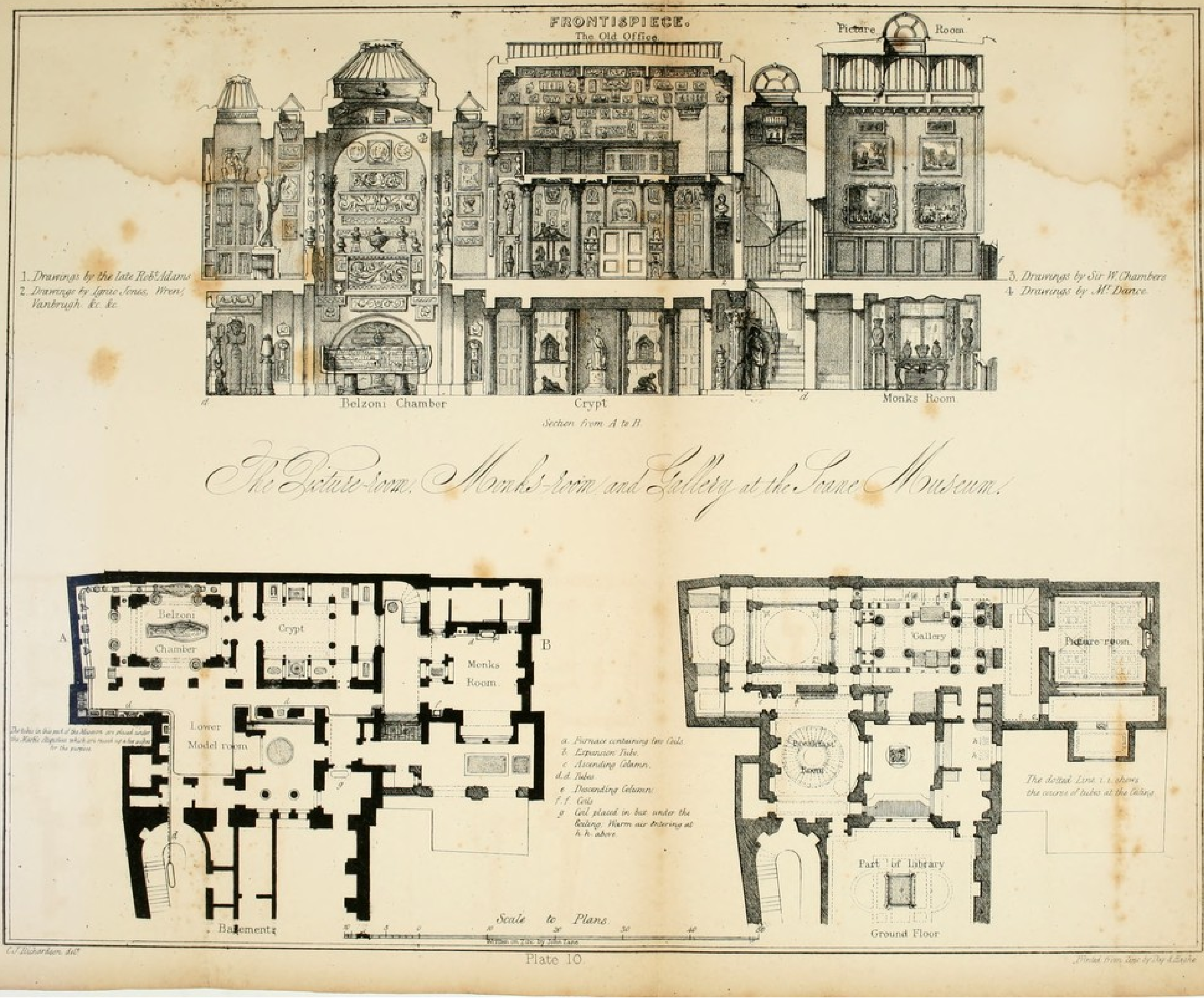
FRONTISPIECE.
The Old Office.
Picture Room
1. Drawings by the late Robt. Adams
2. Drawings by Inigo Jones, Wren, Vanbrugh &c. &c.
3. Drawings by Sir W. Chambers
4. Drawings by Mr. Dance.
Belzoni Chamber
Crypt
Monks Room
Section from A to B.
The Picture-room, Monks-room and Gallery at the Soane Museum.
Belzoni Chamber
Crypt
Monks Room
Lower Model room
A
B
a. Furnace containing two Coils
b. Expansion Tube.
c. Ascending Column.
d.d. Tubes
e. Descending Column
f.f. Coils
g. Coil placed in box under the Ceiling. Warm air entering at h.h. above
Gallery
Picture room
Breakfast Room
The dotted Line i.i. shows the course of tubes at the Ceiling.
Part of Library
Scale to Plans
Basement
Ground Floor
C.J. Richardson, delt.
Plate 10.

A

# POPULAR TREATISE

ON THE

# WARMING AND VENTILATION

OF

# BUILDINGS;

SHOWING

THE ADVANTAGES OF THE IMPROVED SYSTEM

OF

## HEATED WATER CIRCULATION,

&c. &c. &c.

BY

CHARLES JAMES RICHARDSON,

FELLOW OF THE ROYAL INSTITUTE OF BRITISH ARCHITECTS.

THE SECOND EDITION, CONSIDERABLY ENLARGED.

ILLUSTRATED WITH TWENTY-ONE ZINC PLATES.

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1839.

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PRINTED BY J. B. NICHOLS AND SON, 25, PARLIAMENT STREET.

TO SIR ROBERT SMIRKE, R. A., F. R. S.

*&c. &c. &c.*

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SIR,

BEING assured that the system of warming and ventilation earnestly recommended, and imperfectly described in the following pages, has been extensively employed by you with success, I naturally desire to obtain for them the sanction of an architect so high in the rank of professional eminence.

To myself, first a pupil, and many years afterwards in the office of the late Sir John Soane, and honoured by his especial kindness, this system could not fail to obtain the more interest as being the one he cordially approved and adopted in his house and museum, where I daily experienced the benefits it imparts. He observed, "that it bore great resemblance to the contrivance of the brass tube called Draco, mentioned by Seneca as used in supplying the warm water in the Piscina of the Thermæ," and his classical enthusiasm rendered him eager in the adoption of a plan which he considered to have sprung from our great masters, the Ancients, not doubting their acquaintance with that property of water (motion of its particles on the admission of caloric) upon which the apparatus in question is founded.

The following Treatise is intended to show (principally through the medium of the Plates) the means of giving warmth and ventilation, not only to the palace and public building, but the private dwelling of the gentleman, and the workshop of the artisan. If health is allowed to be the greatest earthly blessing, whatever conduces to it must be of paramount importance, and I humbly apprehend that the noble art to which I am devoted, cannot be more beneficially employed, than in giving effect to those studies which may preserve the lives of those most deservedly dear to our country, its heroes and legislators, its philosophers and artists.

I cannot doubt the value of investigation on a subject of this nature, and however imperfect my efforts may prove for its elucidation, my sense of its worth (with such a recommendation before me as your good opinion) can never be diminished.

I have the honour to be,

Sir,

Your most obedient servant,

C. J. RICHARDSON.

24, Manchester-street,
Feb. 1837.

# PREFACE.

THE means for procuring an efficient and systematic ventilation in buildings, has seldom obtained due attention, or been considered a necessary adjunct to the various plans for warming them, which have been introduced since the time Franklin first called the attention of the public in this country to the subject. In most cases ventilation has been rather held in a suspicious light, as being an hindrance to warmth, and has been guarded against by the rooms and spaces being purposely closed. On this principle warming becomes easy, and may be performed by the merest tyro in the art.

The making a room, or the several rooms, and parts of a building warm, and at the same time salubrious, demands not only attention, but knowledge; and it especially requires an apparatus of extensive and convenient form, very superior to those which have hitherto been offered, with more of confidence than ability, to the public consideration. This defect, I shall attempt to remedy in the following pages.

During the time of my professional duties in Sir John Soane's office, I had opportunities (even without leaving it,) of studying the different systems of warming, all of which in their turn have been introduced in that building.

The one which I prefer, and which I have chosen for examination, is Mr. Perkins's system of warm water circulation, and is that at present successfully employed there. The ease with which warmth is communicated to all parts, and its beneficial results, led me to perceive that if the spare tubes connecting together the different coils, were applied for ventilation, this important improvement might be obtained with a very small additional expense.

Observation and experience alike taught me, that to ventilate a building with any of the other warming systems would cause expensive additions to already expensive apparatus, and that the results would be less perfect, than in the plan I have recommended in the following pages.

The first chapter treats more particularly on the application of this system to warming buildings. The second considers ventilation in conjunction with warming. They were written from a conviction of the importance of the subject, and that the ends of warming and ventilation may be conjointly attained.

I trust that my labours will be favourably received by the public and the profession at large.

C. J. RICHARDSON.

Manchester Street, 1837.

# LIST OF PLATES.

## PLATE VI.



## PLATE VII.



## PLATE VIII.



## PLATE IX.



## PLATE X.



## PLATE XI.



## PLATE XII.

## PLATE XIII.



## PLATE XIV.



## PLATE XV.



## PLATE XVI.



## PLATE XVII.



## PLATE XVIII.

# 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 great 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 the 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 axiously 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 fireplace, 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 chesnut 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, shew 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

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

the construction of their towns, renders the mode by which our forefathers communicated warmth to 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 introduced 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 chimneys. 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 chimneys 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 fire-side, 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 cozy 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 fire-side, 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 andirons, 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 realized 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 adaptions, 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 chaldron 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 occurences in domestic life productive of more vexatious, expensive, and alarming incidents, 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 demands made by our medical practitioners, for a temperament 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 ntended to illustrate that apparatus only, (of the warm-water system,) which experience 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. Our health is generally most perfect by the sea-side, where the oxygen abounds in the greatest purity; while it is injured by an excess of vegetation, which, by absorption of one constituent, destroys the equilibrium which constitutes a salubrious atmosphere.

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 or decompose 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, 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 receiving its heat from substances at a low temperature, not sufficiently high to separate or change its constituent parts, 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 of a high temperature, its oxygen is more or less absorbed by the iron, and a greater proportion of heated nitrogen, or azote gas, will, of course, be disseminated through the apartments by means of the flues prepared for that purpose; and 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 highly dangerous, as impeding respiration, while the more remote parts are still left cold and uncheered. It is usual to obviate this by forming more than one entrance for the hot air in the same apartment.

By ventilation, when the air is drawn out of the room below, and the warm air above is forced to descend and mix more intimately with the colder atmosphere of the room, (this I shall treat of more at large in the second 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. It ought never to be forgotten, that the fire of the late Parliamentary buildings was caused by a careless labourer, in overheating flues constructed in the soundest manner, without reference to expense. If such damage was caused in this instance, what may we not expect from flues passing in every direction near timbers, wall plates, lintels, &c. in the small confined walls of a private house? The least crack in an iron plate in the furnace, or the smoke pipe, would carry flames into every room as from a centre.

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 introduction and general use. Under this view of the first system, we therefore turn to the second.

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 lately 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 pressure from the colder water in the descending pipes. The first ascends by its greater lightness; and the other descends in its turn to receive 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 the 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 a supply-cistern at the top. The cold water descended from this cistern to the boiler, and the column of warm water ascended to it, branching off in its passage to the different rooms requiring to be warmed. Since the time of the Marquis, various improvements have been made in the form of the tubes and pedestals; but his system, on the same general form and principle, has been continued by many to the present day.

In order clearly to understand the great improvements on *this* the first system, effected by the apparatus this book is intended to illustrate, the general character of the *former* old one will be described.

It is well known that the pressure of water increases in proportion to its perpendicular height. The danger resulting from having a close boiler connected with a supply-cistern or filling-tube placed at some height above it, can be readily understood by the following experiment, described in most books treating on hydrostatics. If a hogshead or butt is filled with water, and a small strong pipe fixed in the bunghole, and water poured into it; when the water rises in the pipe to a sufficient height (and this will be more or less according to the strength of the cask) the vessel will burst, although but a very small quantity of water may have been poured into the pipe, however small it might be, the diameter of the pipe being, in fact, immaterial. One which was very small, but twenty feet long, was found to burst a hogshead with considerable violence.

Although the boiler of this system of warming can be made to stand this pressure, it is attended with great difficulty and expense; the pressure likewise affects the lower horizontal tubes, and more particularly the joints in the apparatus.

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 fireplace, 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.

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 forcing the ventilation of a building, the tubes of this system are of little use, as they cannot be carried to any great height.

Whatever may be the good or evil of the different systems or apparatus on which I have thus slightly touched, that which I most approve, and which I consider best calculated to supply the deficiencies hitherto felt, is the heated water system invented by Mr. A. M. Perkins, as it combines, before all others, the great requisites of compactness, utility, and frugality, and possesses the power of adaptation with safety to all situations.

This apparatus has now been in use five years, and during that time has been introduced most extensively into buildings of every description with great success. I will endeavour to prove that, in the hands of the architect, it is capable of being adopted in any building, in consequence of the small space it requires; and that, from the high temperature and rapid circulation sustained in the pipes, it is capable of warming even the largest building very efficiently.

A selection of plans which I have 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.

