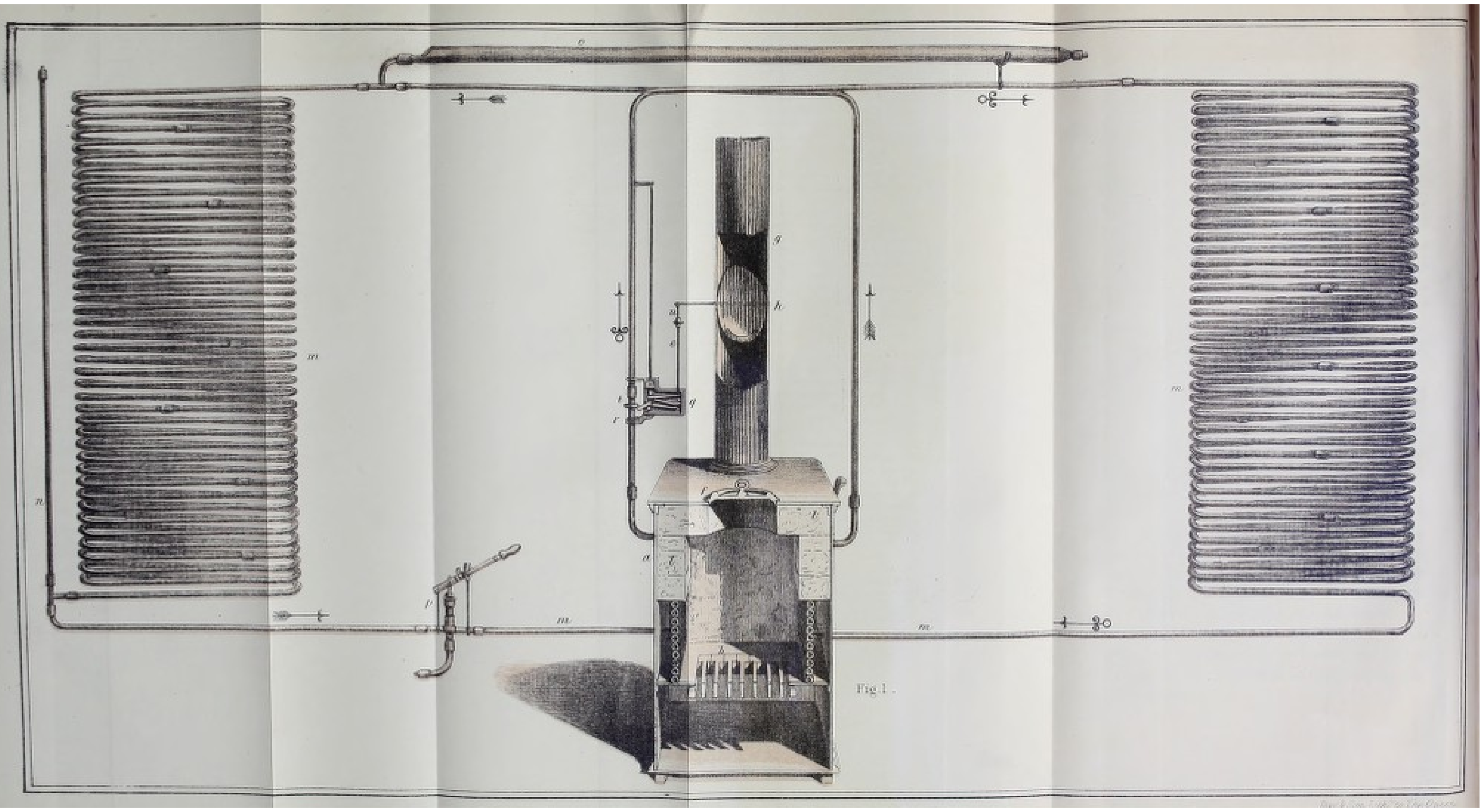


Fig 1.

The dimensions of the furnaces belonging to the apparatus vary, according to the number of coils they are made to contain, and the quantity of work to be obtained from them. To properly proportion the furnace coil to the tubing outside the furnace is of great importance. It is now made one-eleventh only; so that if the whole length of tubing in the apparatus is 110 feet, ten of it is coiled up in the furnace; with this, the proper proportion, it is not possible to overheat the pipes. Of course, any greater or less amount of heat may be obtained by varying the proportions.

Fig. 1, Plate 3, is a perspective section (taken on the line AB, Fig. 2, Plate 4) of the apparatus complete, with its proper proportion of tubing; 60 feet is in the furnace and 600 feet outside. In practice it is usual to make the flow and return pipes leave the furnace on the same side, and to place the expansion-tube in a perpendicular position. The furnace represented in the plate is one of the common size, No. 1: they are made of various sizes, to contain either one, two, or three coils, proportioned, of course, to the work they have to do. The arrows in the plate show the direction of the water-circulation. It will be seen that they are of two forms: this is intended to show that the water flowing out of one coil re-enters the furnace through the other, keeping up a continuous cross-circulation.

The tubes outside the furnace can be taken into a building in any way most convenient, either behind skirting-boards, in trenches sunk in the floor, or coiled up in pedestals.

One expansion-tube only is attached to the apparatus, and one governor (to be hereafter described) is placed on the flow-pipe nearest the fire. Fig. 2, Plate 4, is a plan, and Figs. 3 and 4 are a front elevation and a longitudinal section of the furnace.

For the better understanding the details, the small letters on all the figures represent the same parts; as follows:—*a*, *a*, the outer-case, of sheet-iron, surrounding the coils; *b*, the grate; *c*, the lever attached to the axis which supports the grate, by which it can be thrown down, to clear the furnace of scoriæ; *d*, the spring-latch, which holds up the lever *c*; *e*, the lever opening the soot-trap; *f*, the opening by which the fuel is put into the fire-box; *g*, the smoke-flue; *h*, the damper,—an oval disc, which answers the purpose of checking the draught; *i*, *i*, flue doors, for cleansing out the soot which collects; *k*, the lower door, used for taking out the ashes, and for regulating the draught by hand, when required; *l*, fire-bricks, or Welch lumps; *m*, the tubes; *n*, the filling-tube; *o*, the expansion; and *p*, the stop-cock, or pump, used for pumping the water through the tubes, or for discharging it. The arrows indicate the direction of the circulation. To the flow-pipe is attached the iron rod for suspending the heat-regulator or governor, *q*.

This is a box containing three levers: *r* is the

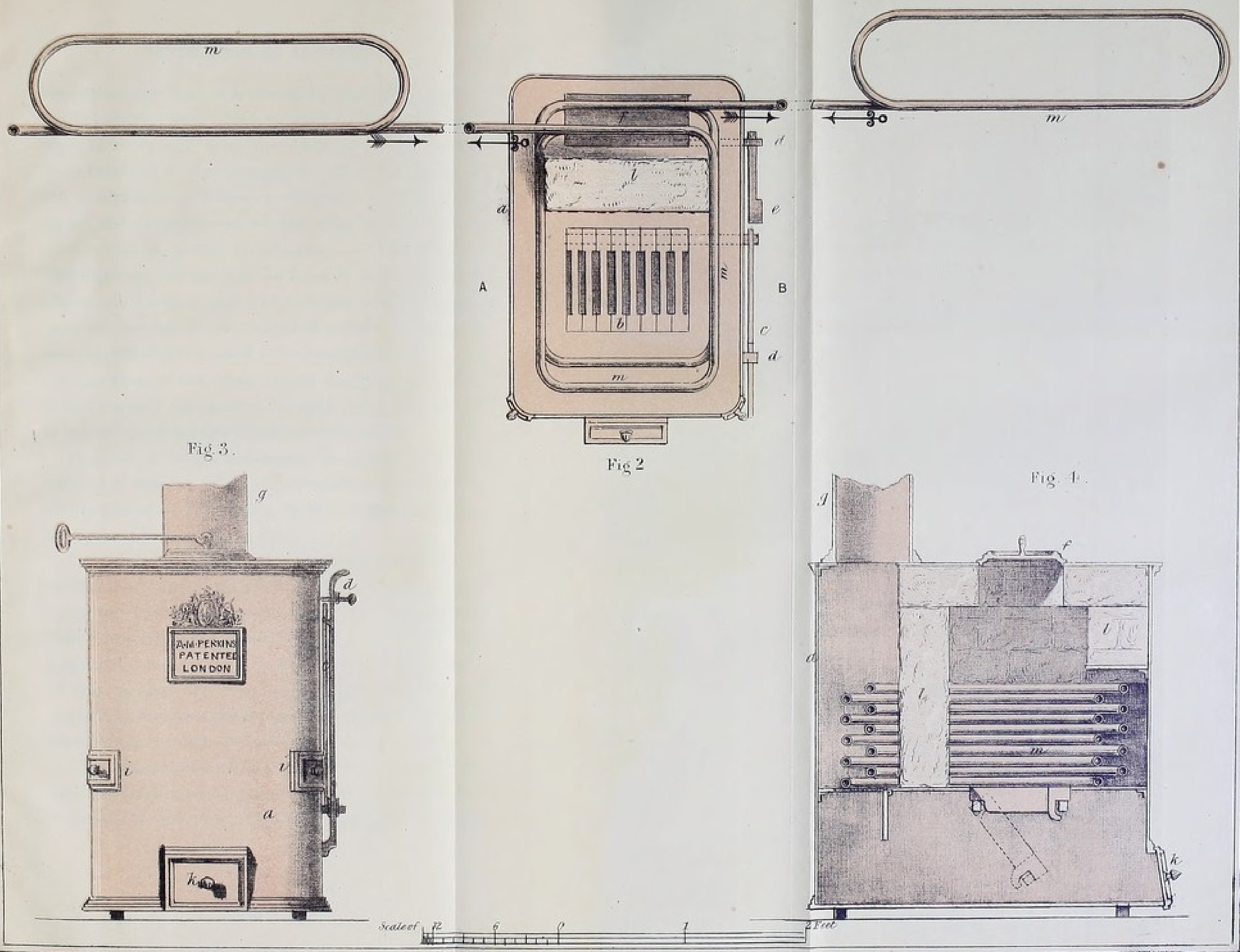


Plate 4.

Day & Son Lithrs to The Queen

support to the box; *s* is the short arm of the lever; *t* is a hexagon nut, which is screwed upon the flow-pipe, so as to act upon the lever *s*; *u* is a balance connected with the damper *h*. The operation of the governor is as follows:—Suppose it be required to fix the temperature of the tube at its hottest part, where it leaves the furnace, at 200, 250, or 300 degrees; let the fire be lighted, a thermometer placed on the flow-pipe will indicate when the temperature arrives at the required point; the nut *t* is then screwed down until it touches the lever *s*. In this position, if the heat of the flow-pipe increases, it will expand longitudinally, and raise up the box in which are fixed the fulcrums and levers.

The nut *t* being a fixture, it follows that the balance *u* will be lifted up, according to the multiplying power of the levers, by the expansion of the flow-pipe which contains them.

In the above arrangement, this power is 192 to 1 of the short arm *s*, which is found to be quite sufficient to close the damper when the temperature rises a few degrees (according to the length of the suspending rod) above the fixed point. The effect of this is, that the heat immediately becomes stationary, and cannot be raised to a higher temperature, however much the fuel may be increased.

This construction of furnace has been found to be the best calculated to preserve equality of heat, and to obtain the greatest effect from any given quantity of fuel; the heat generated is rapidly absorbed by the water ascending through the pipes, and transmitted to the building.

Coke, from the regularity of its heat, or the Welch hard coal, which, from not being bituminous, is thereby not liable to clog, form the best fuel; with which an equality of temperature in the building can be maintained for eight or ten hours without requiring any attention; a most valuable advantage when applied to hothouses and conservatories. The furnace need not communicate with the building it warms; it may either be placed in a cellar cut off from it, or outside the house entirely: by this, the dust and effluvia, which, to more or less extent, invariably attend furnaces, are avoided to the inhabitants of the building, who have all the comforts of warmth, without the annoyance of smoke, &c.

The arrangement of the furnace readily enables us to lower the temperature of the tubes within the building at pleasure. If the heat is at any time too great, by partially closing the ash-pit door, it will be reduced; if that is not sufficient, it may be still further reduced by opening the doors *i*, *i*, and throwing back the handle of the soot trap *e*, thus permitting the cold air to have access to the coils.

In the year 1835, an apparatus was put up in the British Museum, under the direction of Sir Robert

Smirke. The furnace was in a vault in the basement story, and the pipes, entering a flue, were carried up about forty feet to two pedestals, one placed in the print-room, the other in the bird-room ; the former of which contained 360 feet of pipe, and the latter 400 ; about 140 were employed in the flow and return pipes in the flue, and 150 were coiled up in the furnace.

The apparatus, from this great quantity of pipe, 1,050 feet, was a very powerful one, and it fully supplied the warmth required from it. The print-room is about forty-two feet long by thirty feet wide, and the ceiling contains large skylights. This room was warmed during the winter 1835-36 by this apparatus, to the temperature of sixty-five degrees.

The fire, lighted at six o'clock in the morning, was allowed to burn briskly, till the heat produced in the rooms was sufficient, when the damper in the flue was partially closed. This, from checking the current in the furnace, caused a slow slumbering fire, and preserved the fuel. The attendant gave a fresh supply of fuel at eleven o'clock, and the fire kept in till four, when all the fires at the Museum are extinguished.

In 1845, the length of inch hot-water tubing in the Museum was 30,000 feet, with 30 furnaces attached; since that year, 40 more furnaces, with their connecting tubing, have been added. All these apparatus are now in successful operation. The one in the Entrance Hall, where the pipes are sunk in channels in the floor, is particularly deserving notice. During the severe cold weather in the winter of 1854-55, a summer temperature was always maintained there.

In the year 1836, there were several other systems of warming in operation at the British Museum. During the months of March and April in that year, some important experiments were made as to the heat of the various smoke-flues of the different systems.

The following is an extract from the table of temperatures:—

"In the hot-air stove flue, the temperature was sometimes as high as 384 degrees.

"In the hot-water (old system) stove flues, the temperature rose to 360 degrees.

"In the hot-water apparatus, on the small pipe system, the temperature never exceeded 200 degrees.

"These temperatures were taken by a Fahrenheit's thermometer, lowered five feet down the flue, which is sixty feet high; the thermometer thus being fifty-five feet from the stove or furnace."

The extreme heat was taken in the three cases; and in order to come to a right conclusion, the quantity of coke consumed in each furnace was the same, in the same period of time. The temperature of the rooms varied according to circumstances;

but the furnaces of the inch-tube system *were made to do their utmost*, and maintained a temperature in the apartments of seventy-four degrees, for the purpose of drying them, while the other furnaces were merely intended to raise the temperature to an ordinary heat of sixty degrees.

From this experiment, one important fact has been ascertained, that the system of heating on the one-inch pipe plan does not raise the temperature of the flue to any dangerous heat.

When the table from which the above was extracted was laid before Sir Robert Smirke, he expressed his surprise at the great difference of heat between the flues of the small-pipe system and those previously existing in the Museum; as he had been led to suppose, from the water being raised to a higher temperature than was done under the old system, the flues would also partake of the extra heat; but the fact is, that the more rapid circulation of the water in small tubes absorbs the heat more effectually, and consequently less is wasted in the flue.

The apparatus at the British Museum can be so readily inspected and examined, that the description of them has been placed first; through the alterations in the building since 1835, the apparatus used in the print and bird room has been removed and placed in another situation.

In order to illustrate the different methods by which the pipes can be applied to warming buildings, a few examples are now given.

Robert Cadell, Esq., introduced, in the winter of 1833-34, the present system of warming into a new building erected by him in St. Andrew's-square, Edinburgh; and the application has been very successful. The section of the building showing the apparatus, is represented in Plate 5; the flow-pipe (*a*) ascends from the furnace in the cellar to the bookbinders' room, two pipes, *b*, *b*, branching off from it in its course to Mr. Cadell's and the clerk's offices.

The pipe traverses twice round the bookbinders' room; in its way back to the furnace it receives the return-pipes (*c*, *c*) from the coils in the offices, and forming another coil (*d*) in the packing-warehouse, it enters the furnace.

The quantity of tube in the whole is about 1,000 feet; the apparatus was the first of its kind erected in Scotland; it attracted considerable attention; the result was considered by some as too successful to be lasting, and many prognostications were given of its failure, which, however, have not yet been verified. Among the various descriptions which appeared at the time, Dr. Combe * thus speaks of the apparatus at Mr. Cadell's:—

"From the small size of the pipe, and the dis-

* The Principles of Physiology applied to the Preservation of Health, pp. 238, 239, &c.