The quantity of water necessary is reduced to a mere fractional part only of what has been before used. The apparatus is rendered smaller, the diameter of the tube is reduced from four inches to one inch only; and this is done with a proportionate degree of effect. The small quantity of water in immediate contact with the fire, receives the heat more rapidly; hence, a free and rapid circulation is caused.

In its simplest form, the apparatus consists of a continuous or endless tube, closed in all parts and filled with water; about one-sixth part of which tube being coiled in any suitable form, is placed in the furnace, and the other five-sixths are heated by the circulation of the hot water which flows from the top of this 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 1800 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 become 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 Mr. Perkins, senior, has proved, by means of his powerful compressing machine, that it it requires 28,000 lbs. to the square inch to compress water five per cent.; hence the necessity of allowing sufficient expansion for the water.

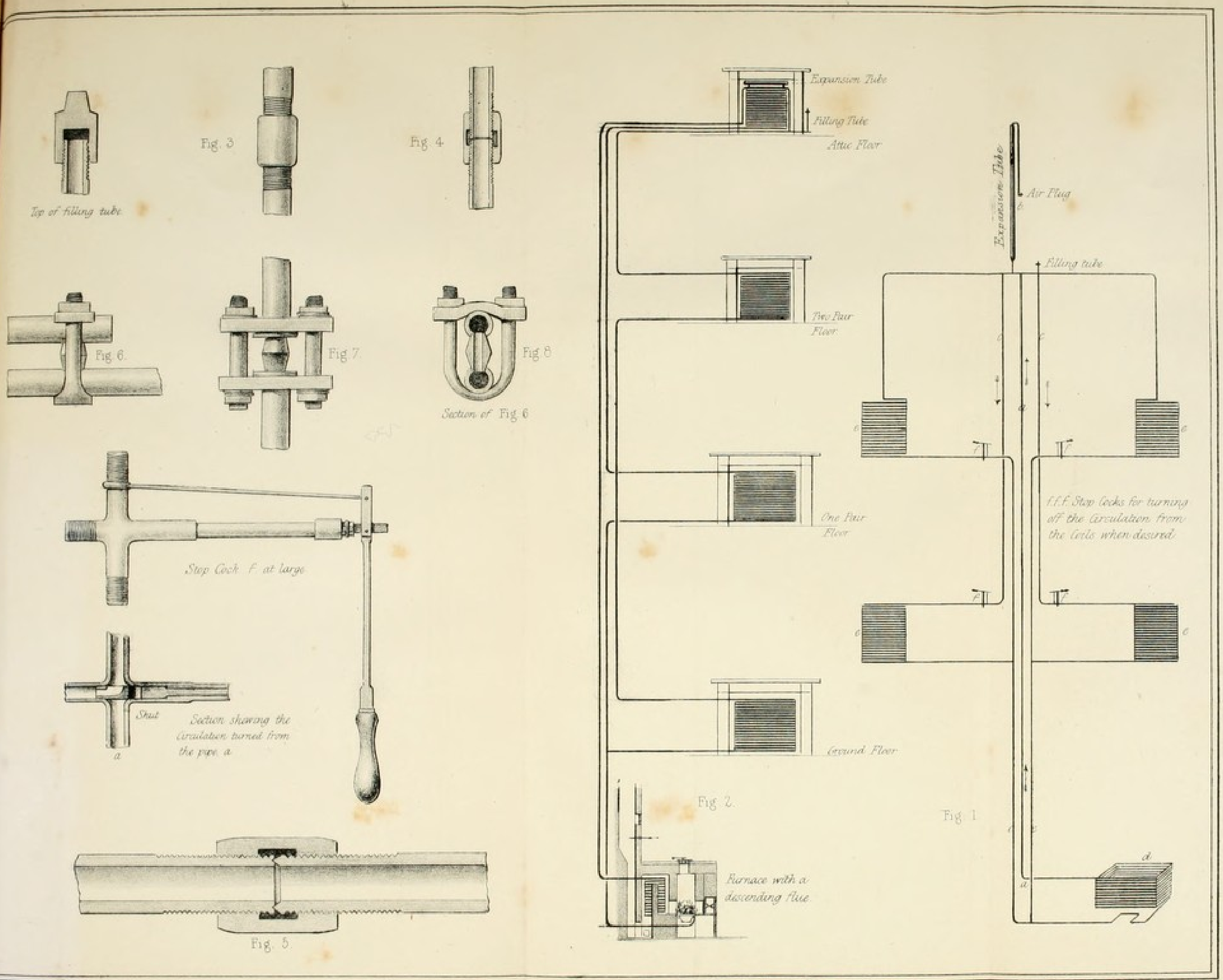
Practice has proved, that fifteen to twenty per cent. of expansion space is ample for the greatest heat which can be attained by hot water.

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,




C.J. Richardson del. Plate 1. From Zinc by Day & Haghe.

with open trellis work in front, sunk in stone floors, or placed in any manner most convenient.

In fig. 2, plate 1, the ascending and descending columns are placed in the angle of the chimney jamb, and the coils placed in the fireplaces of each floor; the flues being stopped, the expansion tube is likewise made horizontal, and lays on the top of the upper coil.

A screw plug is inserted in the upper part of 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 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.

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.

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. These are of wrought iron, and are one quarter of an inch thick. They are manufactured upon the patent of Messrs. James Russell and Sons, 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. 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.

Plate 1, figs. 3 and 4, shew an elevation and section of this joint.

Fig. 5, section of ditto, half full size.

Figs. 6, 7, 8, are cone joints.

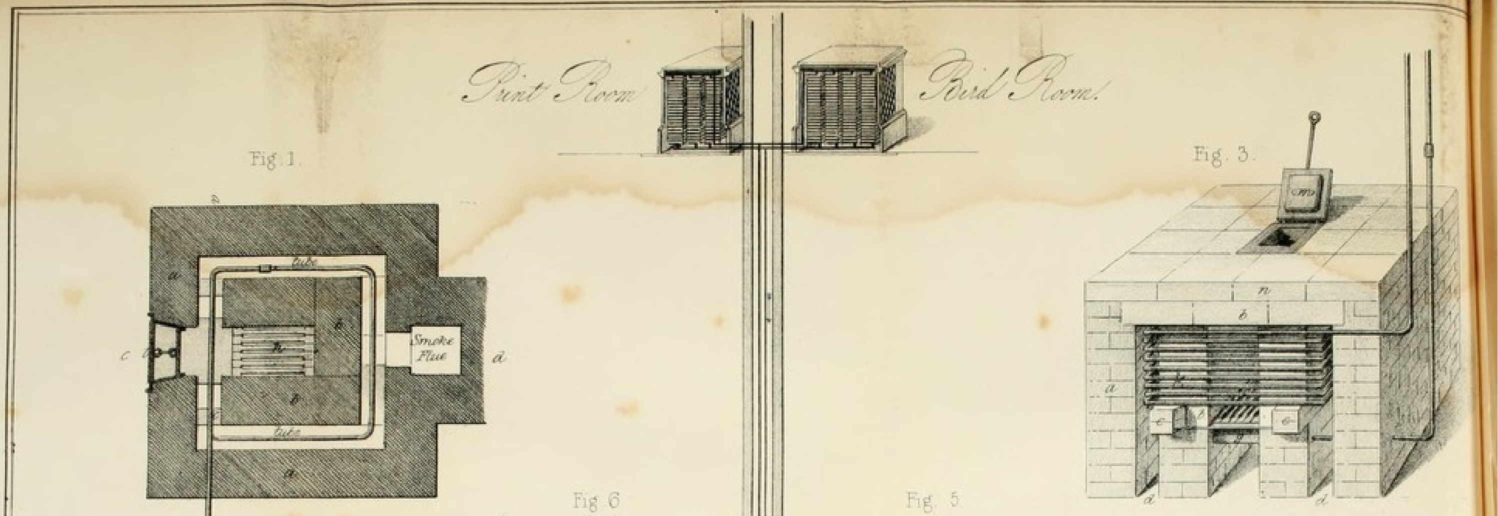



Plate 2.

BRITISH MUSEUM. *The Apparatus there used for Warming the Print and Bird Rooms, with details of Furnace.*

The forms and dimensions of the furnaces belonging to the apparatus necessarily vary according to the localities of the place where they are erected, and to the quantity of work required of them; they can contain both square and oval coils.

The form principally used, which I shall now describe, is represented in Plate 2. Under common circumstances, the size is about three feet six square, increasing to six feet, according to the extent of pipe connected with it; the furnace in Plate 2 is four feet six square, and is considered a powerful one; the fire occupies a small space in the centre, raised about one foot from the ground, and the fuel is supplied from the hopper-door at the top.

An inspection of the plate will best explain the construction. Fig. 1, is plan of furnace above the grate; Fig. 2, plan below grate; Fig. 3, a section on the line *a, b*; (Fig. 1), and Fig. 4, section on the line *c, d*:—*a, a, a,* common brickwork; *b, b, b,* Welch fire-lumps; *c, c, c,* fire-bricks supporting coil; *d, d,* the wells or reservoirs for the dust and soot, which would otherwise clog the coil; *e, e,* doors for clearing out the dust, &c.; *f,* ash-pit door; *g,* bearing-bars for grate; *h,* the grate; *i,* an iron plate for separating the ash pit from the tubes; *k* tubes forming coil; *l,* double fire-door, for clearing out the scoria or clinkers; *m,* the hopper-door; *n,* Welch-tile covering. Fig. 5 shews the descending tube entering the chamber passing through the bearing bars of the grate ; Fig. 6 is a section of the back well, or reservoir, formed so as to support the coil, and to cause the soot and dust to fall to the bottom, so as to be cleaned out from the doors *e*, *e* ; Fig. 7 is the representation of the furnace, with the warm water circulation attached.

It will be seen from the above description, that the ignited coal is surrounded on three sides by a thickness of nine-inch fire-brick, or Welch lumps, and that the hopper-door over the fire is likewise placed in one, round the fire-brick is a chamber four inches and a half wide, containing the coil of pipes ; the pipe enters this chamber, passing through the bearing bars of the grate, which tends to preserve the grate from burning ; the pipe, when it proceeds in its course into the building to be warmed, passes out at the upper part of the chamber.

The outer case is of brickwork, nine inches thick, and the whole is covered with Welch lump and tile.

The smoke leaving the ignited materials passes through the chamber containing the pipes, escaping through the opening at the back.

The meaning of thus surrounding the fire with a thickness of fire-brick (a good non-conductor of heat), is to prevent the too rapid abstraction of heat by the coils in the chamber ; the coil only comes into contact with the fire at the opening in front, where the smoke leaves the ignited embers.

This construction of furnace is 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 hot-houses 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 and the damper it will be reduced; if that is not sufficient, it may be still further reduced, by opening the doors, *e*, *e*, and permitting the cold air to have access to the coil, at the same time reducing the draught of the furnace, by shutting the ash-pit door, and leaving the damper open.

The furnace chosen for illustration is the one erected at the British Museum, under the direction of Sir Robert Smirke; the apparatus complete is represented in Fig. 7, (Plate 2.) The furnace is in a vault in the basement story, and the pipes, entering a flue, are carried up about forty feet to two pedestals, one placed in the print-room, the other in the bird-room, the former of which contains 360 feet of pipe, and the latter 400; about 140 are employed in the flow and return pipes in the flue, and 150 are coiled up in the furnace.

The apparatus, from this great quantity of pipe, 1050 feet, is a very powerful one, and it fully supplies 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 is lighted at six o'clock in the morning; it is allowed to burn briskly, till the heat produced in the rooms is sufficient, when the damper in the flue is partially closed. This, from checking the current in the furnace, causes a slow slumbering fire, and preserves the fuel. The attendant gives a fresh supply of fuel at eleven o'clock, and the fire keeps in till four, when all the fires at the Museum are extinguished.

This apparatus was erected at the British Museum in November 1835; during that season, five furnaces of the same description were in constant use, and others are now in the course of erection.

In a building so extensive as the British Museum, other systems of warming are in operation. Some important experiments were made in 1836, as to the heat of the various smoke-flues of the different systems.

The following is an extract from the table of temperatures:—it was taken at the request of Sir Robert Smirke, in March and April 1836.

"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."

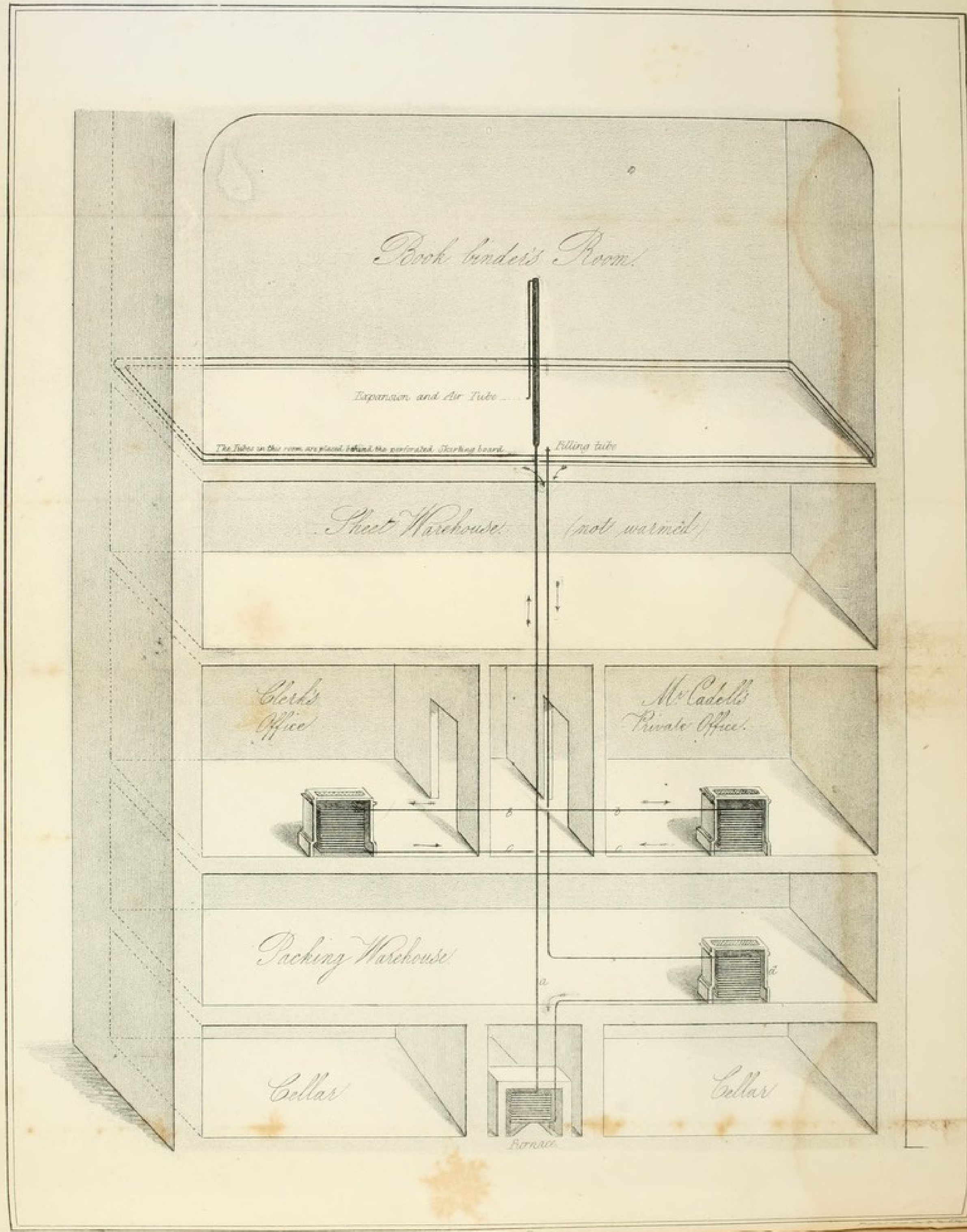
The extreme heat was taken in the three cases; and in order to come to a right conclusion, the quantity of coke consumed in each furnace, was the same in the same period of time. The temperature of the rooms varied according to circumstances; but the furnaces of the inch-tube system *were made to do 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 pedestals containing the coils of pipe to warm the print and bird room of the Museum, can be so readily inspected and examined, that I have placed this description first. I shall now, among numerous examples placed at my disposal by Mr. Perkins, select a few which will illustrate different methods of applying the pipes to warming buildings.

Robert Cadell, esquire, introduced, in the winter of 1833-34, the present system of warm-




C. J. Richardson del.

Plate 3

ing 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 3; 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, has 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 distance 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

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

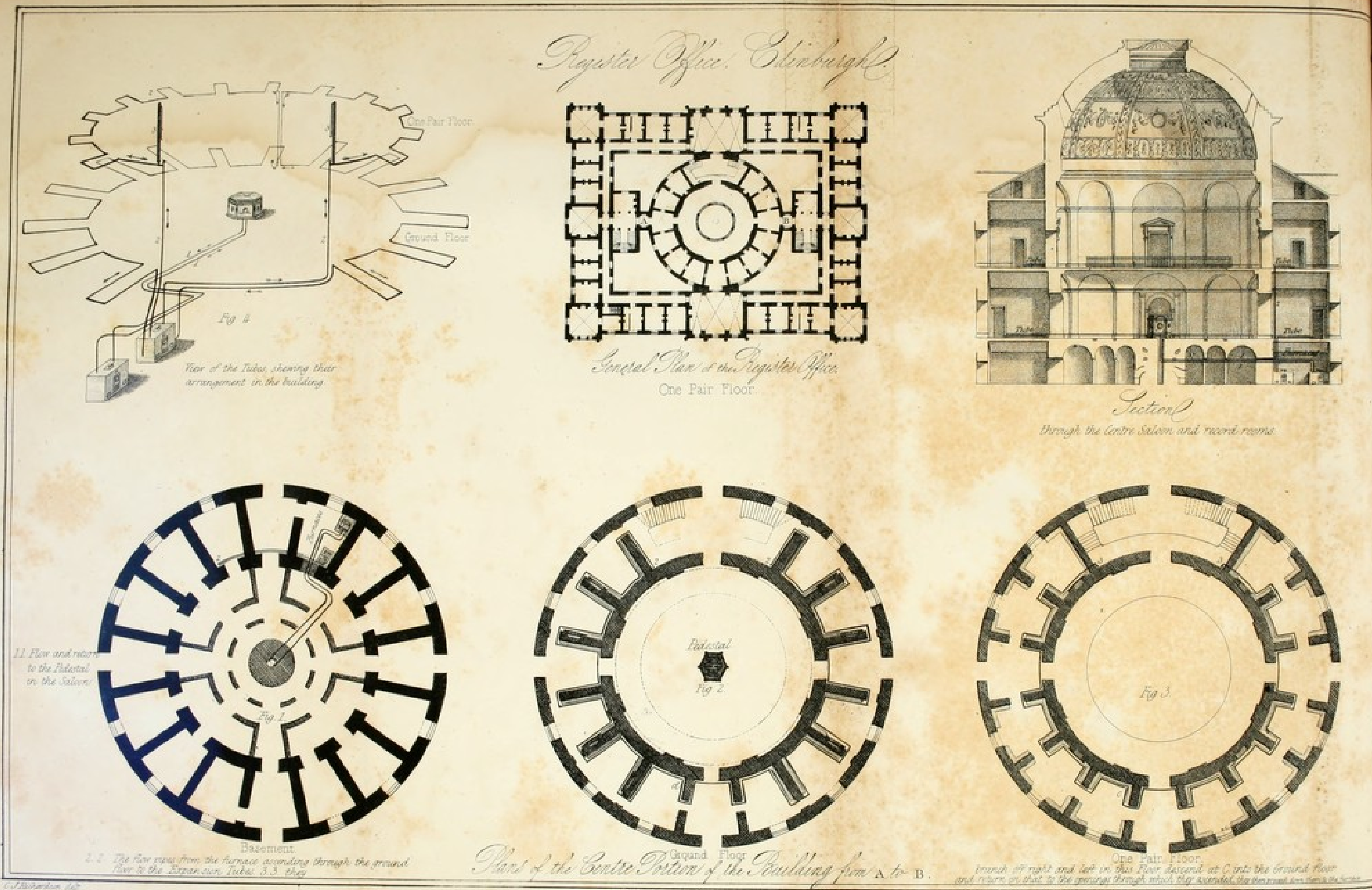
it is greatly more than adequate to the purpose. When I visited Mr. Cadell's premises, I was struck with the genial and pleasant heat which pervaded every part of them, although there is only one furnace for the whole five stories. I was not less struck with the total absence of the empyreumatic odour 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.

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

* 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.




C. J. Richardson, delt.

Plate 4.

On Zinc by H. Bailey

Printed from Zinc by Day & Haghe

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 4, Fig. 1.

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

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

Mr. Perkins's 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 4.)

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 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, Plate 4.

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

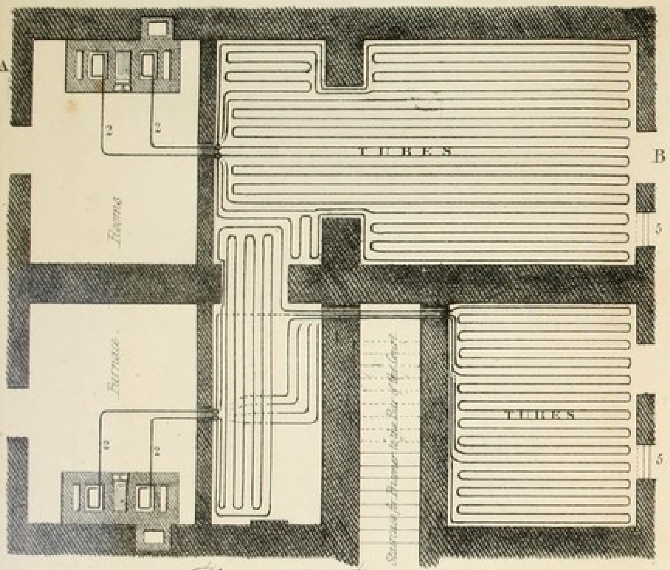
These two apparatus have answered to the extent required. In fact, so completely has this object been effected, that an additional apparatus is now preparing for the preservation of the whole of the records on the basement story, which was not included in the former plan.

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 5, 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 1200 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.

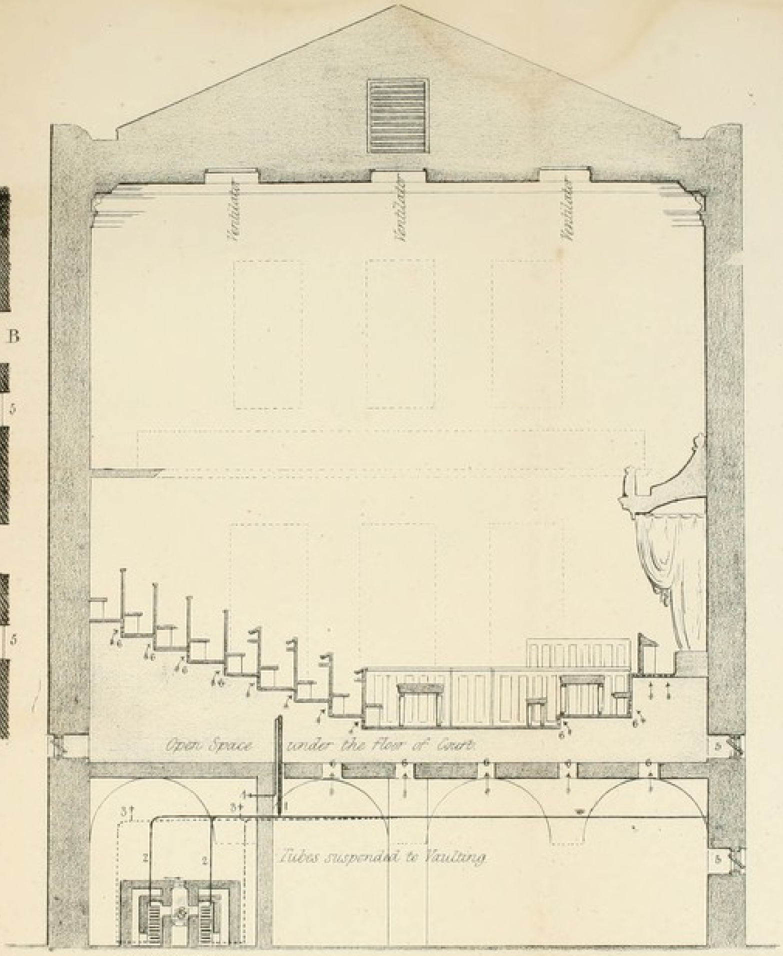
The cold fresh air admitted into the vaults ascends between the spaces of the tubing, and enters by nine openings in the vaulted ceiling into

1.1.1.1. *Expansion Tubes.*
2.2.2.2. *Tubes containing the ascending Columns of Water. the descending or return Columns conveyed in tubes under them and through the same Channel.*
3.3 *Filling Tubes placed on the descending Tubes.*
4 *Small Tube by which the air can be drawn from the expansion Tube without the necessity of the man leaving the furnace room.*




*Plan of the Basement*

5.5.5.5 *Openings for the admission of Cold air*
6.6.6.6 *Openings for the admission of Warm air into the Court, there are 9 of these in the Vaulting & 1000 of a less size above.*




*Section of Furnace*

*Section from A to B on Plan.*

0 10 20 Feet

C. J. Richardson del.

Plate 5.

From Zinc by Day & Haghe.

*New Justiciary Court, Edinburgh.*

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.