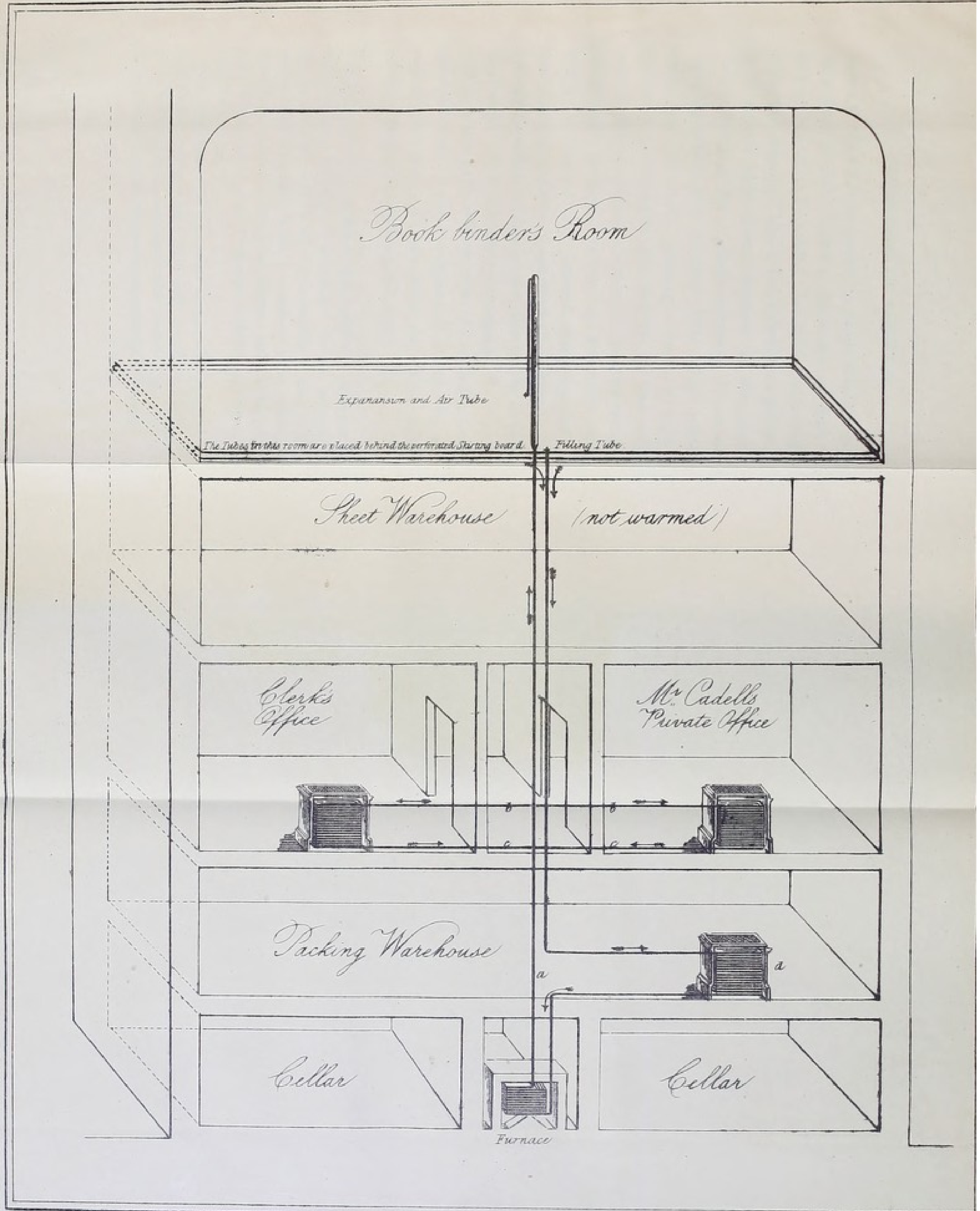


Plate 5.

Day & Son Lithrs to The Queen.

tance to which it is carried in large establishments, like that of Mr. Cadell's, it seems at first sight impossible that it should be able to furnish an adequate supply of heat; but experience shows that it is greatly more than adequate to the purpose. When I visited Mr. Cadell's premises, I was struck with the genial and pleasant heat which pervaded every part of them, although there is only one furnace for the whole five stories. I was not less struck with the total absence of the empyreumatic odour and parched dryness, so generally characteristic of heated air. Indeed, the temperature of the pipe, being little above that of boiling water, is not high enough to decompose the air, or impair its salubrity. This is a great advantage." *

The whole daily consumption of fuel in Mr. Cadell's establishment is three-quarters of a cwt.; of which one-third is coal and two-thirds coke from the gas-works: this quantity lasts till night.

* It is generally considered, that surfaces of a higher temperature than 212 degrees deteriorate the air, and consume the innumerable particles of dust constantly floating in it. It was necessary, perhaps, to fix a maximum above which it was not safe to exceed in any great degree; but this temperature can be exceeded many degrees without producing any offensive results.

The temperature of the plates of iron which warm the air in hot close stoves, varies from 500 degrees to 700 degrees, when the unpleasant sensation from these burnt particles in the air, when it enters the room, is particularly offensive.

The fire office, after having sent inspectors to see this apparatus, agreed to insure Mr. Cadell's premises at one shilling and sixpence per cent. (the lowest rate on inhabited houses).

The Register Office in Edinburgh is the depository of the general register of estates, mortgages, &c., of Scotland; the preservation of these important papers from destruction by damp or fire is of the first necessity.

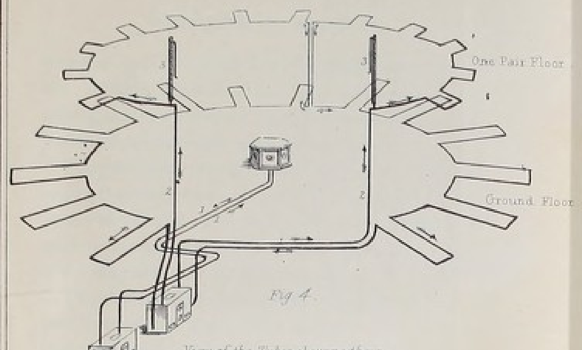
The building is considered one of the greatest ornaments of the Scottish capital, and was the work of Mr. Robert Adams, begun by him in 1774.

The records are placed in a series of small rooms three stories in height, surrounding a circular saloon placed in the centre of the building, which is in the form of a parallelogram. The saloon was intended by the architect to be warmed by means of circuitous smoke-flues, placed directly beneath the stone floor; the fires belonging to them were situated in the basement, and were the only provision made for warming the small rooms surrounding it on that floor.—See Plate 6, Fig. 1.

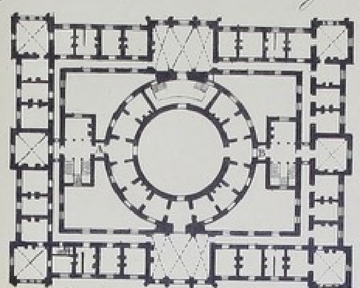
On the ground-floor, Fig. 2, the small rooms had each a fire-place; and on the first floor, Fig. 3, a fire-place for three.

The method of warming by flues having been early found inefficient, and the fire-places in the small rooms, filled with presses, probably not being considered safe, various means for warming were

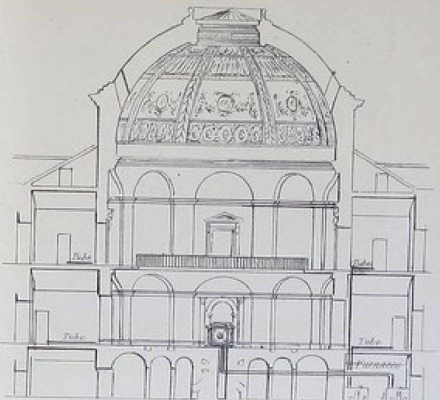
Register Office, Edinburgh



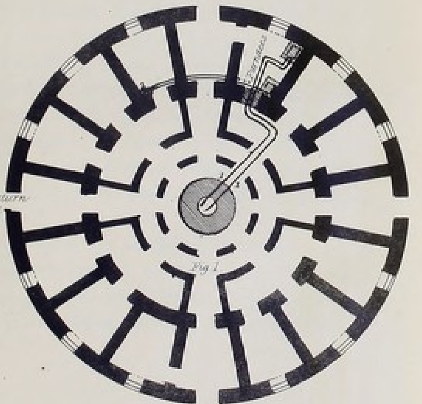
View of the Tubes, shewing their arrangement in the building



General Plan of the Register Office
One Pair Floor



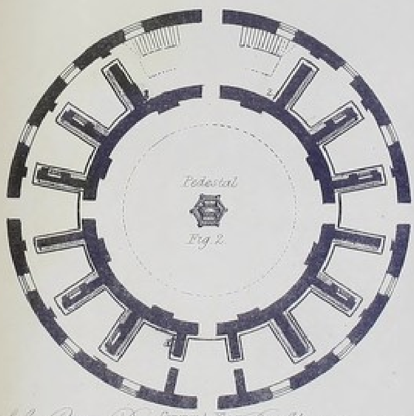
Section
through the Centre Saloon and record rooms.



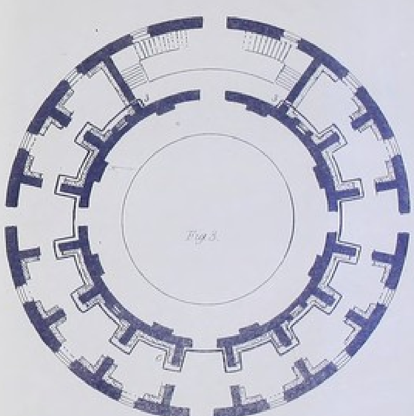
1.1. Flow and return to the Pedestal in the Saloon.

Basement.

2.2. The flow pipes from the furnace ascending through the ground floor to the Expansion Tubes 3.3. they



Ground Floor



One Pair Floor

Plans of the Centre Portion of the Building from A to B

branch off right and left in this Floor, descend at C into the ground floor and return in like manner to the openings through which they ascended, they then proceed down them to the furnace.

Plate 6

Day & Son, Lith^rs to The Queen.

resorted to; but from the difficulties the plan of the building presented for such purposes, it requiring an apparatus of the most ductile form, the whole of the attempts were unsuccessful.

The valuable papers contained in the building suffered greatly from damp, and the inconvenience to the clerks and others who visited the building to make extracts (which was usually done in the room containing the record) was very great.

The successful working of Mr. Cadell's apparatus led to Professor Trail being requested to examine that gentleman's premises, with a view to ascertain its capability of introduction at the Register Office.

In his report on the subject to Thomas Thomson, Esq., of the Register Office, he remarks, "I have carefully examined Perkins's apparatus for heating houses by the circulation of hot water, as fitted up in Mr. Cadell's premises. It is simple, little liable to get out of order, gives little trouble in the management, and does its business effectually and agreeably. I think it admirably adapted for heating the Register Office, where cleanliness and security from fire are of so much importance."

The apparatus was accordingly introduced in this building, and applied to warm, first the saloon, which it effected by introducing an ornamental pedestal, containing about 1,100 feet of coiled pipe; and the record rooms, twenty-six in number, with the staircase.—(See Plate 6.)

Two furnaces were erected in a room in the basement story, one of which warmed the pipes in the saloon, and the other the rooms surrounding it on the entrance and one-pair floors.

In the saloon circulation, the flow-pipe from the furnace was conducted along the ceiling of the basement story, and ascended in the centre of the saloon; it was there disposed in coils placed within the pedestal, and the return-pipe was carried back to the furnace through the same channels by which the flow-pipes were brought from it.

The second furnace was applied to warm the small record apartments.

The room in which the furnaces were placed, it will be seen, on inspection of the plate, was under one end of the staircase; two flow-pipes were conducted up the two angles of this staircase, through the landings, to the one-pair floor,—the expansion-tubes were here placed; the pipes are then conducted from their respective expansion-tubes in opposite directions through the rooms surrounding the gallery on the one-pair story; they meet in the room marked (*c*), (Fig. 3); here they descend to the entrance-story in the room (*d*); they then continue their course in opposite directions through the rooms on this floor, till they arrive at the staircase; where they descend, and through the

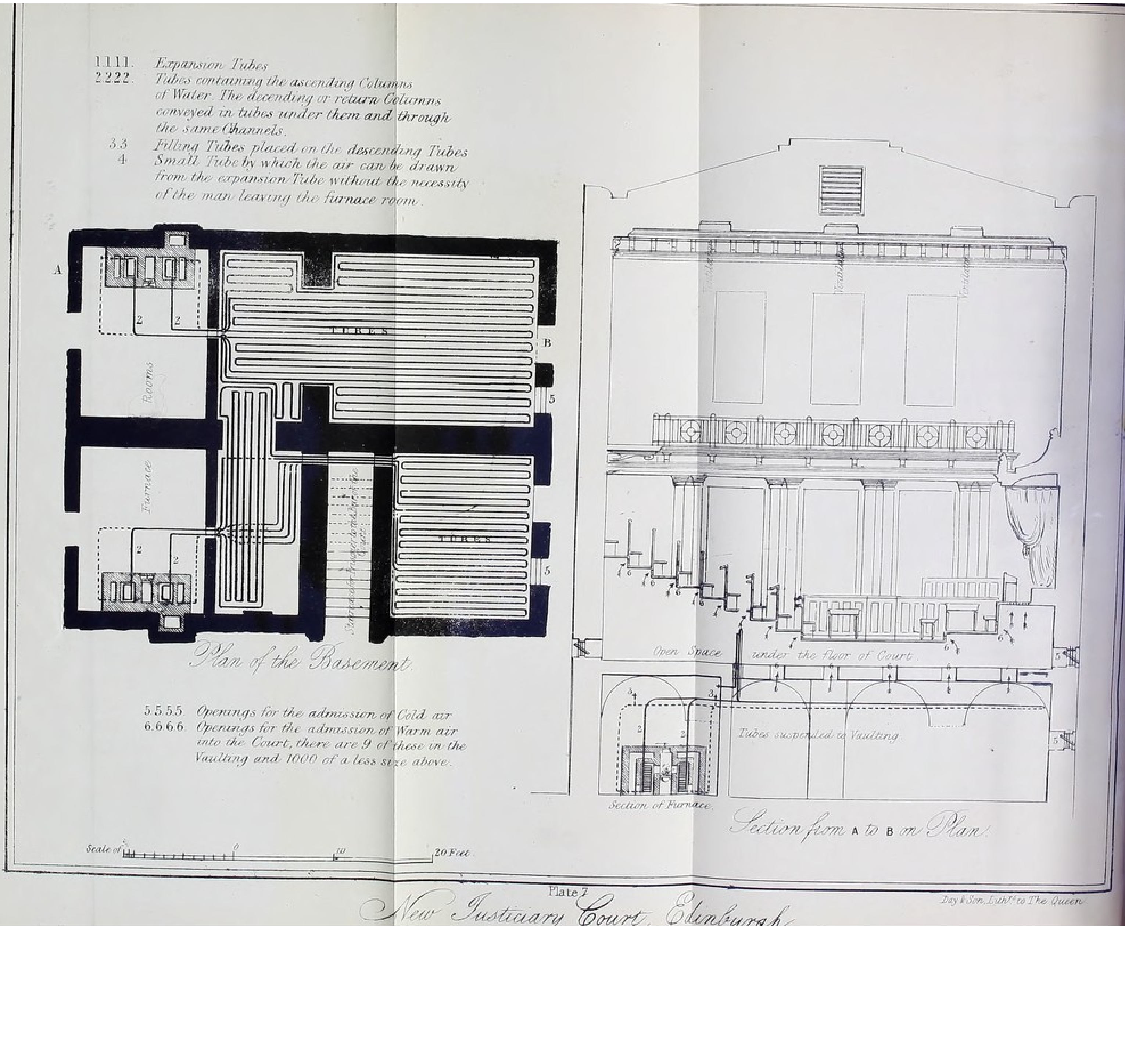


Plate 7

New Justiciary Court, Edinburgh

Day & Son, Lith^{rs} to The Queen

same channels by which they left the furnace they are conducted back to it.

For the better understanding of this complicated course of pipe, a small view of it, with the two furnaces and the pedestal in the saloon, is given, Fig. 4.

In crossing the passages on both floors, the pipes are sunk in channels cut for that purpose.

These two apparatus have answered to the extent required. In fact, so completely has this object been effected, that an additional apparatus has been added for the preservation of the whole of the records on the basement story, which was not included in the former plan.

The last example illustrates to what extent the warm-water tubes of this system can be carried. I will now contrast it with another example altogether different in arrangement, and which offers an admirable specimen of the manner of warming, in an equable and pleasant manner, a very large room. Plate 7 represents a plan and section of the New Justiciary Court, Edinburgh, warmed by Mr. Perkins soon after he had put up the apparatus at the Register Office.

The furnaces are placed in a part of the vaulting below the court, separated from the remaining portion by air-tight walls; each furnace has two flow and return pipes, and about 1,200 feet of pipe appertains to the two: this quantity of tubing is suspended to the vaulting of the room, spread equally over the space like a floor; this is shown in the plan.

The cold fresh air admitted into the vaults ascends between the spaces of the tubing, and enters by nine openings in the vaulted ceiling into a space under the floor of the court. In order to diffuse this warm air equally in the court, small lateral openings are made under the seats, and in every situation where they can be obtained, but none are made in the floor itself; through some hundreds of these openings, the warm air rises into the court. As the furnaces have no communication with the vaults in which the tubes are placed, the heat obtained from them is perfectly pure; if at any time it is too great, it can be moderated by cold fresh air being admitted in the open space between the vaulting and the floor of the court: this can be best understood by an inspection of the plate.

The ventilation is the common, or, as it has been designated, the "spontaneous mode:" openings are made in the ceiling into the roof, from which an opening with luffer boarding permits the escape of the warm air into the open atmosphere.

The great mass of warm air, rising upwards by its own specific lightness, passes very rapidly through these ventilating openings in the ceiling,

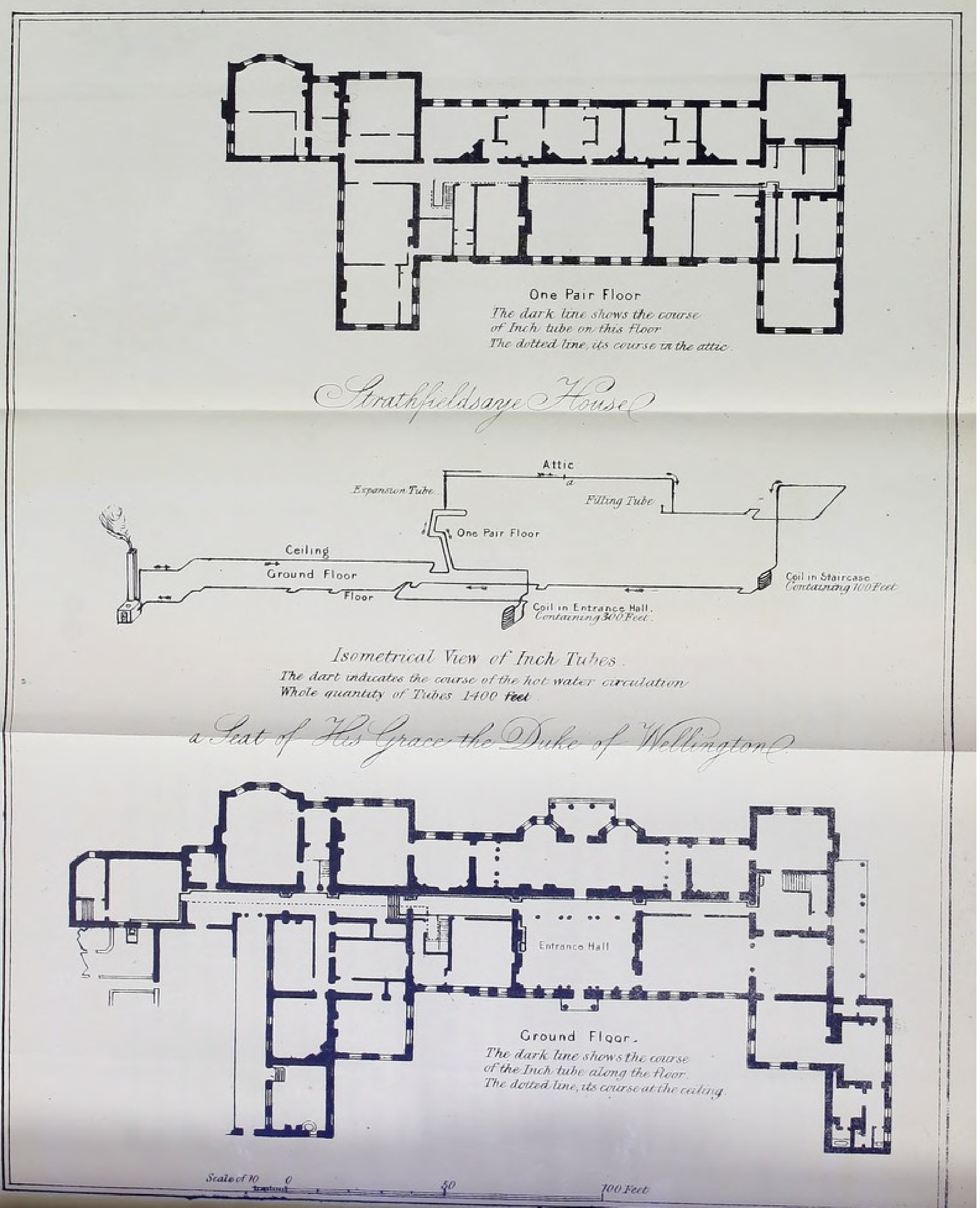

One Pair Floor
The dark line shows the course of Inch tube on this floor
The dotted line, its course in the attic.
Strathfieldsaye House
Attic
Expansion Tube
Filling Tube
One Pair Floor
Ceiling
Ground Floor
Floor
Coil in Staircase Containing 100 Feet
Coil in Entrance Hall. Containing 300 Feet.
Isometrical View of Inch Tubes.
The dart indicates the course of the hot water circulation
Whole quantity of Tubes 1400 Feet.
a Seat of His Grace the Duke of Wellington
Entrance Hall
Ground Floor.
The dark line shows the course of the Inch tube along the floor.
The dotted line, its course at the ceiling.
Scale of 10 0 50 100 Feet

Plate 8.

which, being provided with *registers* to open and shut, the current can be moderated according to pleasure.

A fair example, showing to what extent the pipes can be carried in their career of usefulness, is exhibited at Strathfieldsaye, a seat of his Grace the late Duke of Wellington. The apparatus here is of extraordinary power; the furnace could only be placed at one extremity of the building (see Plate 8), and a staircase 200 feet distant from it is warmed by a coil of 100 feet: before, however, the pipe reaches this coil, its length amounts to 300 feet, caused by its circuitous course in ascending the staircase and traversing the attic-floor.

From the expansion-tube placed in the attic, another circulation proceeds to warm a coil of 300 feet placed in the entrance-hall; the first circulation was found to be too rapid, and to rob this latter of a portion of its heat. In order to equalize them, a copper washer, having an orifice only one-eighth diameter, was placed in the pipe at the point *a* (see isometrical view), and had the effect desired; notwithstanding this check of the circulation, the heat is carried to the extremity of the pipe.

This extensive line of tubing has the effect of keeping the mansion dry and warm; it was put up in 1833, and has continued to operate exceedingly well.

In the year 1845, on Mr. Perkins applying to the Privy Council for an extension of his patent, he wrote to his Grace on the subject, and the letter he received is here given:—

"*London, December* 29*th*, 1845.

"SIR,—I have received your letter of the 20th instant, in which you inform me that you were about to apply to the Privy Council for a renewal of the patent granted to you for the apparatus for warming houses by the circulation of hot water. An apparatus constructed by you has been fixed up in my house for many years, I should think as many as ten. It has answered its purpose perfectly. There is a man in my house who perfectly understands the apparatus, and he can warm the passages, staircases, and halls of the house, at any time in about sixteen minutes.

"I have the honour to be,

"Your most obedient humble servant,

"WELLINGTON."

When this system of warming is introduced in private buildings (large or small), there are several methods of concealing the pipes, or, at least, putting them in such situations as not to be offensive to the eye; placing them in channels about two inches deep in the stone floors of halls or offices, and covering such openings with iron or brass trellis-work, has a very ornamental appearance, and is very effective. Putting the tubes likewise behind skirting-boards, perforated to some elegant design in order to permit the warmth to escape, is, perhaps, one of the best and most convenient arrangements. At Harley House, in the New Road, some pipes are used in this way; and at the Adelaide Gallery, the pipes connecting the pedestals were concealed in the same manner.

A curious example presented itself at the late Lord Rosslyn's house, in Grosvenor Place: the pipe was carried up the staircase appended to the steps; it ran along the landing at the top of the stairs, and returned the same way; the circulation effectually warmed the whole space, and many persons passed up the stairs without perceiving the tubes.

An elegant application of the system is exhibited at Loudwater House, near Rickmansworth. In the centre of the building is a saloon, or ante-room, fifteen feet square, with the angles cut off, and formed into niches. This room leads to a conservatory; right and left of the ante-room branch two rooms, each thirty-five feet in length, and at the end of these there are two others; the furnace is placed in the basement under the ante-room, into which the pipe rises, and forms a coil placed in one of the niches; these niches are covered in the lower part with marble slabs, so that the coil is hid; from the saloon the pipes go twice round the conservatory, in which are placed the expansion and filling tubes. The two rooms right and left of the ante-room were not required to be warmed on this system; but the two rooms at the end of them were, and at the same time it was directed that the pipes should be kept out of sight. It was effected in this way: after leaving the conservatory, the pipes dipped under the floor, and, suspended to the ceiling of the basement story, they were conveyed into boxes formed under the floors of the two rooms; in these boxes, which had openings above (through the skirting-boards of the rooms), and openings below, the pipes formed two large coils, the apertures allowing a current of warm fresh air to pass into the rooms above; from the coils the pipes returned to the furnace.

Another description of warming, very dissimilar to any of the preceding examples, is exhibited in Plate 9, fig. 1. At the Earl of Radnor's mansion, at Coleshill, in Berkshire, a small room is provided in the basement story for this purpose. It is about ten feet cube, and fire-proof. In this room was formerly placed a furnace, with circuitous iron smoke-flues appertaining to it, which nearly filled the room.

An underground shaft, 100 yards in length, having the entrance in an agreeable situation, was connected with this room, which, receiving its air thus, warmed it by means of the iron smoke-flues, and passed it through various openings into the building.

The above method was found to be very defective in consequence of the frequent deposits of soot in

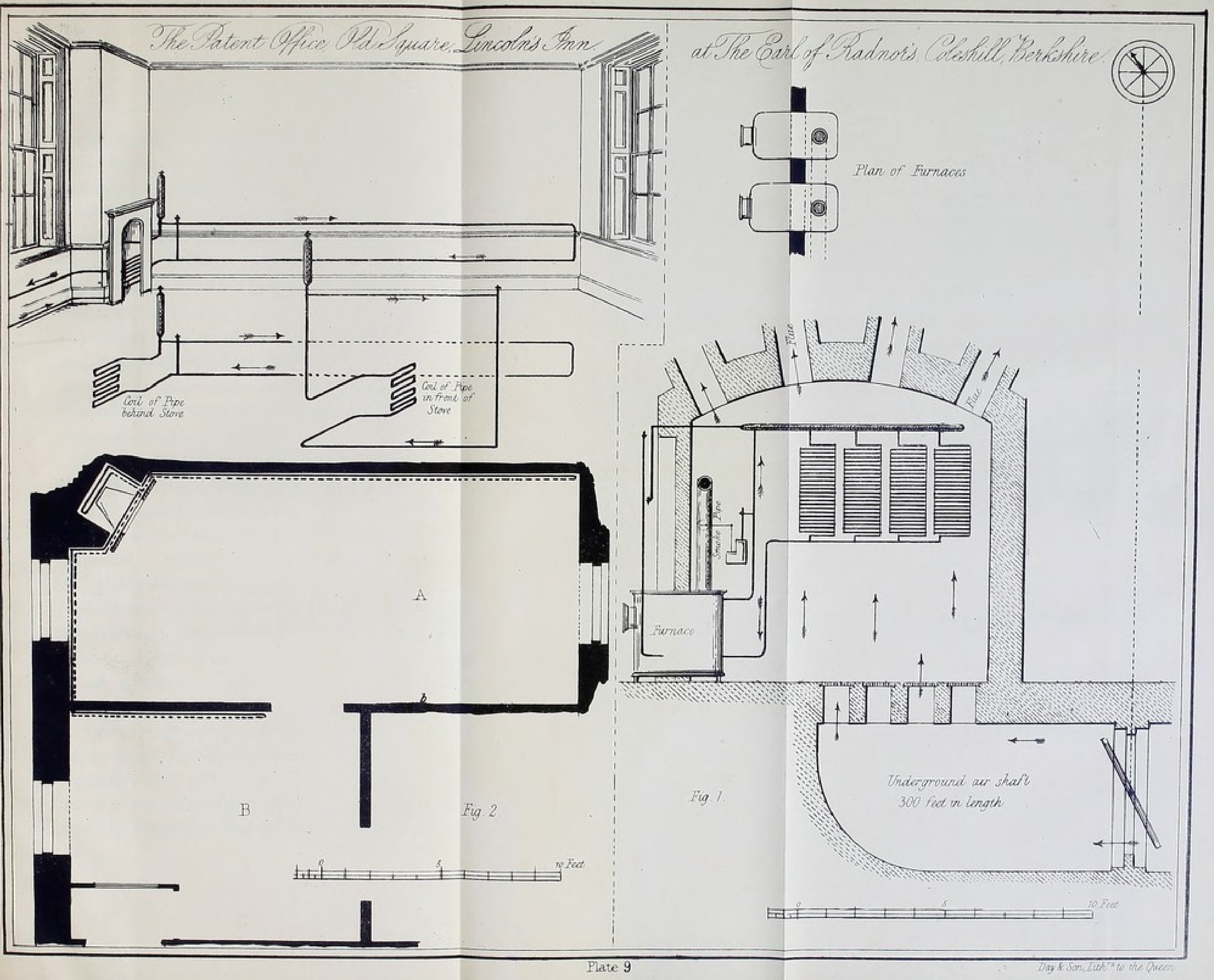


Plate 9

Day & Son, Lithrs to the Queen

the flues, and from the difficulty of cleaning them. They frequently took fire, oftentimes burning or destroying parts of the flues.

When these iron flues were removed, they were found to weigh seven tons. The inch-pipes were substituted, and about one ton of pipe, or 1,000 feet, was introduced. The furnace to heat this is constructed in the room, but has the opening into it on the outside, that no effluvia from the burning materials can be admitted into the room. The flow-pipe ascends to the expansion-tube, which is placed horizontally, and the water, descending through four coils, returns to the furnace.

The quantity of pipe introduced into such a small space is calculated to raise its temperature upwards of 130 degrees. The fresh air admitted into the room from the old underground tunnel, five feet in diameter, is warmed without injuring its purity, and is quickly conveyed through flues opening in the vaulted part of the room to the parts required in the building. The underground shaft is provided with a damper, which is connected with a dial placed in an apartment above; by moving the hand the current can be regulated at pleasure.

In the same plate is another example of warming on a very small scale—the Patent Office, Old Square, Lincoln's Inn. The two rooms have two circulations of the warm-water pipe, each of which is sixty feet in length; a few bends of the pipe of each circulation is placed in front and back of the grate in the larger room. The grate being used for the office fire as usual, thus warms the pipes and produces the circulation. An expansion and filling tube is placed in each room.

On inspecting the rooms in March, 1836, the external air was forty degrees. The thermometer hanging at *b* (Fig. 2) in the larger room was fifty-six degrees, the pipes so cool as to bear the hand on them, the apparatus being very slightly worked at the time. The clerk said that on the coldest day in winter, when the glass externally was eighteen degrees to twenty degrees, the temperature of the room A was fifty degrees with the usual fire, and although the doors were continually opening.

The above example shows with what facility a bedroom or an office may be warmed if it is contiguous to a fire in any adjacent room.

The Soane Museum, Plate 10 (Frontispiece), presents great difficulties to the procuring a circulation of warm air within it, as has been sufficiently proved by the repeated failures of the various systems which from time to time had been introduced there for the purpose; among them was one of steam, and one by the common method of heated water.

There are 1,200 feet of pipe in the Soane Museum: it is divided into two circulations, one of which warms the picture-room and the two rooms beneath. The other, which has the largest circulation annexed to it, first warms the office in which the expansion and filling tubes are placed; the pipe then traverses the whole length of the museum, then passes through the breakfast-room under the long skylight, intended to counteract the cooling effect of the glass; it then passes through the floor into the lower room, forms a coil of pipe of 100 feet in the staircase, and returns to the furnace, passing in its course twice round the lower part of the museum; a coil from this circulation is likewise placed in a box under the floor of the dressing-room, which, by an opening in the floor and the side of the box, admits a current of warm air into the room above.

In the preceding examples, this system of warming was introduced into buildings already erected, where no channels being left for the pipes, their courses were consequently bent, and in some cases rendered awkward and ugly. The small diameter of the tube, the ease with which it is coiled up and placed in any situation, almost amounting to the facility with which bell-wires are hung, render its practical use a great recommendation; so that, in most houses in this country, it appears peculiarly applicable. The pipes reaching from the bottom to the top of the staircase would prevent those sudden transitions from heat to cold at present so generally experienced; and the pipes branching round the upper floors, through bedrooms, nurseries, &c., rendering fires in them unnecessary, would produce greater comfort, and effectually render our winter, "though frosty, kindly."

The comfort and convenience of a moderate, warm, equalized temperature, can scarcely be understood or appreciated, without having been first enjoyed. On entering from the open air, it may feel oppressive at a temperature of fifty-five or sixty degrees, but sitting quietly at sedentary occupations no such sensation is felt; we can move about without being aware that the winter snow is outside, and we are not annoyed by being only partially warmed on one side whilst we are chilled on the other.

The examples already given, practically illustrate to what extent the system is capable of introduction in our buildings: its great importance where valuable records and papers are deposited, for museums, and likewise for hospitals, workhouses, and lunatic-asylums, from the ease with which the pipes are covered, or placed out of reach, will be evident. A clever mechanic could contrive to use them beneficially for many other purposes: Mr. Perkins has already effected by their means the drying corn, roasting coffee, heating ovens for baking bread, &c. Adjoining his factory in Francis Street, Regent Square, is an establishment where picnic-biscuits of every description are made: a large portion of those biscuits so well known in the grocer's shops in London and in the country, are there manufactured, from the first mixing of the dough and the rolling of the paste, by means of these hot-water pipes; the steam-engine which works the machinery has the steam created in the boiler by the pipes circulating within it, and the ovens, which, as regular as clockwork, bake each batch in fifteen minutes, are heated in a similar manner.