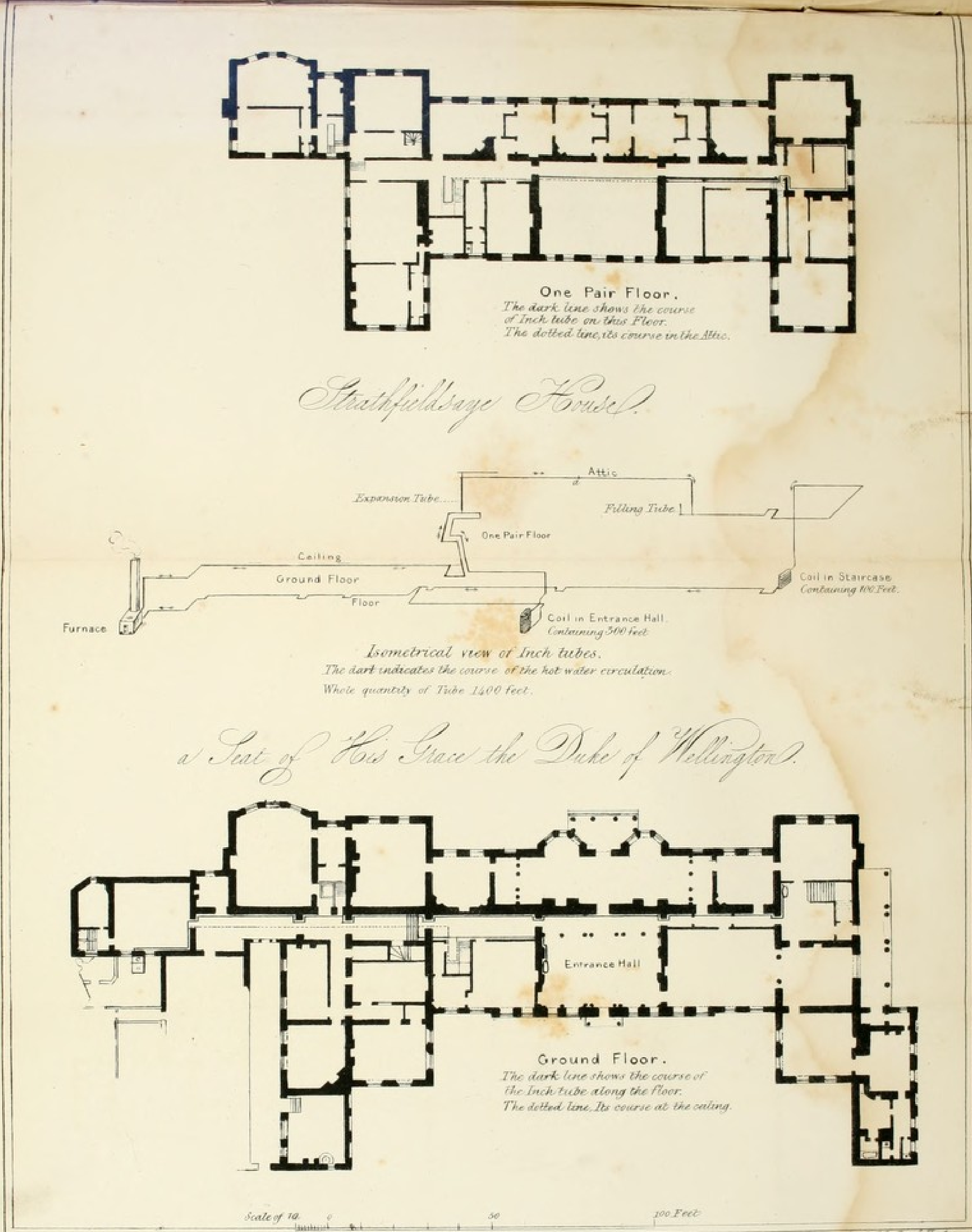
The great mass of warm air rising upwards by its own specific lightness, passes very rapidly through these ventilating openings in the ceiling, which being provided with *registers* to open and shut, the current can be moderated according to pleasure.

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 Duke of Wellington. The apparatus here is of extraordinary power; the furnace could only be placed at one extremity of the building (see Plate 6), 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 proportion 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 exceeding well, giving to his Grace the greatest satisfaction.

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 trel-




On Zinc by Henry Bailey

Plate 6.

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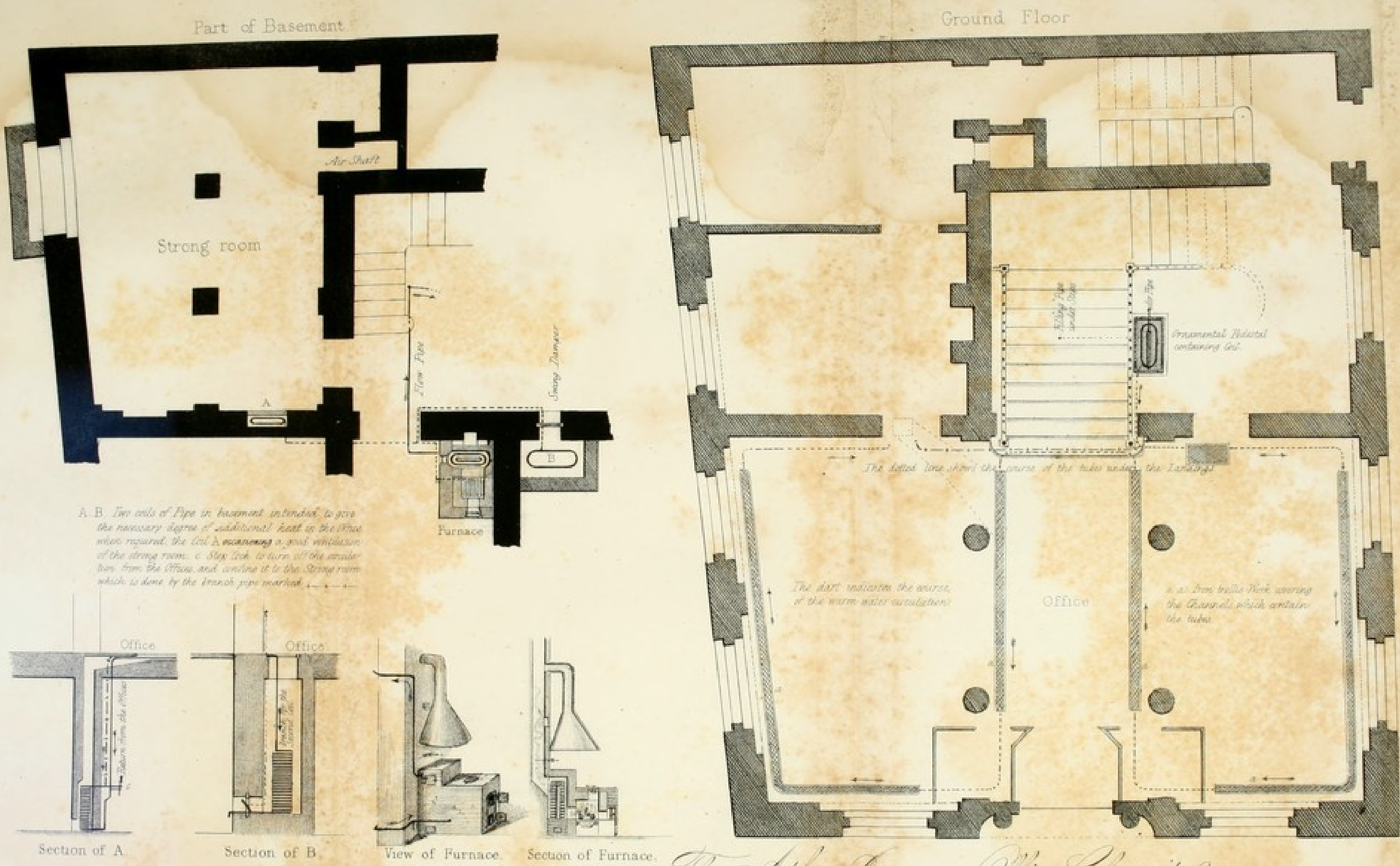


The Atlas Insurance Office, Cheapside.

Plate 7.

C. J. Richardson delt.

Printed from zinc by Day & Haghe

lis-work, has a very ornamental appearance, and is very effective, Plate 7. The Atlas Insurance Office, Cheapside, is here inserted as an example of this kind. Putting the tubes likewise behind skirting-boards, perforated 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 are concealed in the same manner.

A curious example presents itself at Lord Rosslyn's house, in Grosvenor-place; the pipe is carried up the staircase appended to the steps; it runs along the landing at the top of the stairs and returns the same way; the circulation effectually warms the whole space, and many persons pass 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 them 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 these 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; these apertures allowing a current of warm fresh air to pass into the rooms above; from these coils the pipes returned to the furnace.

Another description of warming, very dissimilar to any of the preceding examples, is exhibited in Plate 8, 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, the entrance of which being in an agreeable situation, was connected with this room which, receiving its

## The Patent Office Lincoln's Inn Fields.

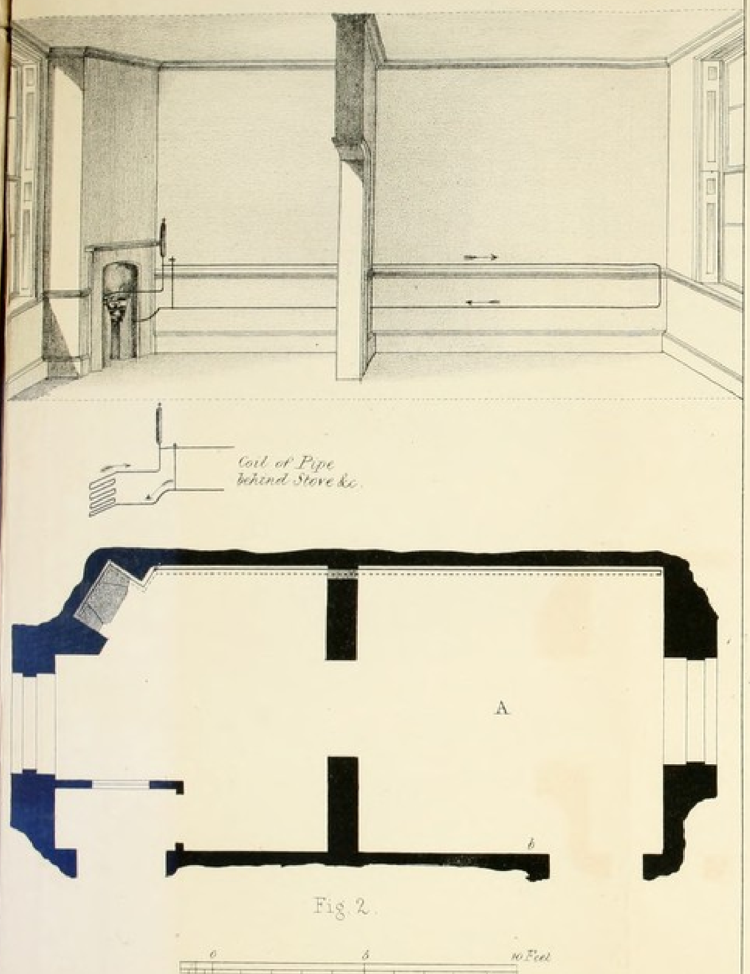


Fig. 2.

## at The Earl of Radnor's, Coleshill, Berkshire

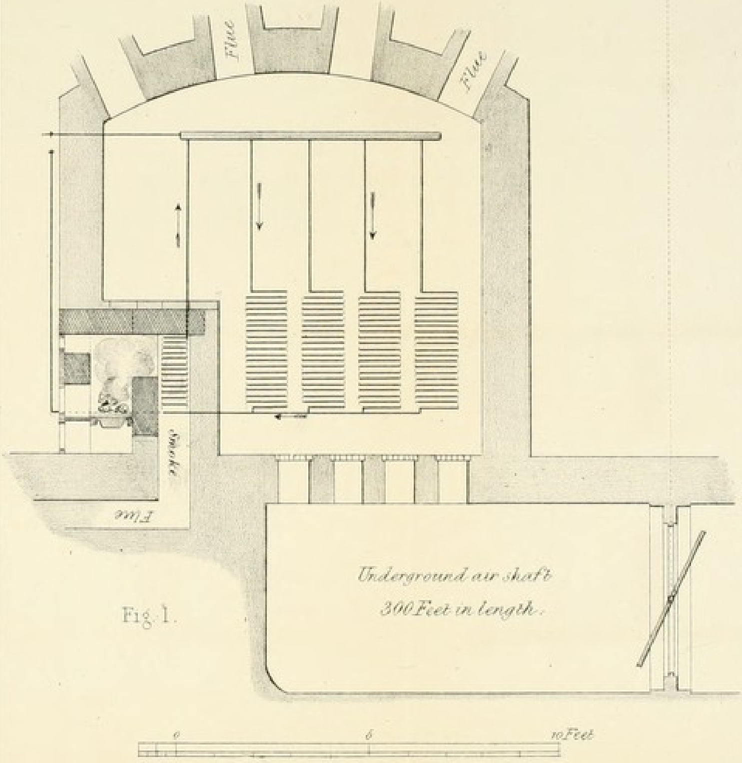


Fig. 1.



Day & Haghe Lith.rs to the Queen

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 the flues, and from the difficulty of cleaning them. They frequently took fire, and 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, were 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 to 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, Lincoln's Inn Fields. These two rooms, one about eleven feet, the other about nine feet square, has about sixty feet of pipe, which is warmed by placing a few bends of pipe, or small coil, at the back of the grate in the smaller room.

The grate being used for the office fire as usual, thus warms the pipe and produces the circulation. The expansion and filling tubes are placed by the side of the fireplace as shown in the plate.