The benevolent and talented author of "Suggestions for the Architectural Improvement of the Western Part of London,"* proposes, in its pages, a plan for substituting healthy, cheerful, and cheap lodgings, in lieu of the dismal abodes of the labouring poor in the metropolis, and he adds in a note, that Mr. Brunel has suggested to him "the practicability of *laying on heat* to a long range of those dwellings, from one common source; a contrivance, which, if perfected, would be of inestimable importance in London, where the high price of fuel is so great a burden upon the poor." To see how admirably the present system of warming meets his views in this respect, we have only to imagine, instead of the extensive building of Strathfieldsaye, a row of small dwellings inhabited by the labouring poor; and if these were constructed, as he describes, with this convenience, a perfect system of drainage, and

* Published in 1834, by Sidney Smirke, F.S.A.

an abundant supply of water, to use his own emphatic language, it would, indeed, be "an invaluable boon to the mechanics and labourers of London."

I trust the time will arrive, when an important convenience of the description we have been considering will not be introduced into any building as an after-thought. It should be remembered, that as its complete success and its economical character depend in a great measure upon a due consideration of its benefits being given at the commencement of a building; so it ought in future to engage the primary consideration of the architect and builder.

CHAPTER II.

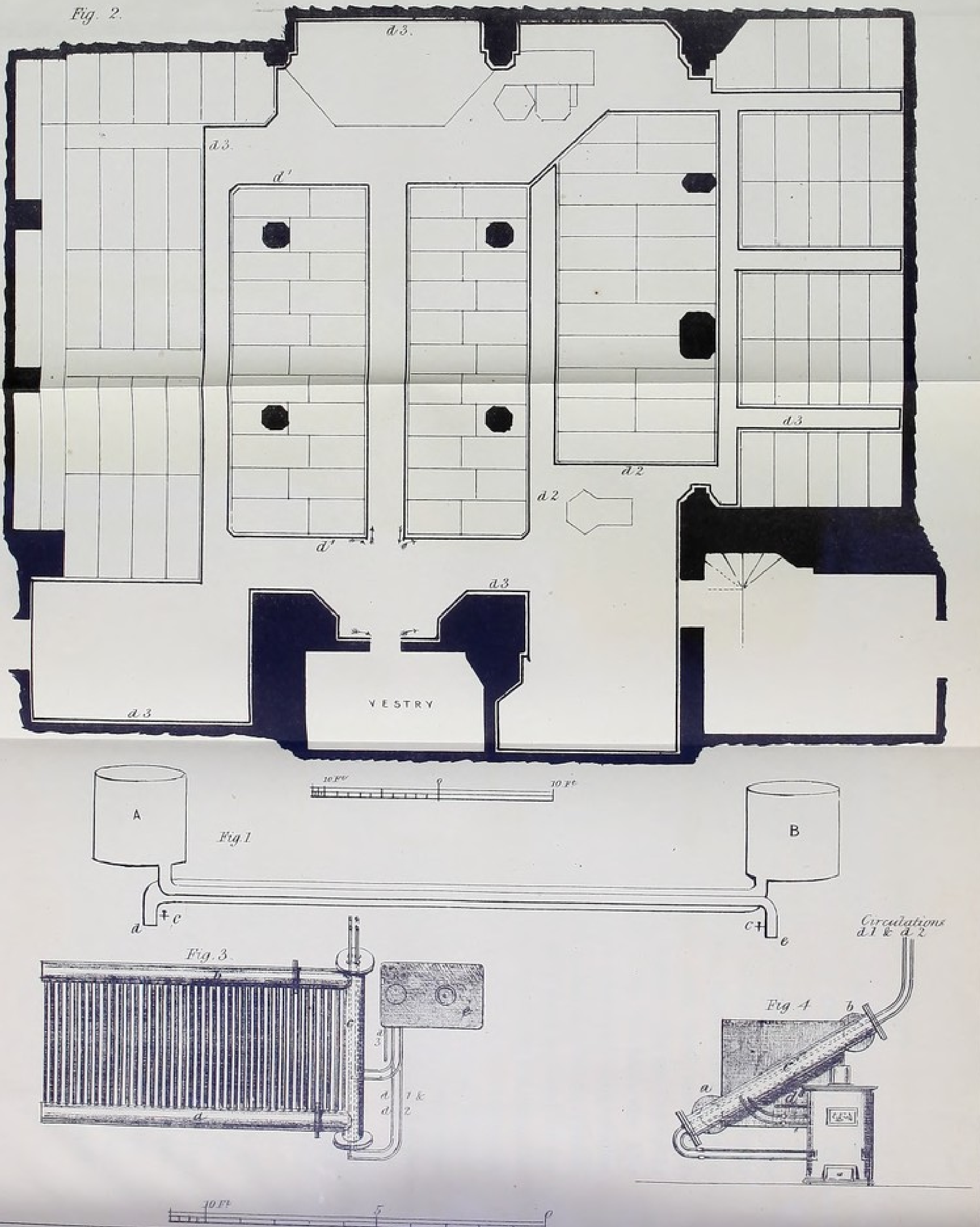
ON THE COMBINATION OF THE HIGH AND LOW TEMPERATURE SYSTEMS OF THE HEATED WATER CIRCULATION.

The various apparatus for warming buildings by the circulation of hot water, may be roughly stated to be of two kinds, each acting on the opposite principle to the other. The first, or more modern one, is the closed system, described in the previous chapter, in which the water circulates with great rapidity, completely under pressure, the pipes being closed, and the whole of the air expelled from them. The second, or older system, is that in which the tubes are not closed, but are connected with a cistern, into which the water is allowed to flow and reflow. The two may very properly be called the high and low temperature systems, and by these terms they shall be so designated here: with the first, the tubes can be made to reach a high degree of heat if necessary, by placing a larger proportion of them than is usual in the furnace; but with the second, a temperature of 180 degrees can alone be reached: with the latter, its greater or less efficiency depends upon the position of its open cistern, which regulates the amount of pressure on the tubes, according as its situation is high or low. The Marquis de Chabannes, who introduced the first apparatus in this country in 1818, placed the open cistern in the upper part of the house, the boiler being below in the kitchen, thus allowing a considerable pressure in the tubes, and securing a quick circulation of the water. By an ingenious method now introduced by Mr. Perkins, the two systems can be combined, and the temperature of both large and small tubes nearly equalized: he does this, using only one furnace, that of his own apparatus, it being more economical than the furnace belonging to the older one; for, as compared with that, the proportion of conducting surface exposed to the fire is larger; it thereby absorbs a greater relative amount of heat, permitting less to escape up the flue.

A diagram given by Dr. Arnott in a lecture delivered by him at the Royal Institution in March 1836, with his explanation, will show the principle upon which the combination is effected.

Suppose A, Fig. 1, Plate 12, is a cistern full of cold water, and B another full of hot water: if the two cocks *c*, *c* are unturned, it is a fact that the water at *d* will be one degree of warmth only above the water at A, and the water at *e* will be one degree less than the water in B. If, therefore, on this principle, some of the pipes of the high-tempe-

St Mary Magdalen, Parish Church, Oxford.
Shewing combined Hot-water apparatus, small & large pipes.



rature system are passed through the large tubing of the low-temperature one, the effect desired is obtained: the large pipes or tablets of one apparatus remain at their full heat, while an additional quantity of inch pipe of sufficiently-warm temperature is obtained, that can be carried into rooms and placed in situations into which the warming surfaces of the low-temperature system could not be made to approach.

To show the practical application of this method, Plate 12 is given. Fig. 2 is a plan of St. Mary Magdalene parish church, Oxford. To warm this building a low-temperature apparatus had been used; it was placed in the basement underneath the vestry: it consisted of forty hollow iron tablets, each three feet square, and one and a half inch thick; these were filled with water, and a circulation effected between them and the boiler by means of the two pipes *a* and *b*, Figs. 3 and 5—the flow, being the upper one, the return the lower.

The cold air was admitted into the chamber, and being warmed by its passage through the tablets, passed up into the church. It was found that it did not there diffuse itself in a sufficient degree,—the church was not sufficiently or equally warmed throughout. Mr. Perkins being called in to correct this, took away the furnace, with its saddle-back boiler, connected the two pipes *a* and *b* by the pipe *c*, and into this he passed two flow and two return pipes of his own apparatus, the furnace of which he substituted for the former: the one he used contained three circulations, one of which was not connected with the old apparatus at all, but was taken up into the church, direct from the furnace.

Fig. 2 is a plan of the church, showing the pews, &c.; the dark line *d*, *d*, *d*, represents the inch pipes laid above the floor; these, as has been before stated, form three circulations; *d* 1, and *d* 2, are the circulations which pass through the large pipe *c* and *d* 3, going entirely round the church, is the one which is not connected with the old apparatus.

By this method of combining the two systems, the tablets of the one give out the same amount of heat they did previously; while the inch tubes of the other are introduced of different degrees of temperature into the church itself, producing, as may easily be imagined, an equalized temperature throughout.

The operation has been eminently successful, and gives the greatest satisfaction to the clergyman and the vestry.

Fig. 3 is a plan of the old apparatus, consisting of the forty tablets connected with Mr. Perkins's furnace, *e*; and Fig. 4 is an elevation of the same at one end: these two latter figures are on a scale thrice as large as Fig. 2.

As regards the low-temperature apparatus, if the

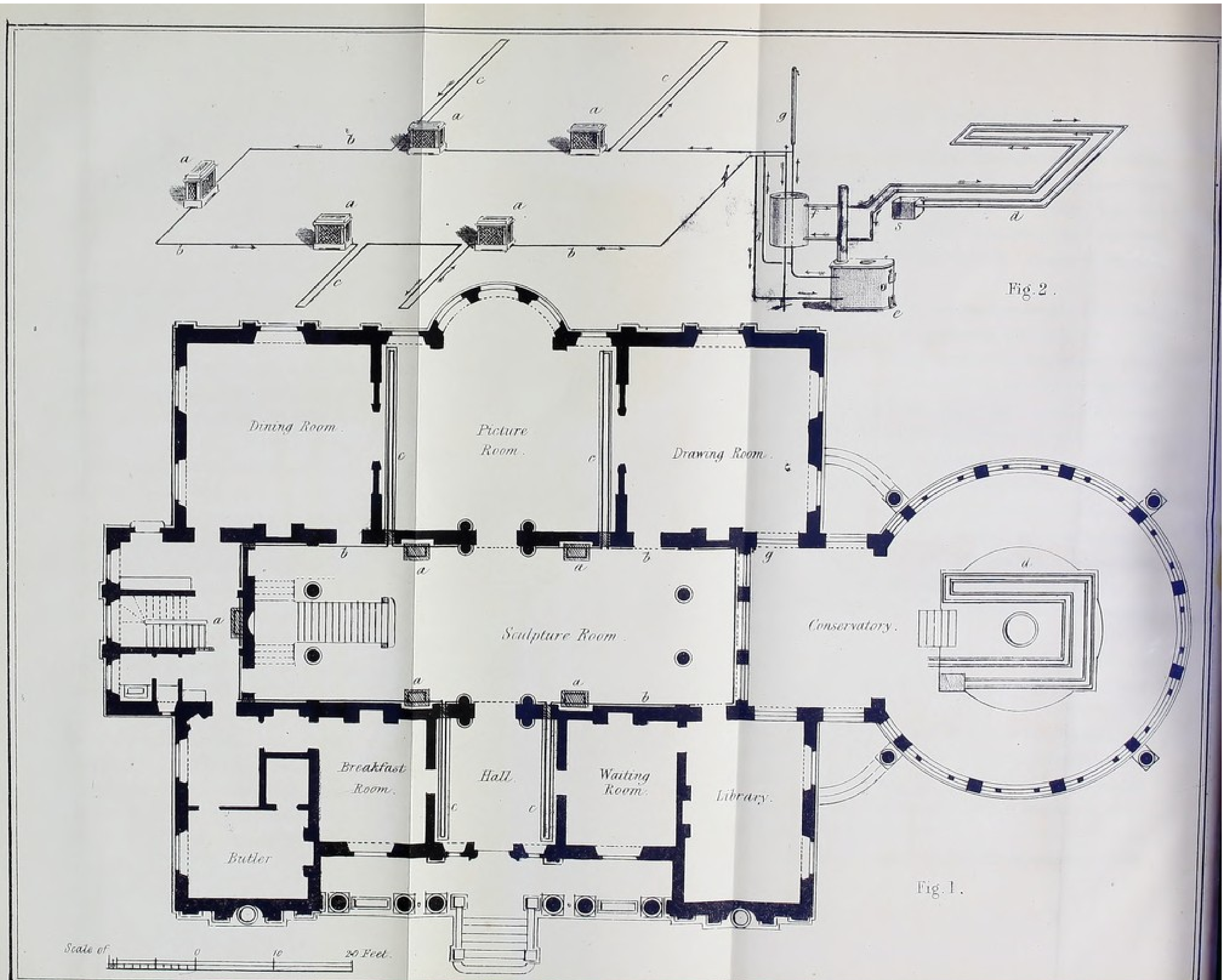


Plate 12

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large pipes belonging to it are laid in sufficient quantity, they doubtless have the effect of producing a moderate, warm temperature. The best way of introducing them into a dwelling-house is to sink them in channels in the floor, with perforated iron-work over them: they are more usually introduced into hothouses, factories, and workshops, where their appearance is not objectionable. A feeling exists in favour of their use in conservatories: in order to show how they can be retained for that purpose, in conjunction with the smaller tubes, a plate of a modern villa is given where the two systems are combined.

Fig. 1, Plate 12, is the ground-plan of the villa: the entrance-hall, the sculpture-room or centre saloon, and the principal staircase, the picture-room, and the servants' staircase, are warmed by the inch pipes; the larger pipes are introduced in the conservatory at *c*, *c*. In the picture-room and hall the pipes are sunk in trenches in the floor; these are close to the walls, are lined with brick, and are covered with perforated ornamented iron-work. *a*, *a*, are pedestals containing coils of pipe; *b*, *b*, are pipes behind the skirting, likewise perforated: where these pipes pass the doorways they are sunk in the floor, like the pipes *c*, *c*. In the conservatory, *d*, are the large pipes; *f* is an open cistern, through which the circulation of water in the pipes flows; at *g* are placed the expansion and filling tubes.

Fig. 2 is an isometrical view of the pipes, furnace, and cisterns complete: *e* is the furnace placed in the basement; *f* is a cistern of cold water through which the flow and return pipes from the furnace pass: the water, becoming heated in the cistern, flows out, and returns in the direction shown by the arrows. The flow-pipe, leaving this cistern, passes up to the expansion-tube *g*, from whence the tubes pass through the building in the manner shown, returning to the furnace: the pipes *d* are two other flow and return pipes, furnished with a stop-cock, by means of which the circulation can be confined either to the house or to the conservatory.

The furnace in reality contains two coils of pipe, having two flows and two returns, the whole of which go through the cistern *f*; the small scale of the plate allows one circulation only to be shown.

In the two previous examples it will be seen, that although the combination of the two systems is effected on the same principle, the manner of doing it is very different: no diagram can be given that would suit every case which offered itself; the manipulation might vary in every instance, especially where one apparatus had been previously constructed.

A healthy opposition is always shown in this country to new contrivances, and the simple principle here described, which in the hand of a skilful engineer is calculated to produce great benefits, may meet with its portion.

The inventor and introducer, in this country, of contrivances for mechanical ventilation, Dr. Hales,—when he published his first account of them in 1758, announcing the happy effects of his ventilators, "in refreshing the noxious air of ships, hospitals, and mines, to the better preservation of the health and lives of multitudes,"—thought it necessary to apologize for the innovation he introduced. He remarked, that "new discoveries are apt to be despised; that we are slaves to old habits and customs, even to a degree of suffering inconveniences which we might easily remedy; that this proceeds from a general backwardness to every new proposal, not caring to give ourselves the trouble to consider and examine them; but it is reasonable to believe that ventilators will, from time to time, come into more general use; and that it will hereafter be a matter of wonder that so plainly self-evident a benefit should be so many years [he introduced them in 1740] before the world could be prevailed on to receive them." And as regards the healthy opposition offered, he adds, "it is sometimes beneficial to us, as it enables us better to bear inconveniences which we cannot remedy."

The state of our buildings, as regards ventilation, in the learned doctor's time, may be gathered from the following small extract out of his volume relative to the Savoy prison, then used as barracks :—

"I desired a surgeon of the second regiment of foot-guards to burn a wax candle, of about half an inch in diameter, for half an hour, among the sick soldiers at the Savoy, where it wasted but eleven grains ; whereas the same candle, in a good air, had wasted in the same time twenty-seven grains, which is more than double of what it wasted in that bad foul air ; and he says that the stench there is sometimes so intolerable, that candles give but a very weak light."

The apparatus for warming buildings introduced by Mr. Perkins has passed through the ordeal of public opinion, and is now fully established ; it has existed for twenty-five years, and the list given at the end of this volume of the numerous places where it is still in active operation, will show and prove its real merits, and the certainty with which it achieves that great desideratum, the introduction of a moderately warm temperature into our buildings. When it was first introduced, a larger amount of tubing was placed in the furnace than is now usually done : with the proper amount, one-tenth or one-eleventh only of the full quantity, it must be obvious that no overheating of the tubes can take place ; in practice, it is more usual to find objections made to the apparatus not giving sufficient heat, than to its giving too much.

Large pipes of four inches in diameter can be coiled up in a furnace in a somewhat similar manner to the smaller tubes. In the year 1845, Dr. Reid was employed by the Corporation of the City of London to warm and ventilate the old and new courts at the Old Bailey Sessions House; under his direction, Mr. Perkins put up 1,500 feet of the large tubing. The furnace contained two coils, one for each court; they left the furnace and formed two other large coils, each about fourteen feet in length by four feet in width and height; these were placed in chambers under the courts, and fresh air was driven through them by means of a gigantic wheel or fan, worked by a steam-engine. The not very picturesque large cowl, on the roof of the building, and which weighs upwards of eighteen tons, forms the outlet for the vitiated air.

The system of warming was the low-temperature one; the open cistern of the apparatus was placed thirty-two feet in height above the furnace, the pressure on the pipes being sixteen pounds to the square inch. These tubes were not the common cast-iron pipes, but some made on the same principle as the smaller tubes, having right and left screw joints. The apparatus has now been in use ten years, without needing any essential repair: the amount of fuel burnt in cold weather is three and a half sacks in sixteen hours.

The pipes were patented by Mr. Perkins; they were made in lengths of nine feet, with all the necessary single and double elbows, return angle, and close syphon bends, and the tie and cross pieces, together with all the smaller detail, admirably suiting them to the usual applications of the common cast-iron pipe, more particularly to hot-water apparatus, gas and steam pipes. The right and left screw-joint, fitted with an India-rubber washer between, renders leakage at the joint nearly impossible; if it takes place, it can always be easily rectified; this is a great advantage over the common iron-cement joint, which must be broken up when any repair is requisite.

CHAPTER III.

ON VENTILATION AND WARMING.

In the present construction of our buildings, it is generally considered that the windows are intended to give air as well as light. When, therefore, we enter an apartment from the fresh air, and are sensible of an unpleasant difference between the closeness of the one and the exhilarating sweetness of the other, we have either to open the door or window, in order to introduce a current of air into the room. This, if the weather is winterly, renders the room uninhabitable, or dangerous to those who remain exposed to the influence of the cold we have invited.

The inconvenience of open windows for ventilation is particularly observable when rooms are crowded, the air within them being rendered of a high temperature. In ballrooms especially, the cold air from without being of greater specific gravity, easily overpowers the lighter air within; and the currents thus formed, together with the cold temperature of our vestibules and staircases, render our houses during such periods of amusement alike uncomfortable and unsafe.

Our close and confined dwellings are certainly never constructed with sufficient attention to procuring a change of air, without exposing ourselves to draughts. We rouse up from sedentary occupation, and issue out to breathe the pure air, as the only resort ; the benefit we then experience ought to make us the more anxious to realize the same elevation of spirits, and sense of enjoyment, by constantly supplying in the best manner we can this mainspring of life in equal purity. The importance of a regular supply of pure air, and the constant removal of that which is vitiated, is little understood. We shall be told, that fresh air will always force its way into rooms through chinks furnished by doors and windows in sufficient quantities—that it is merely necessary to open the windows of our sleeping-rooms, after we have left them, and it is therefore unnecessary to provide any formal medium for obtaining that which is allowed to be indispensable.

Few persons deny that a more equal warmth diffused through their dwellings would not be desirable, and it is a fortunate circumstance that this improvement cannot be procured in the best manner, without making ventilation a principle or necessity. In admitting a regular quantity of pure air, warmed to an agreeable temperature, it becomes necessary that a corresponding proportion of air should be displaced. Unless this is attended to, no system of warming in a private building will be found successful and satisfactory.

In large public rooms, not closely occupied, an agreeable warmth may be diffused by the air within them coming in contact with warm surfaces only; but when a considerable assembly happens to be present, all the evils of window ventilation must be produced.

It ought to be considered, that as the air by warmth expands, and has not the same density or wholesome supply of oxygen as when cold, a warming apparatus in a house should necessarily be capable of forcing a constant supply of pure air into it.

In introducing any new system of warming in a private building (the scene of its most extensive usefulness), good ventilation should therefore become a primary consideration; and a perfect understanding of the means by which it may be produced, together with different methods of effecting the purpose, now demand our attention.

By the act of breathing, the vital principle of air is withdrawn, and an increased proportion of carbonic acid gas issues from the lungs: this is produced likewise by combustion; the deadly effect of charcoal fires in close rooms is well known. This gas, so highly dangerous for respiration, is heavier than the common air, in proportion of 1,520 to 1,000; it could not escape from the lungs were it not, through the wisdom of our Creator, so intimately blended with other matter, more particularly vapour, much lighter than the common air, "that it rises with rapidity, even in an atmosphere of similar temperature."*

This vapour is perceptible in breathing, and in the external atmosphere of a sharp frosty day it assumes nearly the form and density of steam, and must have been observed by the most ignorant; though, as it has been remarked, they are little aware of its use and excellence, as one of the means by which a Divine Providence preserved them in health and cheerfulness, by preventing the inhaling of the same air until it had recovered the density and purity necessary to existence. That the air must soon lose this temperature is obvious, and that the carbonic acid gas then falls, by its greater specific gravity: this gas is considered necessary for vegetable life; plants take it up, and return an equivalent in oxygen,—thus the proper balance in nature is preserved. It is considered, on the principle that nature should be assisted in her operations, the vitiated air formed in rooms during occupation should be drawn off continually at the ceiling, as its state of levity assists the expulsion. It has therefore been usual to provide openings in the ceilings of large rooms, to permit the expanded air to escape. Mr. Tredgold recommends a domed ceiling, with the opening in the centre, with means,

* Tredgold on Warming and Ventilation.

by a plate or regulator, of opening or closing the aperture to any degree, at pleasure; the fresh air, in the mean time, entering at the lowest part of the room, from flues which take their supply from the highest part of the building. On this system of ventilation, which has been termed "spontaneous," Mr. Tredgold observes, "that ventilation is most difficult to maintain in close, still, and gloomy weather." Upon this passage another writer remarks,* "He ought to have added, that it is impossible to obtain adequate ventilation under such circumstances, according to his system. For, as the whole basis of spontaneous ventilation depends on the possibility of producing a current in the air, it will be obvious, that when the exterior atmosphere is in a state of repose, and more especially when it is nearly saturated with water—that it will be difficult, or rather impossible, to create an adequate current for ventilation."

The mere leaving such outlets in the ceiling for the expanded air to escape is found insufficient in practice, when, opening at once into the external air, they produce all the evils resulting from window ventilation.

The air is a fluid which presses in all directions; it will enter an opening above our heads, with the

* Theory and Practice of Warming and Ventilating Public Buildings, &c., by an Engineer; published 1828.

same force as the window at our side. The slightest cause, independent of the superior density of the external atmosphere, such as the course of the wind, the casual currents in the room, will prevent the ready exit of the air, and the cold from without is quite as likely to press in as the impure air to pass out. Who has not felt the cold currents of air descending on his head when he was in a large room, occupied closely, although sashes in the skylights were opened to produce a contrary effect?

It is necessary, in order to procure proper ventilation, not subject in any great degree to be thus counteracted, to make use of mechanical means to draw the air out of the room, and expel it through such openings: the best manner to do this is, to warm by any practicable means the openings in question; in fact, to make artificial fire-places of them, calculated to draw, or force, the air from the room, rarefy it and pass it upwards, this operation being assisted by the colder air pressing behind; any current descending such opening is rarefied by the heat within it, and returns.

The Marquis de Chabannes, to whom the credit is due of first applying practically this system of forced ventilation into buildings, placed the mouths of his ventilating tubes at the ceiling, connecting them with one principal tunnel or tube in the centre of the building, and this alone was warmed, either by the admission of steam into chambers surrounding it, by a small fire-place formed within it, or by the flames of gas. The hot chamber thus produced drew quickly the colder air out of the ventilating tubes, rarefied it, and a continual supply of colder air pressing from beneath, it passed upwards. This tunnel was provided at the top with a cowl to prevent a downward current.

To this excellent contrivance for the purposes of ventilation, the Marquis united a stove for heating the air to supply rooms thus purified. This stove, called the Calorifère Fumivore furnace, one of the best constructions of its kind, could send a volume of heated air into every room of a moderately extensive mansion.

Although the air thus introduced might not be vitiated in any great degree by the stove, it was necessarily of a high temperature; and it being the nature of heated air to ascend towards the ceiling, where the mouths of his ventilating tubes were placed, the warmth must have been drawn off to a very great degree. The ventilating process, thus rendered the warming one nearly nugatory, yet it was probably for the *latter* purpose, that the apparatus in private houses had been principally introduced.

This cause, together with the difficulty, which must always attend hot-air systems, of introducing it safely and at a moderate expense in private houses, prevented its general use.

In our Theatres, in our Houses of Parliament, and in all our large public rooms, the system of ventilation by warming openings in the roof has been carried to a great extent. These remarks on the probable failure of the Marquis de Chabannes as applied to private buildings, shows that the openings for the purpose of ventilation must be placed with reference to the system introduced in the rooms in order to become efficient.

It is easy, by means of forced ventilation, to draw or change the air of a room either at the ceiling or the floor, and to regulate its exit at our pleasure. When air is heated by stoves, and enters a room in small currents, at an elevated temperature, it ascends rapidly towards the ceiling, making that part probably of an overpowering heat, whilst the lower part of the room still remains cold: air of such different temperature does not readily blend together; therefore, the tubes used in ventilation should in this case be placed at or near the floor, and the colder air be drawn off: this, besides securing a change of air, equalizes the temperature of rooms warmed by this method; the warm air is forced to descend, and mix more intimately with the colder air in the room, and is drawn off itself when cooled.

When hot-water or steam pipes are used, the air can be warmed only to a moderate temperature, and this readily admits the ventilating openings being placed at any desired point.

As regards the placing of the ventilating opening, great difference of opinion exists. It must be admitted that it is the nature of all warmed air to ascend through air of a cooler temperature, and consequently a certain degree of the benefit of any warming apparatus must be lost if the ventilating opening is placed at the ceiling. In rooms, therefore, where it is only desirable to have a constant airing and warmth, it becomes a question whether the lower part of the room is not the best and most economical situation for the ventilation to proceed from. Mr. Perkins's system of one-inch tubes becomes, joined to the warming of a building, a forcing power in procuring ventilation in a safe easy manner, such as no other system either of heated water or steam is capable of insuring to the same extent: the ventilation-openings can be placed at any convenient point, and if a lower one is preferred, or is of importance in equalizing the artificial warmth, it can be had singly or in conjunction with another at the ceiling.

In the ventilation and warming of a private dwelling, the staircase should be first commenced with: this we ought to consider the principal artery of the house; and if it was well warmed by a current of warm fresh air flowing into it, and a constant change effected by a ventilating outlet, warmed so as to insure its operation, great part of the business would be performed, as the staircase would supply all rooms not in use with warm air in a sufficient degree, and would gradually ventilate the whole building, rendering it unnecessary to have further ventilation, except in the principal living and sleeping rooms of the family.

Where the latter was desired, by placing two or more spare columns of tubing in flues concealed within the thickness of the wall, two flues, or even one flue, properly constructed for the purpose, might be made to ventilate every room of a London house.

In inspecting Plate 1, it is obvious that if the ascending and descending columns of tubing *a* and *c*, *c*, were placed in a perpendicular flue, which passed in its course two or more stories of small rooms, it would effectually ventilate them all, provided openings were made from each room of the flue for that purpose.

In a house warmed by this system, we could easily contrive to place the tubes connecting the pedestals on the different floors in one or two spare flues of this description, if they were provided, and we could then obtain what we desired.

The common-size flue, fourteen inches by nine, is too large for the purpose; it should be divided into two by a half-brick partition carried up for the expansion tube to rest on, as shown Fig. 1, Plate 13. Fig. 2, shows an additional $4\frac{1}{2}$-inch flue on each side, for the

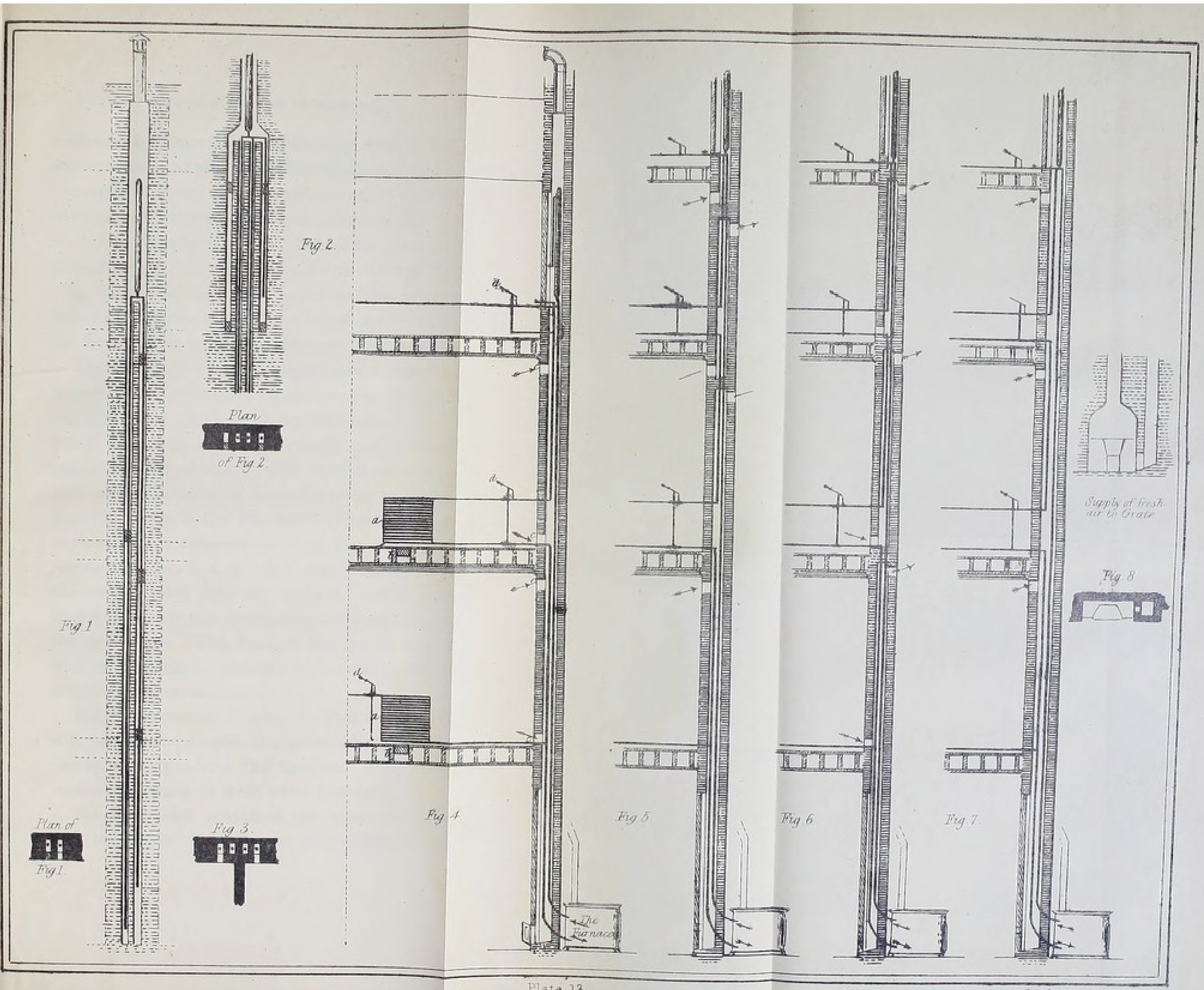


Plate 13

Day & Son Lith^rs to The Queen.

rooms in the upper story. Each room should have its separate flue, the whole of which should of course be perpendicular; and as the houses in London are generally two rooms deep, two such groups of flues only would be required; if the two were joined and placed in the centre of the house as shown in Fig. 3, having only one outlet at top, opening below the chimneys, and carried from them by a tin funnel, they would be still more effectual.

The warming of the different rooms might then be effected by branching pipes from the descending column in the flues to the pedestals, a stop-cock being placed on that part of the tube where it entered the apartment. This would enable us to turn off the circulation from the room, and confine it to the pipes in the flue at our pleasure. Fig. 4, explains this arrangement: *a*, *a*, are coils on the different floors; *b*, *b*, are flues for the admission of the external air into the pedestals which cover them; *c*, *c*, are the ventilating outlets; *d*, *d*, are the stop-cocks. The flues at the top should have thin metal funnels, provided with caps, to prevent downward currents of air.

Before descanting further on this arrangement, it is proper to consider the practicability of introducing the pipes into the flues, and how we shall have ready access to them when necessary.

The flue which contained the pipes which were first introduced to warm the print-room and bird-room at the British Museum, was not built originally for the service. The whole height was sixty feet, the pipes being placed in it from the top. In a private building, the pipes inserted in a flue in this way, and intended for ventilation, might be of short lengths, with the joints carefully placed opposite to the apertures opening into the flue.

At the entrance of the flue at the basement, and at the upper part where the expansion tube would be placed, openings should be left about six or seven feet in height, closed with moveable panels. This would render access to the expansion tube at all times easy, and the tubes could be placed or replaced in the flue at any time when it became necessary.

Having shown the practicability of this arrangement, let us examine the advantages to be derived from it.