When I inspected these 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 told me 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 are 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 vinery and forcing house, represented in Plate 9, was lately erected according to the specific direction of the gentleman to whom it belonged. The pit is supported on a floor of tiles laid on joists, and the space beneath is divided into three com-

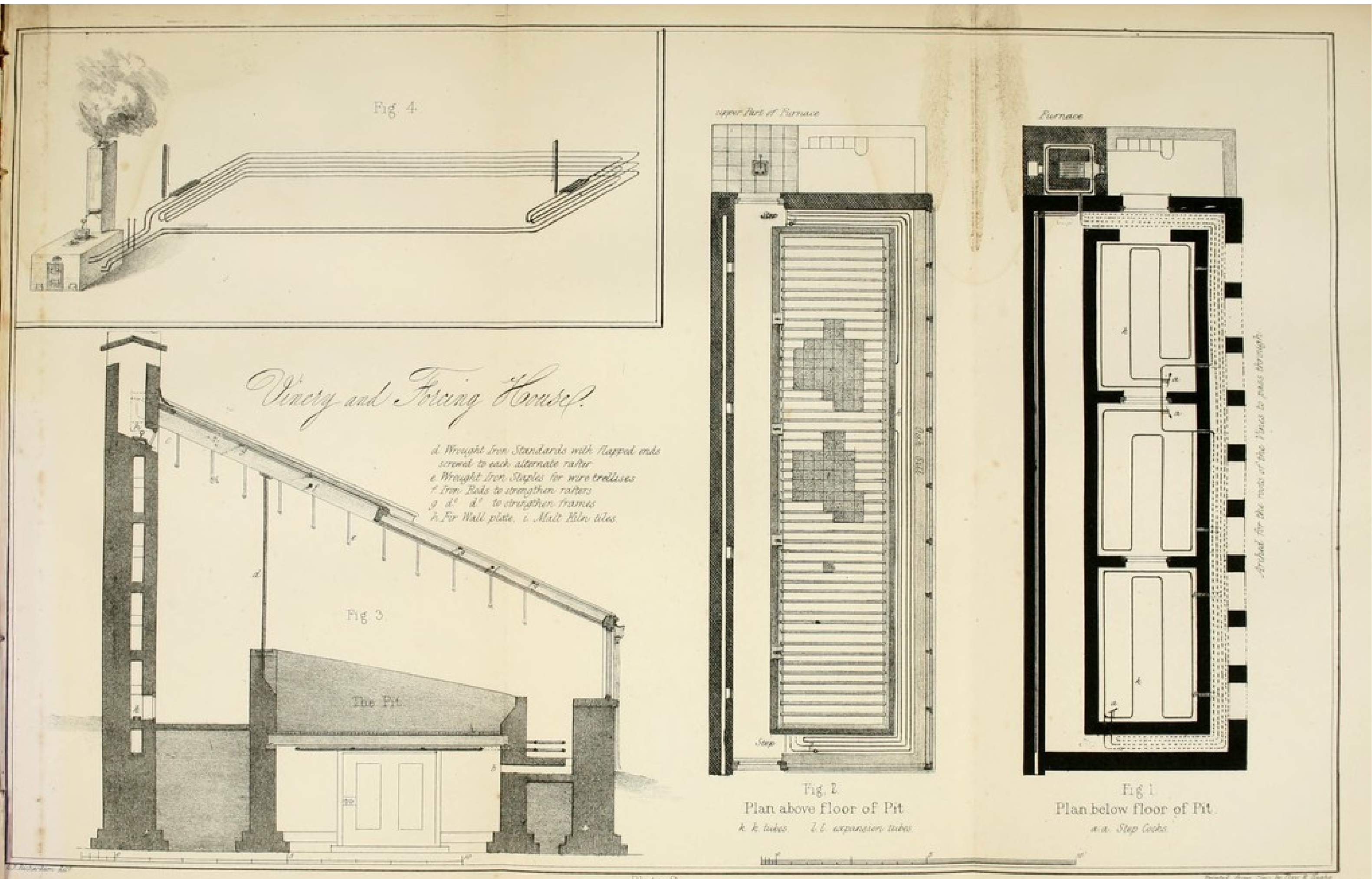
Vinery and Forcing House.
Fig. 4.
Fig. 3.
The Pit
d. Wrought Iron Standards with flapped ends
screwed to each alternate rafter
e. Wrought Iron Staples for wire trellises
f. Iron Rods to strengthen rafters
g. d° d° to strengthen frames
h. Fir Wall plate. i. Malt Kiln tiles.
upper Part of Furnace
Step
Furnace
Arched for the roots of the Vines to pass through
Fig. 2.
Plan above floor of Pit.
k. k. tubes. l. l. expansion tubes.
Fig. 1.
Plan below floor of Pit.
a. a. Stop Cocks.
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Plate 9

partments. The pipes from the furnace ascend and encompass the vinery, in which is placed the expansion and filling tubes; a double coil being placed in the furnace, a circulation is carried through the three divisions beneath the pit, as shown in Fig. 1. The intention of thus dividing the space beneath the pit was, that by means of the stopcocks *a*, *a*, *a*, the circulation may be turned off and confined to any one or two of them as desired, the circulation still going on in the vinery uninterruptedly.

Two pipes are likewise placed within the hollow wall as shown in Fig. 3.

The fresh air admitted under the pit passes through openings (*b*) into the vinery above, and the ventilator (*c*) permits its escape. The temperature of the room can be raised by these means to forty degrees above the external atmosphere.

Fig. 4 is a good arrangement of pipe for a vinery. 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 on the floor, and the six pipes at the lowest end, so that the warmth may spread itself over the whole space—the troughs placed on each circulation, the pipe passing through them, are intended to contain water, and to generate moisture by evaporation.

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 have been introduced there for that purpose, several of which are in my recollection. Among them was one of steam and one by the common method of heated water.

The perfect success of Mr. Perkins's system when introduced there, was one of the first circumstances that called my attention to the system, especially as I well remembered the miserable cold experienced in the office during former periods.

The comfort and convenience of a moderate, warm, equalized temperature, can scarcely be understood or appreciated, without having been 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.

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.

The kindness with which the late Sir John Soane was pleased to regard any attempt on my part to professional advancement, induced me to lay before him, a few weeks only before his decease, the present treatise, and to explain to him my sentiments on the subject, which I have the gratification to know he essentially approved.

In the preceding examples, this system of warming was introduced into buildings already erected, where the want of 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 bed-rooms, nurseries, &c. rendering fires in them unnecessary, would produce greater comfort, and effectually render our winter, " though frosty, kindly."

The examples already given, I think, 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:—I have merely confined myself in these pages to their utility and practicability as an architect, that a clever mechanic could contrive to use them beneficially for many other purposes, is evident, from the fact, that Mr. Perkins has already effected by their means, the drying corn, roasting coffee, heating ovens, for baking bread, &c. &c. 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

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

note, that Mr. Brunel has suggested to him, "the practicability of *laying on heat* to a long range of these 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 burthen 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 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 afterthought. It should be remembered, that as its complete success and its economical character depend in a great measure upon 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 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 ball-rooms 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 main spring of life in equal purity. Allowing for the various causes of the vitiation of air, a single man renders four cubic feet of air unfit for future respiration per minute; but it is considered requisite for healthful respiration that a much larger quantity of pure air should be supplied in the same space of time.

Yet 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 indispensible.

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, and 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 the 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

* Tredgold on Warming and Ventilation.

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 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

* Theory and Practice of Warming and Ventilating public buildings, &c. by an Engineer, published 1828.

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 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 Calorifere 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 with ease. 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 constant airing and warmth, there can be no question but that the lower part of the room is the best and most economical situation for the ventilation to proceed from, in practice, (for both these methods of acting upon has been in use some years,) I have no hesitation in saying, this is the fact, while with upwards ventilation, it is very certain that the heavy nature of the carbonic acid gas will not permit its wholly being drawn off at the ceiling, unless a very strong ventilating power is made use of.

Mr. Perkins' system of one-inch tubes become, 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 ventilating 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.

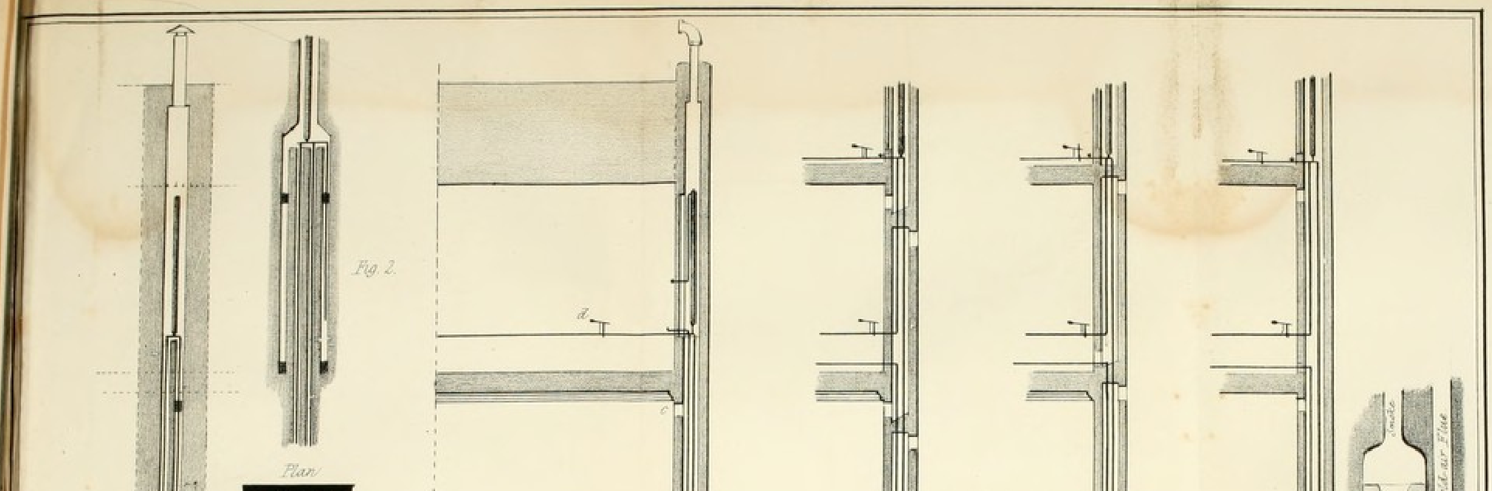
In showing the arrangement of the tubes for the purpose specified, I will adapt them in the first place to a private dwelling, as being more difficult to ventilate than large single rooms. So difficult indeed has it been found to do this with safety, that no plan undertaking the proposal has hitherto found favour in the eyes of the public; yet with due deference I will venture to assert, that a simple principle and easy means can be found, whereby the important benefits desired may be obtained in almost every description of building.

In the ventilation and warming of a private dwelling, I would begin first with the staircase. This we ought to consider the principal artery of the house; and if this 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 ensure its effective operation, great part of the business would be effected, 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. On inspecting Plate 2, and observing the situation of the pipes in the flue at the Museum, it is clear, that supposing that flue passed in its course through two or more stories of small rooms, and if a small opening was made from each room into the flue, it would, (provided it had a proper outlet at top,) effectually ventilate every room.

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; and I should propose forming it like Fig. 1, Plate 11, with a partition in the centre, so as to form two flues, each four and a-half inches by nine, carrying up the partition no higher than the bottom of the expansion tube, which should stand on it. In Fig. 2, it will be seen I have added an additional $4\frac{1}{2}$ inch space on each side for the two rooms on the upper story, as I can only recommend a single flue for each room. The flue should, of course, be perpendicular; and as the houses in London are two rooms deep, two such flues only, placed about the middle of each apartment, would be required; but if the two were joined, and placed




C. J. Richardson, Delt.

Plate 11.

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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, it 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 containing the pipes which warm the print-room and bird-room, at the British Museum, was not built originally for this service, and is not used at present for the purposes of ventilation, not having a single opening in it. The whole height is sixty feet, the present 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, I would leave openings about six or seven feet in height, and close them 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 I think that no current of warm air entering a room when only of a pleasant temperature can 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 11, Fig. 4, that, whilst I provide for the natural current of vitiated air, by drawing it off at the ceiling, I have placed a lower opening into each flue at the floors. 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 prevents it being wholly drawn off at the ceiling. The advantages of having a flue the whole height of the building to receive these tubes is thus apparent: it 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, and at this temperature, continually passing through the room, and carrying with it all the impurities which arise from its occupation. This 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. I cannot conceive any greater luxury, or more refined comfort, than such an apparatus in a dwelling-house would afford.

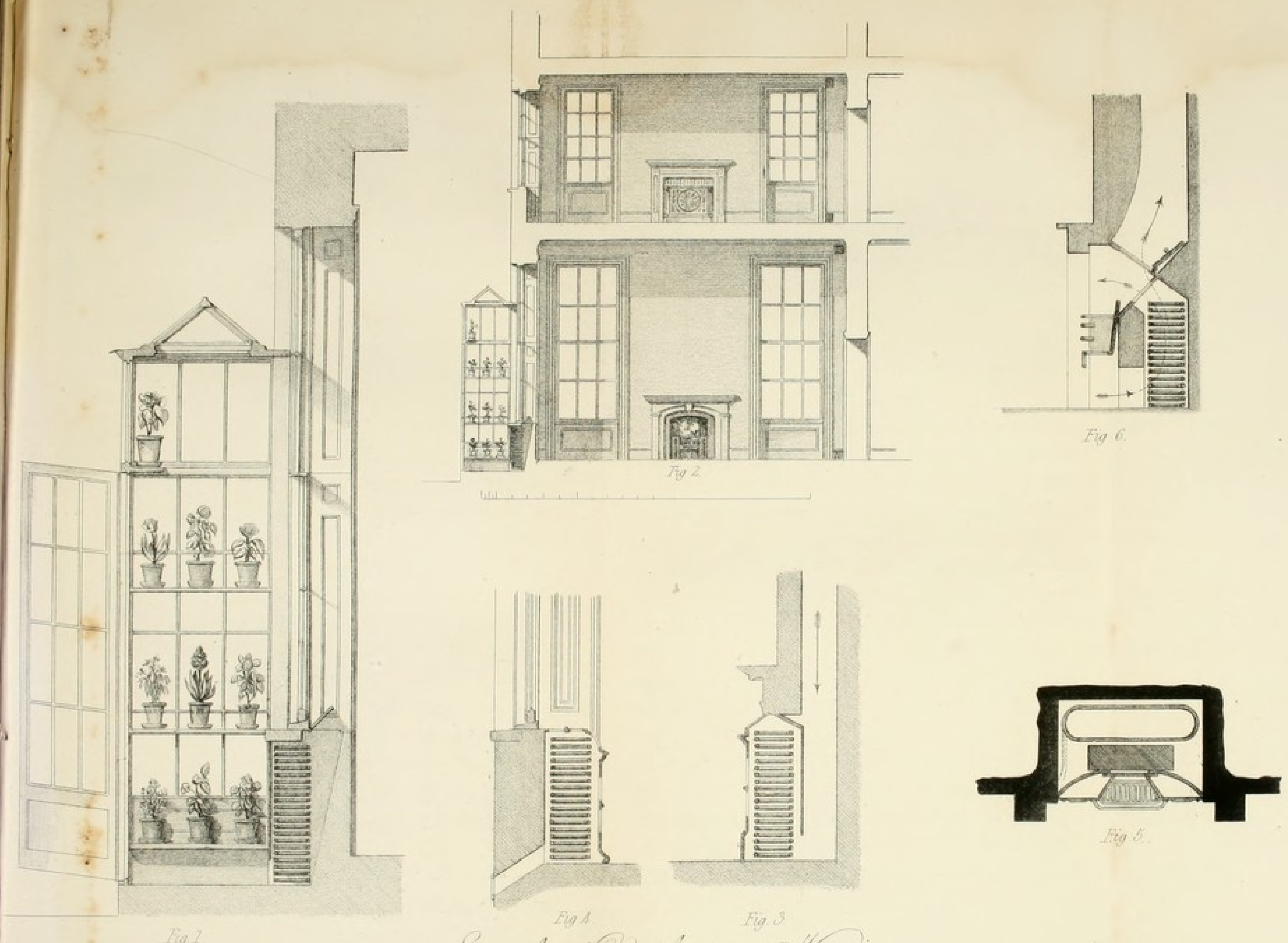
To this I must add, that the cheering sight of a fire-place, if required, can always be had in rooms thus aired and warmed, so that no source of pleasure and comfort is withheld, in consequence of those which are most important being thus supplied.

It may be remarked, that our houses never require such a degree of ventilation and warming as just described; and that to the extent (for I have taken the utmost) it would be too expensive for the generality. Although in the latter I agree, I cannot so readily subscribe to the former; yet as I have before remarked, 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.

It must be here observed, that with every method of this description for admitting warm fresh air into a building, the external doors and windows should be devoted to their proper uses. " The doors are meant to admit the occupants to the chambers, and the windows to give the light." The best way to prevent the external doors from interfering with the business, would be by making a second door, covered with green baize (with a small glass light) in the hall, and either by putting a spring on the back door, or a second door there likewise.

It may easily be imagined by the above descriptions, how readily any large assembly or public room may be ventilated and warmed. When on a large scale, if the tubes in the pedestals were not sufficient for both purposes, a second furnace might be used for ventilation alone, and warm three or four flues, or more, if desirable, and the size of the openings into them adapted to the purpose. In an hospital-room, if rapid ventilation was required, the pipes might be left exposed.

In order to illustrate the system of room ventilation and warming, I subjoin a sketch which I made for the purpose of effecting it in rather a difficult instance. The lower room, Fig. 2, Plate 12, had three windows and three doors, and being small, standing in an exposed situation at the angle of a building. It may easily be imagined that in cold weather, however large a fire was in




*Examples of Ventilation and Warming.*

Richardson delt.

Plate 12

Printed from Zinc by Day & Haghe

the grate, a comfortable situation could not be found in any part of the room. In order in some degree to remedy this, one of the windows on the outside, Fig. 1, was covered with a small square erection made to contain flowers. The coil of pipes placed within it, as shown, admits a warm current of air into the room. It enters through a flap, which can be opened or shut at pleasure. At night, the door of the small greenhouse can be closed, and the plants protected from the cold; the ventilating flue, the openings into which are shown in Fig. 2, is warmed by the pipes connecting the pedestal in the upper room.

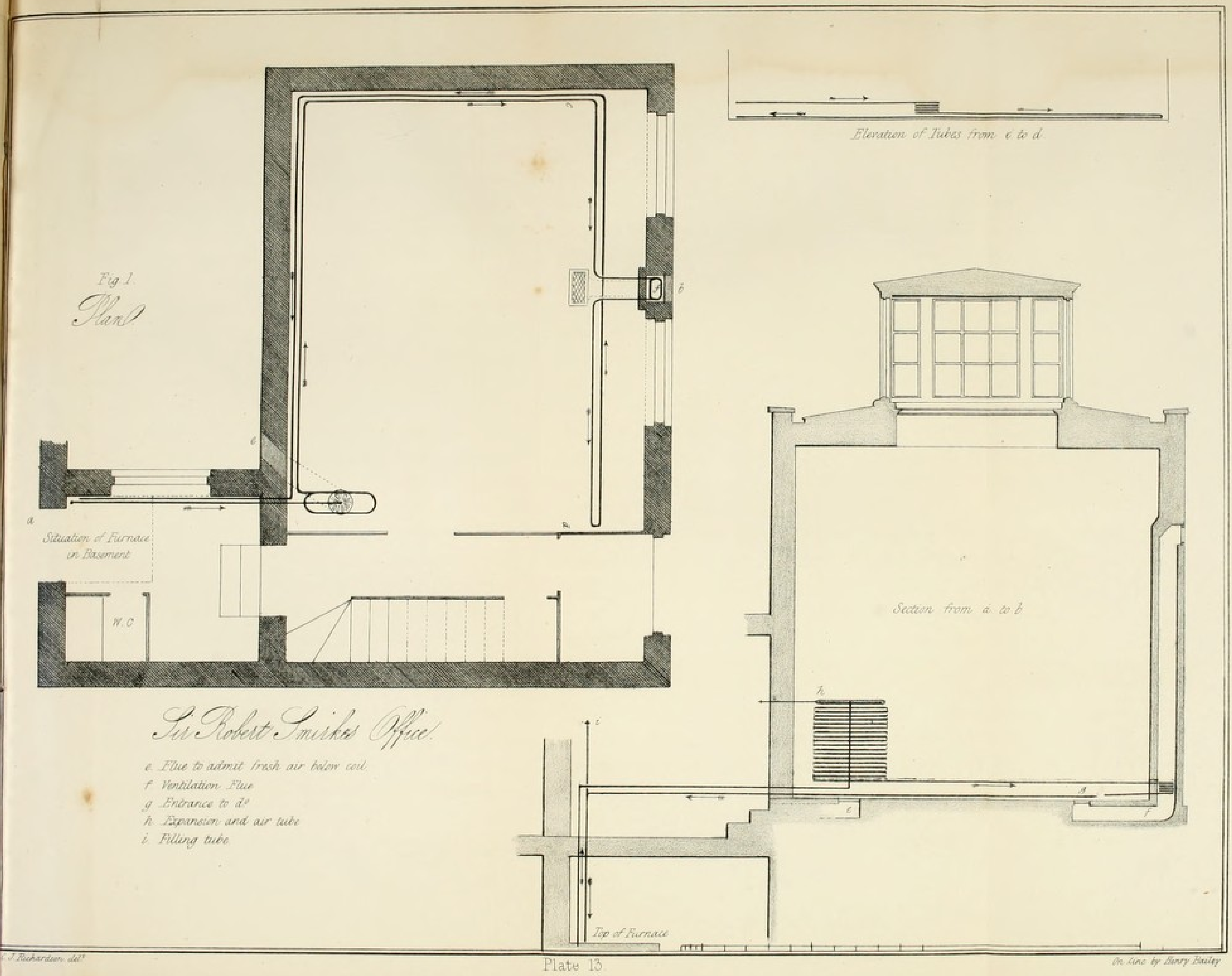
On the same Plate, Fig. 3 shows the contrivance for admitting warm fresh air into the upper room, the air descending down the flue, and through the pedestal into the room. This method, however, can only be used with a new flue, as otherwise the smell of soot would be perceived in the room. Fig. 4, is a method of placing the coil of pipe inside the room, the pedestal having as many openings as possible, to spread the current of fresh air. Figs. 5 and 6, on the same plate, show the arrangement of placing a coil of pipe behind a common grate; this, by opening or shutting the door, or register, in the flue, warms or ventilates the room at pleasure, and admits the grate being used at any time when chosen in preference.

The apparatus erected in Sir Robert Smirke's office, Plate 13, exemplifies the system of ventilation proceeding from the floor. It will be seen, that the fresh cold air is admitted directly under the coil. The pipe, after leaving the coil, passes round three sides of the room, and enters below a perpendicular flue, in which it forms a small coil. This flue has an opening into it at the floor, and through this the air passes into the warm shaft, to the atmosphere above; so that a constant inflowing of warm fresh air, and a constant change is going forward, preventing any oppression from heat, and by the direction of the current, neutralizing, as I should imagine, the cooling effect of the skylight above.

If the situation of a flue, or ventilating shaft, was such that sheltered outlets on the outside could be formed, one small flue only, containing ascending and descending columns of tubing, would ventilate a room on each separate floor it passed in its perpendicular course.

Fig. 5. Plate 11, shows the form proper for such flue, with the vents at the ceiling; and Fig. 6 the same, with the vents at the floor. In practice, in a great many instances, such side outlets may be obtained; they are reckoned, however, bad in principle, as at times when the wind blows towards them, the operation is stopped.

If ventilation alone was consulted, as in a warehouse, a small flue containing two columns of pipe, with openings cut into it on every floor,



Elevation of Tubes from c to d
Fig 1.
Plan
a
b
c
Situation of Furnace in Basement
W.C
Section from a to b
h
i
g
f
e
Top of Furnace
Sir Robert Smirke's Office
e Flue to admit fresh air below coil
f Ventilation Flue
g Entrance to d°
h Expansion and air tube
i Filling tube
C. J. Richardson del.t
On Zinc by Henry Bailey

Plate 13

Fig. 7, would be the most effective. This, however, I do not recommend in a dwelling-house, as I am uncertain how far such a flue might act in conveying sound from room to room; when in use, the strong current of air from the rooms through the openings, and the current up the flue itself, would be against any such objection; but we must guard against it when not in use.

The common size flue, 14 inches by 9, with the half-brick partition in the centre, and the contrivances, as shown in Figs. 1 and 2, (Plate 11,) is what I should recommend.

It remains to notice another method of conducting the ventilation and warming of rooms, which has (by Mr. Perkins) been acted upon to some extent.