All the openings into the flues, about six inches square, would become, as soon as the fire was lighted in the furnace below, so many artificial fire-places, deficient only in the presence of radiant heat and flame. They would draw from the room a constant current of cooler air into the flue, which, being warmed to a very high temperature by the great quantity of pipe within it, the current of warm air would rapidly ascend into the open air above, thus constantly ventilating the room without attention or inconvenience.

The warm pipes, or the expansion-tube, being carried to within a few feet of the funnel, would preclude the impure air drawn into it from re-entering the apartments.

The kitchens of our houses are not included in this provision for ventilation, as the large fires usually kept in them are more than sufficient for every purpose.

In summer time, the circulation might be turned off from the whole of the apartments by the stop-cocks, and the effects of the heated water confined within the flues. The ventilation would proceed as usual, and no additional warmth be experienced from the action of the pipes.

This arrangement has a great advantage in a climate so changeable as ours, if we happen to have a cold day in June, or any of our summer months (an effect we frequently experience), the stop-cocks being unturned, the circulation would proceed through the coils in our apartments, and enable us in a short time to regain the warmth of which we had been unexpectedly deprived.

The admission of the external air at any desirable temperature, in order to supply the quantity drawn off, is an easy matter, and we can resort to methods that will lessen the effect of the current its entrance produces.

Although no current of warm air entering a room, when only of a pleasant temperature, could be thought disagreeable, yet, in this age of refinement, an apparatus for ventilation not capable of obtaining the removal of all that was objectionable, would be deemed imperfect.

It will be seen, on inspection of Plate 13, Fig. 4, that while the natural current of vitiated air is provided with an aperture at the ceiling, a lower opening into each flue is placed at the floor. This will tend in a great degree to neutralize any such current, and likewise materially assist the purification of the room, if the heavy nature of the carbonic acid gas prevented it being wholly drawn off at the ceiling. The advantage of having a flue the whole height of the building to receive these tubes enables us to draw the air out of a room at any point: by the lower opening the temperature of the room is equalized, and a tendency given to allay any sensible current; and, if the upper door is only partly open, it will assist in carrying off the effluvia of the room. The superiority of this method over the hot-air systems, in which you are (in order to procure an equal temperature) obliged to have a door below, and none above, is apparent.

The operation of regulating currents is one of great nicety, but yet it may be easily effected: moveable slides might be placed before the openings, so that they could be enlarged, or contracted, according to necessity. The airing of bed-rooms is of more especial consequence, as it must be remembered that our climate is more damp than cold, a fact known to every one by the necessity of airing beds which have not been slept in for three nights only.

In rooms which are occasionally occupied by large assemblies, the size of the ventilators becomes a matter of calculation for the architect who undertakes the business. It must be remembered, that by increasing the temperature in the flues, they become more effective, and that the perpendicular form of them adds very materially to the draught.

With the warming and ventilation of a dwelling, managed by this apparatus, we should not depend for the supply of pure air in our rooms on the action of doors and windows. Let them remain as tightly closed as the skill of a modern joiner can make them; without their aid the air within will be maintained as pure as the air without. It can be raised to a warm temperature capable of being supplied higher or lower as desirable. The operation would be performed gradually, yet continually, giving at once the advantages of the open air and a genial climate, and at the same time be free from the evil effects of draughts and currents.

In summer the ventilation would be perfect, and tend to lower the temperature occasioned by the state of the weather, and this constant admission of pure air could be extended to every room in our dwelling.

Unless a system of warming is formed in conjunction with one of ventilation, it will not be calculated to produce the benefits desired; and if both cannot be obtained with safety and economy, such system can never be one of general utility and extensive adoption. That which is here investigated and recommended, appears more likely to answer these salutary purposes than any other which has hitherto employed the minds of the learned, or been offered to the consideration of the public.

Nothing can be more important and interesting to every individual, than obtaining purification of the air which he breathes, and proper regulation of the temperature in which he dwells.

A gentleman whose house was provided with the means above described, for insuring that which was excellent in both cases, would naturally interest himself in the management of them, and in consequence of the simplicity of the contrivance, would be independent of the services of his domestics, beyond that of lighting the fire below. He could provide in all his rooms pure air and pleasant warmth, could sit in any of them without being subjected to hot or cold draughts, and regulate the admission and discharge of air with equal ease, whether he were the sole occupant, or the entertainer of a considerable party. It is difficult to conceive any greater luxury, or more refined comfort, than such an apparatus in a dwelling-house would supply.

To this must be added, that the cheering sight of a fire-place, if required, could always be had in rooms thus aired and warmed, so that no source of pleasure and comfort is withheld, in consequence of those which are most important being thus supplied.

It may be remarked, that our houses never require such a degree of ventilation and warming as just described; and that to the extent described it would be too expensive for the generality. Although the latter may be true, the former cannot be so readily subscribed to; yet, if the staircase, the principal artery of the dwelling, was well warmed and ventilated, great part of the business would be effected; to do this, let the furnace be placed outside the house (it might, for economy, be placed in a laundry), the ascending and descending columns of tubing placed in a corner of the staircase, reaching from the basement to the attic-story, and remaining exposed; the pipes might branch off and encircle the rooms on the bed-room floors, keeping them warm without requiring any attention; they could likewise warm the hall below; with this arrangement, if in a convenient part of the staircase a coil and pedestal were placed, permitting a current of external air to pass through it, and a similar contrivance being again formed in a remote part of the staircase to draw the air in an equal degree out of it, it would form an excellent mode of ventilation for the whole building.

The simple arrangement of the tubing just described, shows with what facility the private dwelling, piled story upon story, can be warmed and ventilated. Hitherto no method but that of the common fire-place has found favour with the public: the introduction of the warm-water tubing would not only create an equal temperature throughout, which the fire-place does not do; but it could be made to provide warm baths, give us hot water in our dressing-rooms, heat drying-closets, ovens, and other essential requirements.

To warm and ventilate great public rooms in which large and small assemblies are in the habit of collecting, to introduce the warm air in certain proportions without any sensible current, and to abstract the vitiated air in a regular constant stream, requires a different arrangement of tubing to that proper for a private dwelling. To secure successful results in such cases, often a most difficult matter, requires considerable study and attention on the part of the engineer or architect. The apparatus must be expressly arranged to suit the room, and every local advantage must be secured to aid the operation.

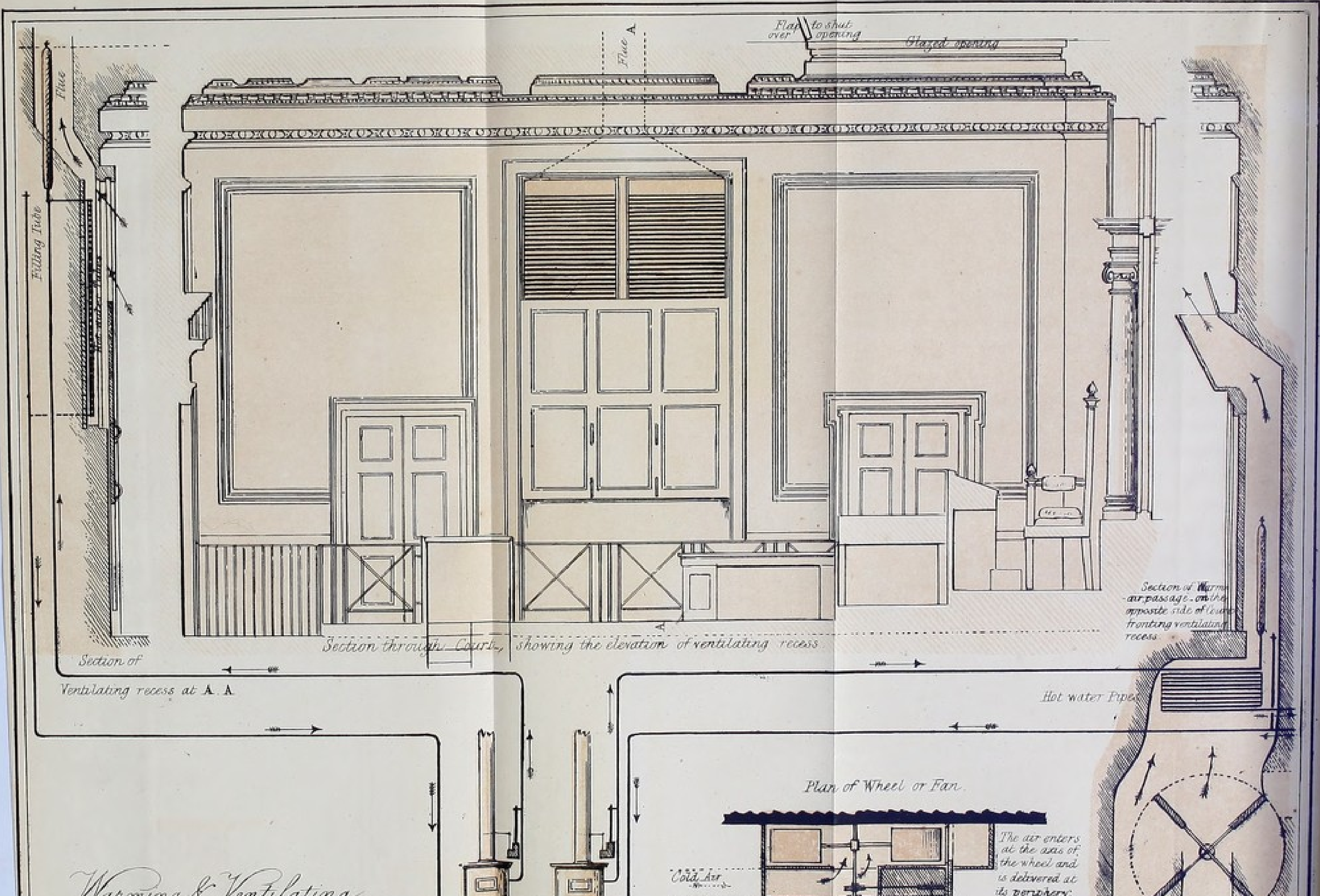


Plate 14

Day & Son Lithrs to The Queen

The very well-known room in the metropolis, the Lord Mayor's justice-room at the Mansion-House, has lately been very efficiently warmed and ventilated, under the direction of Mr. Bunning the city architect; the method by which it has been effected is represented in Plate 14.

Two small furnaces are placed on the basement, under the court, one of which is used for the warming, the other for the ventilating process; about 800 feet of tubing is made use of for the purpose.

For the warming, a coil of pipe is placed in a chamber through which the fresh air is driven by the mechanical contrivance of the fan. In summer it is forced in at its natural temperature, or it could be easily cooled by artificial means. The entrance of the fresh air into the court is over a blank door, at an elevation of eight or nine feet from the floor, from which height it diffuses itself over the court without any sensible draught or current.

The ventilating process is of a very novel character: the outlet for the vitiated air is placed on the opposite side of the room to that where the fresh air enters; it is a flue twenty inches square, and is the only outlet that could be obtained for the purpose, the Lord Mayor's justice-room being immediately beneath the great ballroom. Under the flue is a recessed panel, occupying nearly the whole height of the court; in this panel is placed a series of horizontal tubes, seven feet six inches in width, and eight feet in height: the furnace connected with this tubing is always in operation, both winter and summer. The effect of the tubing is similar to that of the open fire-place; radiant heat from the tubes is given off into the court, while the air being warmed immediately under the flue, a quick passage of the air from the court passes up it.

A slide moving up and down is placed in front of the panel, leaving an aperture only as large as the opening of the flue above; by moving this either to wholly cover the tubes or to leave them exposed, any required degree of ventilation can be obtained; by shutting it, the whole of the heat is confined to the flue; and should a damp or cold day occur in summer, the radiant heat from the tubes is immediately obtained.

The plate shows with sufficient distinctness the whole of this arrangement: the panel containing the tubes is lined at the back with glazed tiles, so that the heat should not be absorbed by the wall behind, and the moving slide is lined, first with felt and then with iron.

Connected with the warming apparatus are additional pipes which warm the cells in the basement of the building: these it was not necessary to show in the plate.

Another court-room very successfully warmed and ventilated under Mr. Bunning's direction,

Plate 15.

Day & Son, Lith^rs to The Queen.

is the third Criminal Court at the Old Bailey. Dr. Reid had previously been employed by the Corporation of the City of London to warm and ventilate the old and new courts in the same building: the system he introduced was the common one, treated on his usual large and powerful scale; by its use the whole body of air in the two courts could be changed in a few minutes. The operation practically met with great objection, as the velocity with which the warm air entered the court, which it did through numerous apertures in the floor, cooled the bodies and legs of the persons standing or sitting above; a sensation of cold being experienced by them, although the air introduced was warm. To obviate this, Mr. Bunning introduced the warm air into the third court, which was erected under his superintendence, over the heads of the parties occupying it, letting it enter in large quantities and diffuse itself equally throughout. An inspection of the plate will show how this is effected: the panelling projects from the wall about six inches, and the space thus formed is the passage by which the warm air enters; it is forced in by the large fan or wheel put up by Dr. Reid, for the other two courts: this fan is twelve feet in diameter and seven feet in width, and is propelled by a steam-engine.

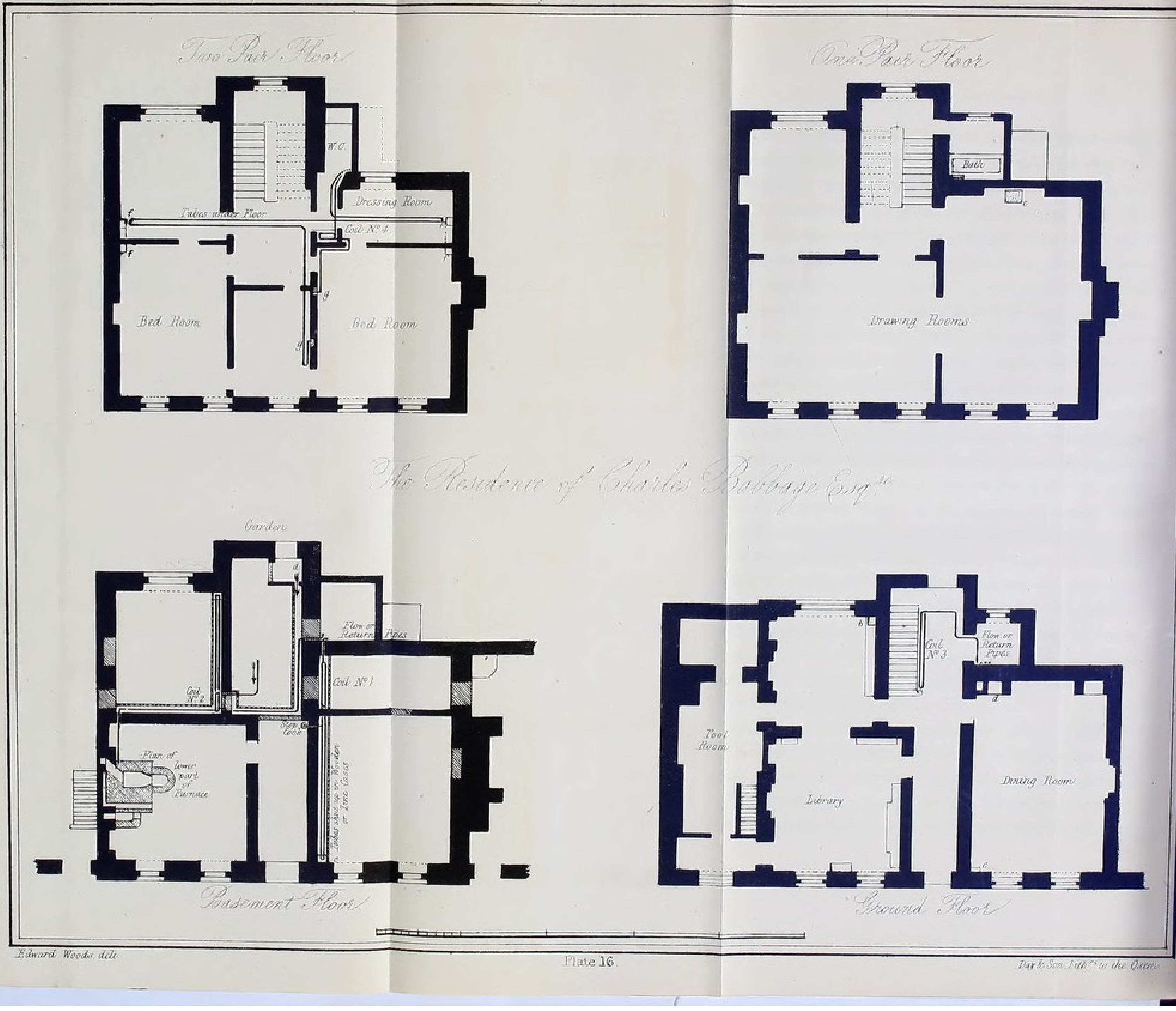
Mr. Bunning, without erecting or using any fresh furnace for the third court, made use of the spare steam from this engine for the purpose of warming.

Mr. Perkins's tubes, instead of being filled with a circulation of hot water, are warmed by the free passage of this steam through them : from the coil in the ventilating chamber above the roof the steam passes into the atmosphere; from that in the fresh-air chamber under the court, the steam escapes into the drain. Both coils contain about 900 feet of tubing each, which is warmed to 220 degrees, about half an hour after the lighting of the fire.

To please all parties in the warming and ventilation of a public room of this description, is one of the most difficult, if not really unattainable, tasks that can be imagined. At present the apparatus is considered a great benefit; it has produced a genial warmth in the court, and the officers, barristers, and lawyers, admit they no longer experience the inconvenience they feel in the other courts.

The following Plates, Nos. 16 and 17, which close the present collection of examples, illustrate an apparatus which has been made, by skilful mechanical contrivances, to produce some of those conveniences and luxuries which might be more generally applied than they are at present in the dwellings of this country.

At the commencement of the winter of 1837-38, Mr. Babbage introduced Mr. Perkins's apparatus into his house. Desiring to secure every advantage, experiments were made by him,—first, with a view to secure economy in fuel, with the perfect regulation



Edward Woods, delt.

Plate 16

Day & Son, Lithrs. to the Queen

or control of the combustion; secondly, the power of warming any portion of his house separately from the rest.

The value of the contrivances introduced for these purposes will be best understood by an inspection of the plates, and a perusal of the following description.

The different floors of the building are represented in Plate 16. The furnace is placed in the basement: here, about six inches under the ceiling, the tubes are inclosed in air-channels, formed of wooden frames with zinc panels. By pasting paper on the two sides of the frame, two layers of air are formed, which tend to confine the heat within the channels, and prevent its being wasted on this floor, as those tubes are only intended to warm the rooms above.

On an inspection of the plan, these inclosures will be seen in four of the rooms; at the point *a*, in the direction of the arrow, the current of fresh air for the flues is obtained from the garden: the supply is shut off at night.

At the points *b* and *c*, openings are made in the floor above; from these the warm air rises into the library and dining-room, on the ground-floor.

The coil No. 1 is intended to warm the drawing-room, a channel *d*, being formed to convey the warm current of air to the outlet *e*.

On the ground-floor the coil No. 3, containing

104 feet of tube, is placed in the centre of the staircase; it has an air-flue beneath it, framed in a similar manner to the other flues, and drawing a current of fresh air from the same point.

The tool-room in this floor is always kept at a temperature of from fifty degrees to fifty-four degrees in winter, which is effected in this way: the furnace is separated from the party-wall by an empty space of about four inches; a small current of air is brought under one part of the furnace, and passing through this space arrives in the tool-room moderately heated. By these means the cellar beyond the party-wall is saved from injury by heat, and the tool-room is sufficiently warmed for its purpose. It may, however, be proper to remark, that the room has a double skylight; the staircase in it leads down to the wine-cellar.

On the right of the principal staircase is a small room used as a hat-room; here are placed the flow and return pipes, and the coats and gloves are, even in the dampest weather, always kept dry. Over this room are the store-rooms, the bath, and water-closet, through all which the pipes pass in their way to the second floor.

Near them are the water-pipes of the building, which are thus prevented from freezing, even in the coldest weather.

On the second floor the return-pipe runs through a channel in the floor between the rafters, of about ten inches square; there are about seventy feet of pipe, and this warms slightly the air which passes into the channel from the staircase: it is introduced into the bed rooms and dressing-rooms during the night. Apertures for the warm air to ascend are shown at *f*, *f*, *f*, *f*.

On this floor is the cistern which supplies the bath; it is delineated in the one-pair plan. This cistern has within it a coil of twenty feet; the quantity of water it holds is sufficient for about $2\frac{1}{4}$ baths.

The cistern serves also to heat the dressing-room; it is of copper tinned, and the top is covered with wood, with zinc panels, to keep the steam in. It is fed from the cold-water cistern. The cold water flows in as the bath fills, the warm-water cistern being supplied for that purpose with ball-cock, &c.; if two warm baths are required, one immediately after the other, the run of cold water may be stopped.

These two cisterns supply hot and cold water in the dressing-rooms, for the washing-basins, cleansing the house, &c.

The expansion-tube is placed in the attic, the ascending and descending pipes to it are placed in the two small flues *g*, *g*. These flues are used to give a slight ventilation to the bed-rooms and drawing-rooms below.

Having now described the general course of pipes in the building, it may be proper to enter minutely into the construction of the apparatus and its management.

The apparatus is divided into four circulations by an equal number of return-pipes from the upper part of the building. These pipes are united together at one point before they enter the furnace. At this point Mr. Babbage has placed an ingeniously-contrived multiple-cock, Fig. 1, Plate 17, by means of which the four circulations can be carried on either separately or together, as required.

On inspection of the figure, the four return-pipes are shown as entering at the sides. The first circulation warms the bath; the second the library and stairs; the third the drawing and dining-rooms; and the fourth the bed rooms.

The bath is twenty-five feet above the fire, and it is possible to heat it sufficiently, even when the flow-pipe is less than 212 degrees. The time usually required for heating the bath depends upon the heat of the furnace; but when the bath-cistern has been once heated up to 160 degrees, which may be done in an hour, it remains sufficiently warm for a bath during twenty-four hours.

Any two or three, or all four of the circulations, can be worked together, by simply turning an index provided for the purpose, on the upper part of the cock.

The figures in the plate are copied from the

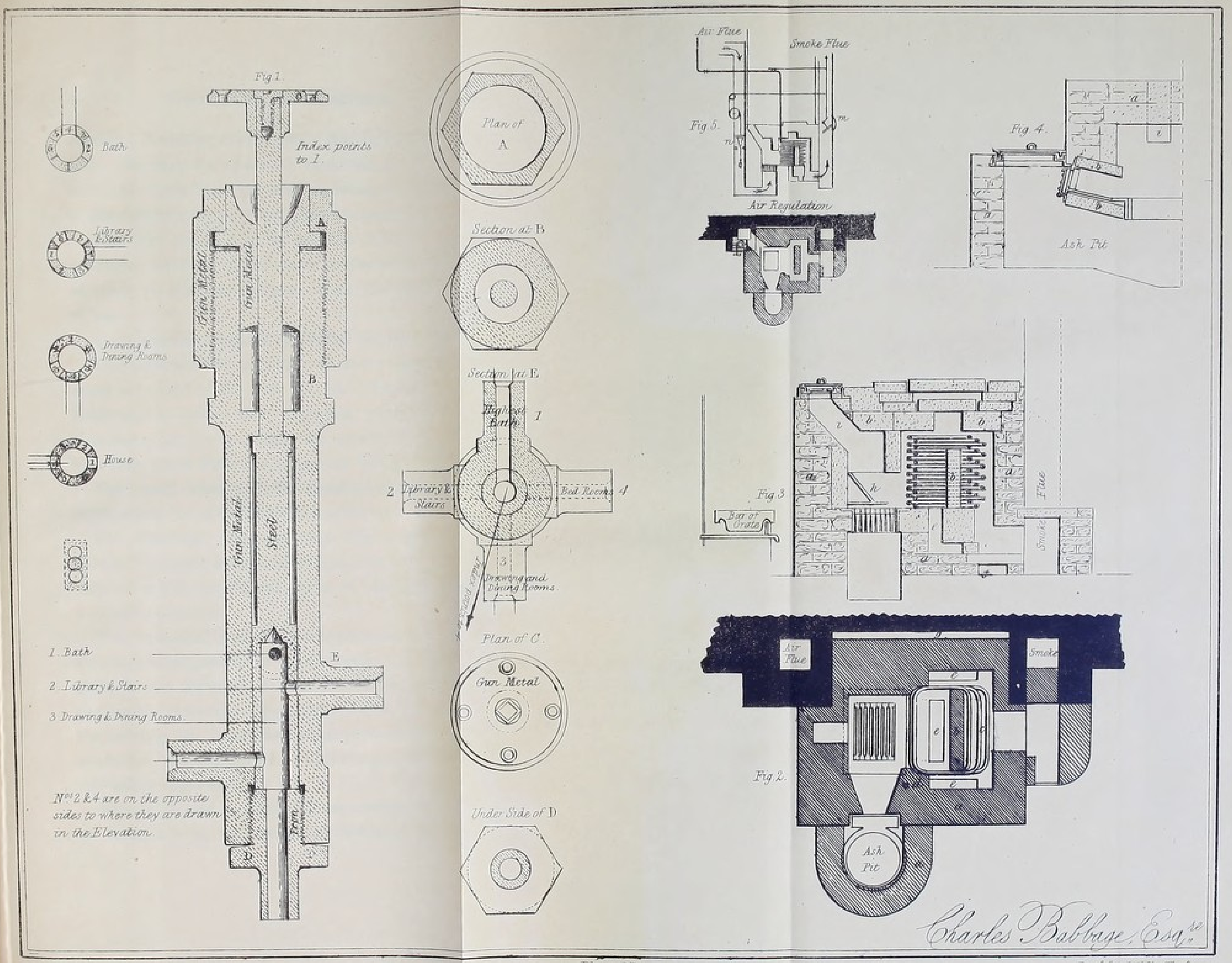


Plate 17.

Day & Son Lithrs to The Queen

working drawings made under Mr. Babbage's direction. It may be observed that, being an experiment, the cock is rather costly, being stronger than is absolutely necessary for general operations.

The four small figures on the left of Fig. 1, represent sections of the steel cylinder or plunger, at each of the circulations, when the bath only is in use.

An important diagram is placed beneath these.

The steel cylinder has two or more openings for every entrance of the pipe into it. These openings being placed rather close together, permit a slight circulation at every point; no accident can therefore take place from the stop-cock being quite shut.

This must always, in the construction of such an instrument, be particularly attended to.

Mr. Babbage suggests that the multiple-cock should be made larger, as in that case more combinations could be formed, each of which might be worked separately.

The principal part of the apparatus, the formation and arrangement of which requires the greatest skill, is the furnace: to this Mr. Babbage has paid particular attention; and although, in his opinion, his own is far from the most perfect that can be made, he has succeeded in obtaining a very perfect *self-acting regulation*.

Figs. 2, 3, and 4, Plate 17, are sections and plans of furnace:—*a*, represents brickwork; *b*, Welch lump; *c*, inch tubes; *d*, the situation of an iron rod, which, by means of a lever acting below, lifts up every alternate bar of the grate, and thus breaks up the clinkers when hot; *e*, wells for the dust; doors are provided for cleaning them out; *f*, a small flue formed under the furnace, communicating with the space *g*, the warm air from which is conveyed by a small opening into the tool-room;—the current through this passage is very strong, and the room is kept at a temperature of 50 deg. and above during winter.

The space *g* has another use; it isolates the furnace from the wall, and protects the wine-cellar on the other side; *h* is a temporary iron plate intended to push the fuel more towards the pipes, likewise to try the effect of more intense combustion at one point;—this is attained by limiting the supply of air to the space only between two of the bars of the grate; *i* is the aperture for the supply of fuel.

In order to make the furnace air proof, all its openings have double doors, the outer of which have sand-joints; this is shown clearly in Fig. 4; the frame which receives the lid having a deep groove going all round, filled with sand, into which a projecting rim on the cover is sunk. The inner doors have a piece of talc inserted in each, to admit a view of the fire without the necessity of lifting the door off.

The Welch lumps, which form the top of the furnace, are laid in sand, and can therefore be taken off, and ready access can at all times be obtained to the coil.

The way in which the supply of air is managed is shown in Fig. 5. The flow-pipe ascending from the furnace is fixed firmly to the wall at the point *c*; an inflexible rod is fastened to this tube at *k*, which is connected with the lever *l*, acting upon the damper *m*, in the chimney.

There is also attached to this lever a metal chain, which passes over a pully, and regulates the air-flue.

As the expansion of the flow-pipe takes place by the heat, it moves towards the smoke-flue; at the same time the lever *l*, moves to the right, the damper closes in proportion, and the cylinder in the air-flue is drawn upwards, allowing the conical valve to drop.

The supply of air, and the consequent combustion and quantity of fuel, is thus regulated by the fire itself. It is not possible to make a brick furnace quite air-tight, the bricks being porous; in this furnace it has been found that a sufficient quantity of air is admitted through the brickwork or through the sand-joints, to maintain a slow combustion during the night, when the air-valve is quite closed.

The fire is never suffered to go out after it has been lighted, except it be necessary to remove the clinkers. This occurs about once a fortnight. In the morning, about seven o'clock, the fire is well raked by means of the lever. Coal or coke is then supplied, and the air-valve opened. The stop-cock is then turned to supply the coils for the library and stairs. At about eight o'clock in the evening, the house being sufficiently warm, the stop-cock is turned to heat the coil of the bath; and at eleven o'clock, fuel having been supplied, the air-valve is completely closed, and the damper also if necessary.

By these means the fire burns very slowly during the whole night, and the bath cistern receives the warmth thus generated.

From thirty to eighty-five pounds of strong coke has hitherto been consumed during twenty-four hours, according to the state of the weather.

Mr. Babbage's object was to use the apparatus at a more moderate heat than is usually applied, and to maintain a uniform temperature.

He finds that the regulative power is perfectly effective; that warm fresh air is supplied to the library, staircase, tool-room, and hat-room, without in any instance the offensive smell of burned air occurring.

That hot water may at any time be had on the second floor, and that a bath is always ready.

The following page, extracted from a book kept by Mr. Babbage's direction by the servant who attends the fire, proves the great delicacy which has been attained in the regulation.

Sunday, 3rd February, 1838.

	Thermometer on flow-pipe.	Thermometer in chimney.
8 0 A. M. ...	... 185°...	... 116°
9 0 ...	... 225 ...	... 130
9 40 ...	... 244 ...	... 132
10 15 ...	... 249 ...	... 176
11 20 ...	... 249 ...	... 182
12 30 P. M. ...	... 249 ...	... 178
1 50 ...	... 249 ...	... 180
3 20 ...	... 240 ...	... 182
4 30 ...	... 249 ...	... 184
5 50 ...	... 247 ...	... 146
7 30 ...	... 235 ...	... 135
11 0 ...	... 229 ...	... 202

From this it appears that a temperature of about 247 degrees was kept uniformly during the whole day with only a deviation of four degrees below and two above.

It is found that the thermometer in the smoke-flue seldom equals 212 degrees, when that in the flow-pipe equals 240 degrees.

The whole quantity of pipe in the building equals 891 feet.

The quantity in furnace, 135 ;

The stairs and library circulation has 222;
The dining and drawing-room 283;
Bath 200;
Bedrooms, including expansion-tube, 322.

The quantity of pipe in the furnace is proportioned to the whole circulation, but the expansion-tube acts as a safety-valve when the smaller ones are in action.

It is very desirable, when the fire is low, that the air-valve and damper should open to their full width instantaneously, and as the fire rises that they should shut rapidly. A second damper and air-valve, to be managed by hand, should be provided immediately above the former.

The bath-coil should be as near the bottom of the cistern as possible.

It is desirable, in the formation of the furnace, to have the fire inside the coil.

The low temperature in the flue is assisted by obliging the heated gases which rise from the fuel to pass downwards, and by the return-pipe, which has given off all its heat in its passage through the house.

The following recapitulation shows what was desired, and what has been obtained.

1st. To keep a uniform temperature in the pipes for a long period of time. This has been completely accomplished by the regulator.

2nd. Cheap, effective, and durable air-channels. This has been effected completely by zinc panels and brown-paper coverings.

3rd. To allow a very small portion of the heat to ascend the chimney. This has succeeded.

4th. To apply the whole heat of the furnace to any part of the house by one simple process. The stop-cock does this perfectly.

5th. To keep the fire very slowly burning during the night, and to avoid the trouble of lighting. This is done.

6th. To rake the fire effectually without opening any door, and also to break up the clinkers when red-hot. The alternate motion of the bars does this.

7th. To have a warm bath at any period of the night or day, without the necessity of giving any directions to servants for that purpose. By having rather a large bath-cistern this is accomplished.

The apparatus at Mr. Babbage's has continued in constant action to the present time, producing, as that gentleman declares, a very great amount of comfort; it saves servants' labour in cleaning, lighting of fires, is economical, and causes little dust. The brick furnace has been replaced by an iron one, similar in principle to that shown in Plates 3 and 4, but only on a larger scale; this performs all the functions of the former furnace in a more complete manner. The fire is kept up for six months, at a slow combustion, the consumption of fuel being about a bushel of coke in the twenty-four hours.

The small scale of the plates will not permit the whole of Mr. Babbage's ingenious contrivances connected with the apparatus to be shown: his rooms in winter are at the various temperatures he requires; his dressing-room is kept a few degrees warmer than his bedroom, an inducement for early rising; his linen is aired, and warm water is provided in the dressing-rooms and for the use of the servants;—and this is done with entire safety to the building. As regards this latter important consideration, the following letter shows that in using the high-temperature tubes no danger need be apprehended:—

County Fire Office, 50, Regent Street,

London, 5*th September*, 1855.

Sir,—Having experienced for upwards of ten years the great comfort derived from the use of your system of heating by hot water, and having been largely benefited by its economical working, I may with great confidence offer the aid of my testimony, both as to its efficiency and freedom from danger.

In our large offices, as also in my private house, I have used it, as before stated, for many years.

I may state, in confirmation of my opinion, that the directors of this office accept readily, and at the lowest rate of premium, all proposals for the insurance of buildings in which your system is adopted, and without even the customary inspection; so satisfied are they of the absence of all danger.

I am, &c.

J. A. BEAUMONT,

Managing Director.