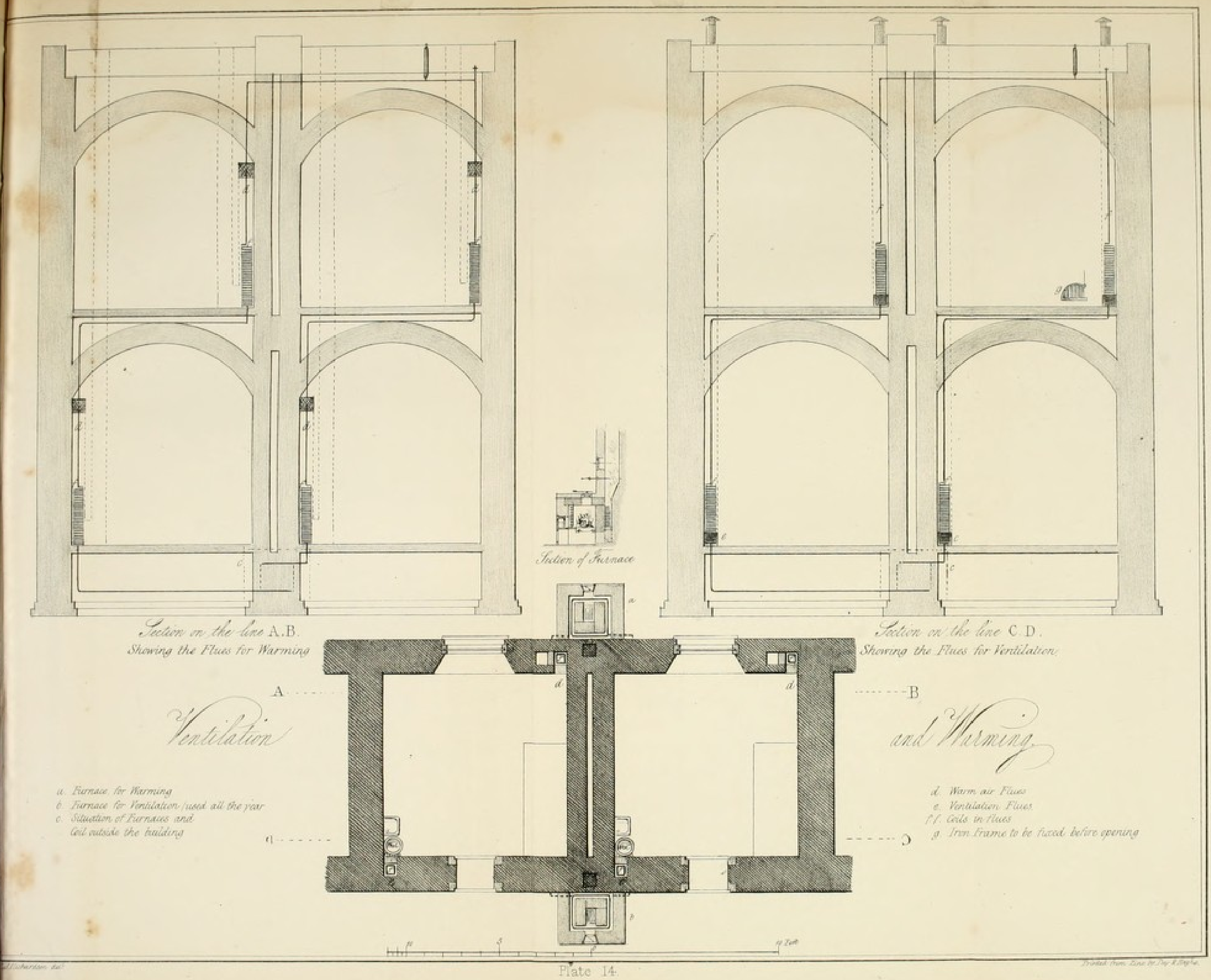
The admission of the current of warm air at the ceiling, or upper part of the room, and the forming a descending current, by placing the ventilating opening at the floor. This, Mr. Perkins considers the best method of placing the openings and conducting the process; it introduces a warm temperature insensibly, and he apprehends removes the impurities of the room more effectually. Mr. Alfred Ainger, the Architect, who has paid considerable attention to this subject, likewise advocates this system; he remarks that "with upward ventilation, a great part of the vitiated atmosphere" (of crowded rooms) "being specifically heavier than common air, is liable, by the slightest check or condensation, to be thrown down and mixed with the air which is already partly unfitted for the purposes of life.

"But let the ventilating current descend, we have a bright atmosphere, consisting of an immense reservoir of pure air, arriving immediately at the lungs, and which, as it becomes contaminated is drawn downwards by a force with which most accidents will co-operate."

In order to show how this system can be practically applied in a building, I have added Plate 14. These are four prison cells, the walls of which contain flues nine inches square; the ventilating flue with the opening at the floor encloses a coil and pipe, and is provided at top with a cowl, to prevent downward currents of air. The warm air flue is double, the coil only placed in that portion which opens into the room, the warmth of the coil drawing the fresh air through the other from above.

It will be seen on inspecting the plan, that the ventilating flue is placed on the opposite side of the room, in the extreme corner to the other flue. In summer the ventilating flues alone act.

It must be particularly remembered that the method proposed in this volume, as a system for warming and ventilating buildings, is not applicable in the same form to all; we must adopt the principle only, and suit the construction of the apparatus to


Section on the line A.B.
Showing the Flues for Warming
Section of Furnace
Section on the line C.D.
Showing the Flues for Ventilation
Ventilation and Warming
a. Furnace for Warming
b. Furnace for Ventilation used all the year
c. Situation of Furnaces and Coil outside the building
d. Warm air Flues
e. Ventilation Flues
f.f. Coils in Flues
g. Iron Frame to be fixed before opening
10 Feet
Plate 14.

the building, to which we wish to apply it. The tubes adjust themselves readily in any form, and become by their high temperature, an easy forcing power to procure ventilation; indeed, I may here remark, that all other apparatus, formed either on the different systems of hot air, steam, or hot water, are only fit for particular purposes, and can only be introduced with effect in particular situations; whilst this, by its convenient form and efficient acting, suits equally the most complicated, or the most regular building.

The practical formation of the apparatus, as already described, is suited to private dwellings of moderate superficial extent, as to ground plan, and which are piled story on story; and equally to public rooms, churches, and hospitals. In such an edifice as Strathfieldsaye, Plate 6, we find a building of a different character to any of these, and one presenting peculiar difficulties to the introduction of the warming and ventilating system. Here, the furnace could only be placed at one end of a long range of building, from which the hall, passages, and staircase were required to be warmed, and this was efficiently performed. If it had been thought desirable to warm and ventilate the sitting rooms also, upon the principle here recommended, some new mode of construction must have been resorted to. Portions of the ceilings of the passages nearest to the rooms required to be ventilated, might be raised to a high temperature, by placing in them a greater quantity of tubing, a number of very small apertures in the form of perforated pateræ, might then be made through the upper part of the rooms under the cornice, into the passage and hall. The expansion tube of the apparatus, or some feet of pipe, might then be placed in a ventilating flue or tunnel, commencing from the ceiling in any convenient nook, or corner of the passage, which would have the effect of ventilating the rooms gradually and effectively; three such tunnels, I apprehend, would be sufficient for a building of the same dimensions.

In summer a like effect could be produced by placing the pipe containing the circulation of heated water in a wooden case behind the openings specified, and connecting it with the tunnels.

Those important buildings, the theatres in this metropolis, do not offer at present any good specimens of ventilation; but sufficiently make known to all who frequent them the value of that art.

If three or four perpendicular tunnels, constructed either in wood or metal, and containing sufficient heating surface for the purpose, could be so placed as to draw off the air quickly at the ceiling of each tier of boxes, the openings for this purpose placed immediately above the line of the door heads, and the galleries ventilated in a similar manner, it would materially assist the purification of these buildings. The operation being performed as extensively as possible, would occasion little current, and consequently not affect the sound, which strong currents of air in theatres are likely to do.

At this time the gas chandelier is the only ventilator in our theatres; a funnel being placed above it, entering the open air, formed principally to create a draught, and procure fresh air to supply the lights.

This forms a hot chamber, and the rarefaction produced within it draws the air out of the body of the house, as up a chimney; but that it does not wholly effect the ventilation of the house must be evident to any person who may have been in any of our theatres on a crowded night. The intense head-ache with which many persons are afflicted during their stay, and even a considerable time after leaving the house, is a proof of insufficient ventilation, and likewise of its vital importance.

Perhaps the funnel in this case is not carried up high enough, and the heated column of air within it of too low a temperature; but there may be several other circumstances which contribute to the cause. In so large a building as a theatre, the means of ventilation should not be confined to one place only; and flame especially should not be the medium employed to produce it. It must be remembered that flame requires the oxygen of the air, as well as the human being, and a gas burner is particularly destructive of it. The numerous burners in the centre chandelier of one of our large theatres, require a very large portion of pure air to supply them; and whence can they draw it? Is the heavy impure air beneath to answer the demand? Does it come from the opening of the stage, or rush down the ventilator? In any of these cases it would prevent the ready and necessary ascent of impure air from the pit and boxes.

If we make a large fire in a close room, and allow no opening for the admission of the external air, however excellent the construction of the flue, the air will rush down it with the smoke, in order to fill the vacuum caused by the fire.

The honest character of our common fire-place, which in such instances compels us to procure fresh air, is not sufficiently known on the continent, where they burn charcoal in braziers, and numerous instances of suffocation arise from the absence of such a friendly monitor.

The mass of vitiated air in a theatre, rendered by the excess of carbonic acid gas of greater specific gravity than the external air, does not readily rise and escape, according to our wishes, in any single direction. Whatever it ought to do in theory, it is rather sluggish in practice, and requires us to attack it and draw it off gradually from *many* points, and if these points were only a few feet above the part where it is generated, so much the more effectual would the ventilation become. If contrivances of the kind I have pointed out were adopted in our theatres, and a sufficient quantity of pure warm air was supplied from better sources than the corridors and stage, the oppression and danger resulting from several hours' continuance in such an impure bath would be removed, and the gas chandelier in the centre, relieved from a part of the great body of deteriorated air beneath, might then become an effectual ventilator for the body of the house.

Before I quit the subject I wish to show how far the present system can be made to effect the warming and ventilation of the new House of Commons, according to the ideas of the different gentlemen who were examined before a Committee of the House on the subject.

I humbly conceive, that the only approachable means of ventilating such a room with the various galleries placed at different heights within it, together with the corridors and lobbies appertaining to it, upon any of the plans here proposed, would require two or three furnaces for that purpose alone. In order to suit the ventilation to the various number of members present at different times, the openings should be formed into six sets, each set being closed by itself. If 400 members were present, four sets might be opened, and two remain closed; if 100 members only were assembled, five might be closed, and one remain open upon the principle that a fresh supply of air will not enter a room, unless a corresponding portion of air is permitted to escape from it; this plan would regulate the admission of the warm air in a corresponding proportion.

A slight essay like this will not admit the investigation and developement, demanded by a subject possessing such national importance, and requiring such accurate scrutiny.

In the above plan it must, of course, be concluded, that the six sets of ventilating openings should more than insure the ventilation of the room when quite full.

As to the means of warming the room effectually, I think the method applied at the Justiciary Court, (see Plate 5,) answers the requisites deemed necessary by the gentlemen who were examined by the Committee. On this plan, the heated pipes would be so equally distributed under the floor of the house that the warm air would ascend in every portion of it at an equal temperature:—the risers of the steps in the house are nearly two feet in height; these, with all the lateral surfaces, could be pierced with some thousand of small holes for the admission of warm air from beneath, and this situation for them would prevent dust from the floor being carried up by the current.*

* This was written immediately after the Report of the Committee was printed.

With this arrangement, and the fresh air to supply the house descending through a tunnel formed in one of the loftiest towers of the new building, and received, after being warmed, in a chamber where the temperature could be properly regulated, (if possible by an admission of air from the same turret,) the happiest effects might be produced; not only might the present comfort of our statesmen and orators be thus insured, but that slowly-working, yet certainly influencing principle of impure air be avoided, which, in conjunction with the cares and fatigues of office, has carried off in the prime of life, some of the nation's greatest benefactors, and of human nature's brightest ornaments.

I beg to add, that by such an arrangement of pipes equally distributed below the floor of the house, great aid could be given to the cooling of the room in summer. If the pipes were at that period connected with a cistern of cold water at the highest level, drawing it off at the lowest, the fresh air from the turret descending and entering the house would be cooled in its passage, a constant supply in a proportionate degree being insured by the ventilators drawing off the air in the upper part of the building, although this effect would be counteracted in some degree from open doors and windows in the house itself.

The means for warming and ventilating either large or small buildings on this plan, must, as I have already said, be varied according to circumstances and the discretion of the architect. I have refrained from giving the quantity of feet in pipes necessary to raise rooms of a certain size to a given temperature, because this varies as to situation, aspect, and the number of doors, windows, or skylights, and 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 led me to perceive, 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.

* "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

I must again remark, that colds are caught in our climate, almost as frequently 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, hinder them from being employed to the extent I have here applied to that of Mr. Perkins.

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 employod 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*, page 99.

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 had been provided with effectual means for insuring a comfortable temperature throughout, how many of those losses, caused by the fatal influenza, raging at the present period,* would have been 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 most 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

* January, 1837.

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 ensured, by that proper attention which he alone could give to the warmth and ventilation of their dwellings.

I must particularly press upon the reader this fact, that 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 I have confined myself to the description of one system, which, from close investigation of the subject and experience of its effects, I conclude 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 ensure 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, of which I have been treating, I have so far respected their general opinions, as to render my plans 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. I see 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 I cannot but believe that, sooner or later, it will be universally adopted, and that the more intelligent portion of the community will countenance it at a very early period.

# APPENDIX.

*An account of the following methods of warming and ventilation, some of which have been only lately introduced, will be alike interesting and useful.*

The flame of gas has lately been employed in stoves to warm rooms. These stoves are of iron and circular, in the form of pedestals, standing a few inches from the ground on claws; the gas lights, forming a circle of about six inches in diameter, are placed beneath an inverted cone of iron, the smaller opening of which is about four inches, and the upper the same diameter as the inner part of the pedestal to which it is attached. The gas light being confined by this contrivance between the cone and the outer case, warms the cone of iron; and the cold air entering at the bottom of it, is warmed and admitted out at the top of the pedestal into the room.

No chimney, or contrivance for carrying off the impure air caused by the gas, is provided.

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A system of heated air for warming and airing buildings has lately been introduced by Mr. F. A. Bernhardt.

In order to better understand this system, I will describe the contrivances separately.