A. M. Perkins. Esq.

P.S.—You may make whatever use you please of this letter, which I have written in acknowledgment of the great advantages which I am sensible of having derived from your labours.

The means for warming and ventilating, either large or small buildings on the high-temperature hot-water system, must be varied according to circumstances and to the discretion of the architect. The quantity of feet in pipes necessary to raise rooms of a certain size to a given temperature, must be proportioned to their cubical content; and this depending as well on the situation and aspect of the building, the number of doors, windows, or skylights, no rule can be given with certainty which should be applicable to all places.

The aid of practical experience is called upon in behalf of every building at all distinct from the generality; and practical men must be consulted where any difficulties are likely to arise.

The insertion of a warmed surface in a flue, in order to effect ventilation of rooms, is mentioned by Tredgold; and on this contrivance he depends principally for the general purification of an hospital.* The situation of the one-inch pipes at the British Museum pointed out, that, if the spare pipes in Mr. Perkins's system were arranged in a similar manner, an efficient ventilation of buildings might be procured, and the warming system assume a form of which it has never been deemed susceptible.

Colds are caught in our climate, almost as fre-

* "Let a pipe, on the principle of a distiller's worm, pass from the top of the boiler up the middle of a trunk or air-tube, through the closets, and return to the boiler by a smaller pipe, furnished with a cock to let out the air when the apparatus is set to work. The steam which rises and condenses in the steam-pipe, will afford a continual supply of heated air in the trunk, which being made open at the top, with a vane to turn its mouth from the wind, and being supplied only from the closets, its effect will be to draw a continual current of air from them, while they are supplied with other air from the passages of the house.

"Another method may be employed in this manner. Let a flue be formed, of a sufficient magnitude to contain a copper tube within, which copper tube should form the smoke-flue of a fire that is constantly kept on. The warmth which a pipe of this kind would communicate to the air in the flue round it, would cause an ascending current of air, which, being supplied from the closets, they would be constantly ventilated without trouble or attention. If the copper pipe formed the smoke-flue to a close or boiler fire-place, it would be still more effective."—*Tredgold on Warming and Ventilation*, p. 99.

quently in July as November, which may in a great degree be owing to our not possessing any other means of ventilation during the summer months than by opening doors or windows. If the close heated air could be drawn out of our rooms and pure air admitted in small quantities, and, when possible, from the shaded side of the building, it would be an advantage of which we have little idea at present.

The low temperature of the tubes of other warm-water systems, seldom exceeding 150 or 180 degrees, together with their large size, hinder their being employed to the extent done here with those of Mr. Perkins.

The importance of this system cannot be insisted upon too strenuously, or brought too frequently before us as a subject for consideration, and active exertion also. The opinions of medical men prove that the comfort of warmth in our habitations, when equally and moderately diffused, is conducive to health, a preventive of disease, and, in many cases, imperatively required by the delicate, the young, and the aged; we are alike injured by the warmth of over-heated apartments, and the cold currents too frequently admitted into them, when a renewal of air becomes absolutely necessary.

If our buildings were provided with effectual means for insuring a comfortable temperature throughout, how many of those losses, caused by influenza, colds, and such-like complaints, would be prevented! A climate, indeed, like ours, in winter, cold and bracing one day, warm and damp the next, essentially requires a protection for those who at the time may not be able to bear up against it.

Above all, the situation of consumptive patients should demand our especial attention, and insure for them every amelioration which science can suggest and affection furnish. This interesting class of sufferers, the young, the intellectual, and the virtuous, beings formed "of a finer clay," frequently informed also by a finer mind and acuter sensibilities than their fellow mortals, are now compelled, in their "day of visitation," to go forth as wanderers, and seek in a more genial clime that warmth which may renovate the shrinking frame; that equality of temperature which may preserve the good obtained; yet it is well known to all, that the peculiar comforts rendered necessary by the national habits, and more particularly demanded in the languishing hours of sickness, can nowhere be obtained on the continent. They necessarily leave the circle they love (the familiar faces, whose smiles can soothe, whose voices cheer them), to encounter the dangers of the sea, the fatigues of the land, the petty disgusts which annoy the weak, and the carelessness which wounds the suffering; yet there can be no doubt, if the architect was consulted as well as the physician, this trial might have been spared, health restored, and all the blessings of a long, happy, and useful existence insured, by that proper attention which he alone could give to the warmth and ventilation of their dwellings.

In proportion as a greater degree of warmth is imparted to our buildings, so will a greater supply of pure air become necessary. Hence the necessity of conducting the process of warming and ventilation on the soundest scientific principles, lest we neutralize the benefits of either.

Although this small volume has been confined to the description of one system, which, from close investigation of the subject and experience of its effects, shows itself to be the best, an architect ought to be well acquainted with every means of introducing warmth and comfort in our dwellings, and rendering them a sure safeguard from the evils of climate. He should be capable of applying all the different systems, so far as their respective principles will admit, to lay hold of whatever advantages the building affords him, and be particularly careful that what he introduces shall lessen, not increase, the dangers of fire. He should not leave the possibility of this evil as likely to result from the carelessness of servants, and remember that, although it is a difficult matter to insure success, it is a very easy task to warm a building by a kitchen or parlour fire, if any construction may be resorted to.

In the *new-fangled* contrivances, as builders may term them, which have been here treated upon, their opinions have been so far respected and the plans made so easy of adoption that no material alteration in the style of building is called for, and the appearance of the house would remain uninjured. There is no reason why the most extensive mansion, with warm baths, conservatories, covered walks for exercise, and stabling, might not be benefited through the same medium; the smoke, dirt, and dust being all on the outside of the building. The most ignorant domestic is capable of conducting it, and the small expense of fuel used, in proportion to the effect produced, combine so many recommendations of this system, that, sooner or later, it will be universally adopted, and the more intelligent portion of the community will countenance it at a very early period.

APPENDIX.

List of some of the Public Buildings, Churches, Conservatories, Mansions, Manufactories, and Offices, in London and in the country, where the Hot-water Apparatus of Mr. Perkins is in operation.

PUBLIC BUILDINGS, CHURCHES, ETC.

The British Museum (72 apparatuses)	London.
The Soane Museum	London.
Lord Chancellor's Court	Westminster.
Vice Chancellor's Court	Westminster.
Insolvent Debtors' Court	London.
Registrar General's Office	Somerset House, London.
School of Practical Art	Marlborough House, London.
Foreign Office	Downing-st. London.
Chancellor of Exchequer's Office ...	Downing-st. London.
Guildhall Law Courts	London.
Sheriff's Court...	Guildhall, London.
Lincoln's-Inn Hall and Law Courts	London.
Inner Temple Hall	London.
New Justiciary Court...	Edinburgh.
Kneller Hall College	Hounslow.
Chapel Royal	St. James's, London.
Chapel Royal	Whitehall, London.
Lincoln's-Inn Chapel...	London.
Gray's-Inn Chapel	London.
St. Andrew's Church	Holborn, London.
St. Andrew's Undershaft Church ...	London.
St. Margaret's Church	Lothbury, London.
St. George's Church	Botolph-lane, London.
St. Mary's Church	Park-st. London.

Christ Church	Kensington, London.
Christ Chapel	Maida Hill, London.
Bedford Chapel	Bloomsbury, London.
Wesleyan Chapel	Liverpool-st. London.
St. Peter's in the East Church ...	Oxford.
St. Paul's Church	Oxford.
St. Mary Magdalen Church	Oxford.
St. Giles's Church	Oxford.
Littlemore Church	Near Oxford.
Minchinhampton Church	Gloucestershire.
Putney Church	Surrey.
Clewer Church	Windsor.
Thorp Church	Staffordshire.
Presbyterian Church	Birmingham.
Wesleyan Chapel	Newbury.
Friends' Meeting-house	Peckham.
Friends' Meeting-house	Hitchin.
Lock Hospital Chapel...	Paddington.
Governor's House	Royal Hospital, Greenwich.
Fever Hospital...	Islington.
Dispensary	Kensington.
Union Workhouse	Melton Mowbray.
Union Workhouse	Wellington, Somerset.
Lunatic Asylum	Northampton.
Lunatic Asylum	Surrey.
Lunatic Asylum	Hanwell.
London Provident Institution ...	Blomfield-st. London.
National Provident Institution ...	London.
County Fire Office	London.
Equitable Life Office	Bridge-st. London.
New Equitable Life Office	Charing Cross, London.
North British Insurance Office ...	Edinburgh.
General Steam Navigation Office ...	London.
London Joint-Stock Bank	Princes-st. London.
London and County Bank	London.
Union Bank (West branch)... ...	London.
National Bank of Scotland	Edinburgh.
Royal Bank of Scotland	Edinburgh.
Leicestershire Banking Company ...	Leicester.
Stroud Bank	Gloucestershire.
Mansion House Justice-room ...	London.
Coal Exchange...	London.

Sessions' House	Old Bailey, London.
Gaol of Newgate	London.
City Police Stations	London.
New Smithfield Market Banks ...	London.
Baths and Washhouses (Drying appa.)	George-st. London.
Baths and Washhouses (Drying appa.)	Endell-st. London.
Model Lodging Houses (Drying appa.)	Portpool-lane, London.
The General Register House	Edinburgh.
Religious Tract Society	London.
Sion College	London.
Sidney College and Chapel	Cambridge.
Shelton Schools (Earl Granville's) ...	Staffordshire.
City of London School	London.
Home and Colonial Schools	London.
East St. Pancras Schools	London.
Grammar School (Rev. J. B. Dyne)	Highgate.
Redmaid's Schools	Bristol.
St. Katherine's Dock Offices... ...	London.
Taxing Master's Office	Staple Inn, London.
Corn Exchange	Kidderminster.
Town Hall	Stoke.
Infirmary	Stoke.

CONSERVATORIES AND HOT-HOUSES.

Her Majesty the Queen	Royal Conservatory, Kew.
Her Majesty the Queen	Royal Conservatory, Buckingham Palace.
His Grace the Duke of Beaufort ...	Badminton.
Earl of Listowel	Knightsbridge.
J. Horsley Palmer, Esq.	Fulham.
L. Sulivan, Esq.	Broom House, Fulham.
J. T. Selwin, Esq.	Down Hall, Essex.
H. G. Dugdale, Esq.	Bordesly Park, Warwick.
W. S. Dugdale, Esq.	Blyth Hall, Warwick.
J. Levison Gower, Esq.	Bill Hill, Berks.
Jas. M. Richardson, Esq.	Blackheath.
G. Barclay, Esq.	Epsom.
Rev. T. W. Franklin...	Tunbridge Wells.
C. Duffield, Esq.	Marcham Park, Abingdon.
Earl of Harborough	Stapleford Park.

MANSIONS AND PRIVATE DWELLINGS.

Her late Majesty Queen Adelaide ...	Whitley Court and Marlborough House.
H.R.H. the Duchess of Kent ...	St. James's.
H.R.H. the Duchess of Cambridge ...	St. James's.
H.R.H. the Duchess of Gloucester...	Park-lane.
His Grace the Archbishop of Canterbury	Lambeth Palace and Addington Park.
His Grace the Duke of Wellington...	Strathfieldsaye.
His Grace the Duke of Hamilton ...	Hamilton Palace.
His Grace the Duke of Beaufort ...	Badminton.
Rt. Hon. the Marquis of Ailesbury...	Grosvenor-sq. London.
Rt. Hon. the Earl of Radnor ...	Coleshill, Berks.
Rt. Hon. the Earl of Rosslyn ...	London.
Rt. Hon. the Earl of Clanwilliam ...	London.
Rt. Hon. the Earl Bruce	Savernake, Wilts.
Rt. Hon. the Earl of Wilton ...	Egerton Lodge, Melton Mowbray.
Rt. Hon. the Earl of Scarborough ...	Rufford Abbey.
Rt. Hon. the Earl of Charleville ...	Tullamore.
Rt. Hon. the Earl Cowper	Panshanger, Herts.
Rt. Hon. the Earl of Lanesborough...	Swithland Hall.
Rt. Hon. the Earl of Eldon	Encombe Hall.
Rt. Hon. the Earl of Warwick ...	Warwick Castle.
Rt. Hon. the Earl of Aberdeen ...	Blackheath Lodge.
Rt. Hon. the Earl Stanhope	Chevening Park.
Rt. Hon. the Earl of Jersey... ...	Middleton Park.
Rt. Hon. Lord Sherborne	Sherborne Lodge.
Rt. Hon. Lord Vivian	Glyn, Bodmin.
Rt. Hon. Lord Monson	Gatton Park.
Rt. Hon. Sir Charles Wood, Bt., M.P.	Hickleton Hall.
Rt. Hon. Henry Piercepont	Conholt Park, Andover.
Hon. Richard Watson	Rockingham Castle.
Sir Robert Peel, Bt., M.P.	Drayton.
Sir John Hall, Bt.	Dunglas, N.B.
Sir Thomas Baring, Bt.	Stratton Park.
Sir M. Hicks Beach, Bt.	Williamstrop Park.
Sir George Beaumont, Bt.	Colcorton Hall.
Sir Robert Smirke	Stanmore.

R. B. Sheridan, Esq., M.P. ...	... Frampton.
James Whatman, Esq., M.P.	... Carlton Gardens and Vinters, Kent.
W. Whitmore, Esq.	... Dudmaston.
J. W. Lyon Winder, Esq. ...	... Vaenor Park.
Joshua Bates, Esq.	... Arlington-st. and East Sheen.
H. H. Hungerford, Esq. ...	... Dingley Park.
W. B. Stopford, Esq.	... Drayton, Northampton.
P. Duncombe, Esq.	... Brickhill Manor.
D. Ricardo, Esq.	... Gatcombe.
A. Isted, Esq.	... Ecton Hall.
Higford Burr, Esq.	... Aldermaston.
J. J. Bulkeley, Esq.	... Linden Hill.
Captain Bulkeley	... Clewer Villa.
Mrs. Bulkeley	... Montague sq. London.
Miss Tunno	... Taplow, Bucks.
James W. Farrer, Esq. ...	... Ingleboro' House, Clapham, Yorkshire.
Walter Long, Esq.	... Rood Ashton.
G. H. Vansittart, Esq. ...	... Bisham Abbey.
C. Babbage, Esq.	... London.
P. Hardwick, Esq.	... London.
J. B. Bunning, Esq.	... London.
E. Lapidge, Esq.	... Tulse Hill.
Carlton Club House	... Pall-mall.
Charles A. Saunders, Esq. ...	... Paddington.
Colonel Hanmer	... Stockgrove.
Colonel Fremantle	... London.
C. Mills, Esq.	... London.
Colonel Delop	... Stoke.
W. B. Bull, Esq.	... Newport Pagnell.
John S. Hunt, Esq.	... Muswell Hill.
A. T. Malkin, Esq.	... London.
E. Marjoribanks, Esq. ...	... London.
Mrs. Thornhill...	... London.
F. F. Weiss, Esq.	... London.
John Kelk, Esq.	... London.
Thomas Webster, Esq. ...	... London.
W. Herbert, Esq.	... Clapham Common.
C. Elsee, Esq.	... Henley.
Edmond Foster, Esq.... ...	... Clewer.

E. H. Day, Esq.	Brixton.
F. P. Hooper, Esq.	Acton.
C. Meeking, Esq.	Streatham.

RAILWAY STATIONS.

London and North Western	Euston Station.
Great Western...	Paddington.
Great Western Hotel	Paddington.
Eastern Counties	Shoreditch.
Clearing House	Euston Station.
North London	Bow Works.

MANUFACTORIES, OFFICES, ETC., IN LONDON.

Allison, Ralph.
Barber & Groom.
Bevington, T., & Sons.
Bevington & Morris.
Brooks, T. & H.
Banting, W., & Son.
Brandon, T.
Barrett, R.
Barclay, George.
Curling & Proctor.
Carpmael, W.
Cow, P. B.
Candy, C., & Co.
Courtauld & Co.
Chappell, F., & Co.
Chappell, F. P.
Curtis, R. M. (Drying stove).
Day & Martin.
Dickinson, J., & Co.
Debenham, Son, & Co.
Eyre & Spottiswoode.
Fownes, Bros.
Foster, Son, & Duncum.
Hallmarke & Co.
Hindley, C., & Son.
Jarvis & Barry.
Jackson, P.
Kinderley, Denton, & Co.
Learmonth & Roberts.
Le Gros, Thomson, & Bird.
Meeking, C., & Co.
Mayor & Dove (Drying stove).
Macintosh & Co.
Murphy, George.
Nevill, J. B. & W.
Roberts, C., Son, & Co.
Rowley & Davies.
Smee, W., & Sons.
Storrs, J.
Snell, W. & E.
Scantlebury (Drying stove).
Taylor & Francis.
Taylor, B., & Sons.
Twinings & Co.
Trollope, G., & Son.
Travers & Sons (Drying stove).
Torry, Paget, & Co. (Drying stove.)
Vyse & Sons.
Watkins & Hooper.
Weiss & Son.
Wheeler, G. & M.

Dodge, Bacon, & Co.	West Ham.
Herbert & Embling	Oxford.
Ransom, R. J.	Kidderminster.
Spiers, R., & Son	Oxford.
Tucker, John	West Ham.

COX (BROTHERS) AND WYMAN, PRINTERS, GREAT QUEEN-STREET.