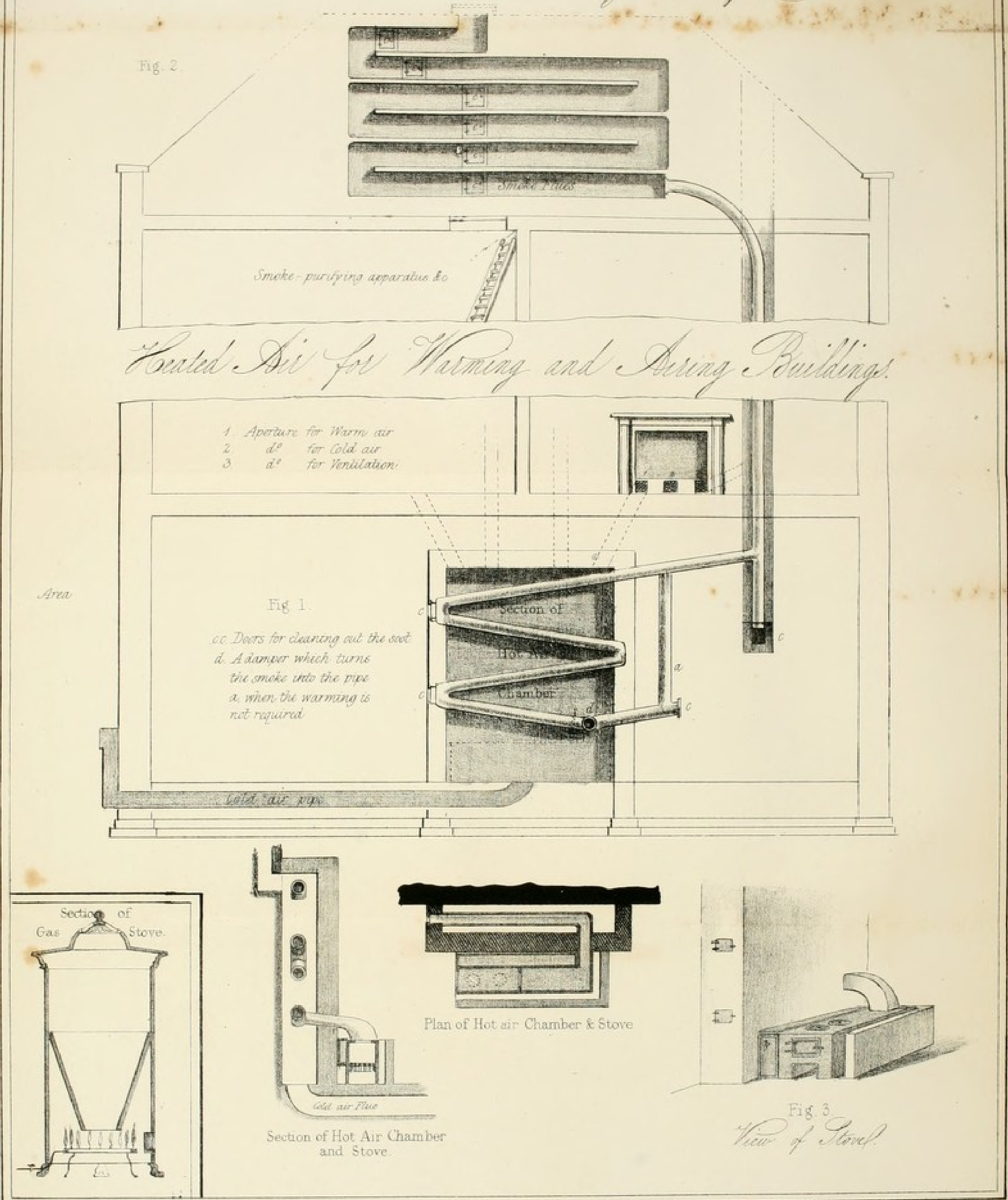
The stove used is of iron, in the form of a box, fig. 3, Plate 15, about one foot nine inches high, eleven inches broad, and five feet in length; in one half is the fire, which being provided with a grate, is reduced in height to six inches. It has a door in front, and two apertures at the top or lid; these can be enlarged at pleasure by circular iron rings fitted one within another. The draft from these openings propels the smoke from it into the other half, which forms the entrance into the smoke pipe.

This stove is placed in the kitchen, and serves for cooking; about sixteen gallons of water is kept boiling on one side of it for the same purpose; on the other side, an erection of stone work about three inches in thickness, and the same distance from the stove, prevents passers by from accidents by burning.

The fire, thus boxed up within the room, renders it excessively warm. The steam from the water, and part of the superabundant heat, is permitted to pass up a flue prepared for that purpose.

For the warming, the smoke-pipe (*of cast iron*) leaves the back of the stove, and enters, in a slightly vertical course, a brick chamber of about eight feet in height, eight feet in length, and one foot six inches in width. In this, the hot air chamber, it takes two courses, leaving it at the upper part, and

# Mr. F. A. Bernhardt's System of Heated Air for Warming and Airing Buildings.




C. J. Richardson, del.

Plate 15.

Printed by Day & Haghe

proceeding in the same vertical direction to a perpendicular flue in the wall at a little distance; see fig. 1.

The cold air is admitted into the chamber through a tunnel formed under the kitchen floor, the external opening of which is in the area. The air, after being warmed by the smoke-pipe, ascends through flues to all the rooms and passages requiring to be warmed, including, if necessary, the whole of the rooms of the house.

The ventilation and the equalizing the temperature of the rooms, I have reason to believe, from a careful consideration, is thus managed :—

The smoke-pipe, on leaving the hot chamber, is inserted into a perpendicular flue, in which it is carried up above the attic ceiling. This brick flue opens into the air above. The smoke-pipe from the furnace being thus contained in this perpendicular flue, renders the air within it of a very high temperature, and the flue thus becomes a forcing power for ventilation. Openings are made in the lower part of all the rooms, which are connected with this power by means of flues, through which the cold air from the lower surface of the rooms passes. The heated air then descends and distributes itself. This ventilation may be carried on in summer; separate from the warming, a smoke-pipe, *a*, fig. 1, being provided, connecting at once with the perpendicular flue, and not entering the hot chamber, which is by this means cut off.

One of the chief recommendations given by Mr. Bernhardt to his system, is a smoke-purifying apparatus attached to it, "in which the soot deposits itself, by a chemical precipitation in the channels which are prepared for its reception."

These smoke or soot deposits are thus managed: The iron smoke-pipe contained within the perpendicular flue is carried up a few feet higher than the attic ceiling; the smoke is then discharged from it into the first of a series of horizontal flues formed in the main wall; each flue is about fourteen feet in length, and they rise one above another, with about three inches thickness between each, fig. 2. The soot deposits itself in its passage through these flues, and the smoke separated from it is discharged at the funnel in the form of vapour.

For clearing out the soot, there are, in the first place, beginning with the kitchen, two doors in the smoke-pipes contained in the hot chamber. They are placed in the bends, and thus the two doors serve for the four lengths of pipe; these require to be cleaned out about once every week or ten days. The perpendicular brick flue is continued downwards a few feet from the point where the iron smoke-pipe enters it, and is here provided with a door. The iron pipe is likewise continued downwards, and has a door opposite; when it is to be cleaned, a bag is put over this door, a very heavy circular brush is then put in the pipe at top, which, by its weight, falls to the bottom with the soot into the bag ; this operation can be performed by a female servant.

The horizontal smoke-flues at the top of the house have each a door, and from the great quantity of soot deposited in them, require cleaning, of course, often. The length of these flues, which, in a London house at least, must be formed in the party wall, appears to prevent the introduction of any of our present upright flues. If, therefore, the English open fire-place is introduced in any of the rooms of the building, the flue from it must be carried into the one belonging to the stove below.

The system of illuminating by gas attached to Mr. Bernhardt's system of warming and ventilation is as follows: In his own house it is laid on from the street main; burners are placed in the fire-places, either for a cheerful appearance or to boil a tea-kettle, &c. Each burner is provided with a small flue of about four and a-half inches or two and a-half inches square, formed in the wall; those in the middle of the room are provided with tubes of about two inches in diameter, to carry off the vitiated air from them to these small flues. A horizontal flue made of copper is placed in the roof of the house; this is warmed by the ventilating flue into which it opens; into this the small flues from the gas-burners enter; thus the impurities generated by the gas are drawn out of the rooms.

I may probably be incorrect in this latter description of the illuminating apparatus, having, when I inspected it, paid more attention to the warming and ventilation. The stove, in its present form, is more fitted for a foreign than English kitchen. Large joints of meat are dressed, by being placed in a dish put directly on the top of the stove, with a cover over them.

In order to fully understand the above system, (as it is almost impossible to do so from any written description,) I have added a plate of it, and likewise a section of the gas stove.

The attention directed for some years past to the better warming and ventilation of the two Houses of Legislature, will render the following few particulars concerning them acceptable.

The Commons appear to have given greater attention than their Lordships to the warming of their House, having had several different systems introduced from time to time for that purpose. The Upper House had been warmed almost from time immemorial on the ancient and classical system of smoke or hot air flues placed immediately beneath the floors, which system at last caused the destruction of the whole building.

The earliest introduction of any regular method of warming in the House of Commons appears to have been in 1791, when a Committee of the House was appointed to consider the best method of regulating the temperature of the air, &c. in that building. Before this date, charcoal braziers were placed in the House previously to the assembling of the Members, for the purpose of warming it. By the time business commenced, the air must have been rendered by their means very pernicious yet they had been in use many years.

The Committee, upon due consideration of the several plans laid before them, placed the ventilation of the House, or method of carrying off the foul and rancid air from it, in the hands of Mr. Henry Holland, the architect, whose estimate for which amounted to £45.

They likewise recommended a stove for injecting warm air through the floor of the House, and the placing two thermometers there, in order to ascertain the degree of heat in the House at all times. The estimate of the stove, with the fittings, amounted to £120, and the two thermometers to £14. 14*s*.

The stove by Jackson and Moser was denominated an Empyreal stove. It was six feet square, and fourteen feet high; the great height being occupied by earthen pipes and retorts, through which the cold air in its passage into the House was warmed. This stove was placed in the crypt under the House, and only one open patera in the floor above was provided for the admission of warm air, but this was three feet 6 inches in diameter.

The above plan was by Mr. Adam Walker. Mr. Henry Holland recommended the placing an earthen stove (like those used on the continent) in Solomon's Porch (a small passage immediately behind the Speaker's chair, and leading to the Members' galleries, and making the windows of the porch larger, that, when open, a supply of pure air might be obtained. "This," he observed, "would warm the House sufficiently, and the effects of both the warm and fresh air could be regulated by a very little attention to the doors opening from the porch into the House."

This plan was not acceded to; but his proposal for ventilation, which was to improve that already existing, by forming two chimneys, with cowls on the roof, was carried into effect.

The ventilation previously was by four apertures in the ceiling of the House, opening into upright wooden trunks concealed in the roof; these entered a horizontal flue formed in the centre, from which the air was exhausted out by means of a machine (fig. 1, Plate 16), placed away from the House, in a room over the adjoining one, which was occupied by the chief clerk of the House of Commons. Mr. Holland proposed to place the air machine immediately above the centre of the House itself, on the roof, and this appears to have been ultimately carried into effect.

Mr. Adam Lee, in a Report on the House of Lords' Ventilation, made in 1817, recommends for that building a similar machine; and remarks, that "the one used at the House of Commons seems to have answered the purpose to ventilate that House for the last thirty years past."

The whole of this was cleared away, and the Marquiss of Chabannes, about 1820, attempted the warming and ventilation of the House by steam, in consequence of objections being made to the erection of a ventilating furnace under the roof, and for the means of regulating more easily the heat according to the number of Members present. He remarks, "that considerable difficulty arose from the small size of the House for its Members, and from the construction of the galleries, which prevented the free ascent of the air."

A large case or trunk was constructed over the body of the House, and below the roof, of seven, six, and five feet square, and about twenty feet high, into which the ventilating tubes from the different parts of the House were conducted; the four first drew from under the galleries to prevent the stagnation of the decomposed and impure air in those parts. The six openings in the ceiling led into the main trunk, and were each continued in separate trunks to the top, so that the draught from every part was equal.

Sixteen steam cylinders were placed inside the main trunk; and the body of heat these produced was intended to rarefy the air in the ventilating tubes so powerfully as to cause its quick ascent, and escape through a large cowl of four feet diameter outside the building.

For the warming, he placed twelve steam cylinders all round the House under the Members' seats; each of these cylinders, of sixteen inches diameter, contained thirty pipes of two inches diameter, in passing through which, the external air was heated when steam was admitted in the bodies. A single cock turned off the steam from all the cylinders, so as to raise or lower the temperature rapidly.

The external air was brought to these cylinders by a large air trunk, from which there was a separate branch to each cylinder.

This system did not remain above a few years; it was taken away, and others were afterwards introduced.

Before I describe the excellent system of warming and ventilation, introduced in the present temporary House of Commons, by Dr. Reid, of Edinburgh, I shall describe Sir Humphry Davy's plan of ventilation for the House of Lords, as it seems to have been the model for many subsequent ones.

It must be previously stated, that the warming of the House of Lords was effected by horizontal smoke or hot-air flues placed beneath the floor. The following letter was addressed to the Earl of Liverpool, at that time his Majesty's principal Secretary of State:—

"21, Albemarle-street, 7th Sept. 1811.

"My Lord,

"I am informed by a person attached to the

House of Lords, that it is your Lordship's wish that I should give some more minute information respecting the plans which I submitted to the Lords Commissioners for considering the ventilation of the Upper House in February 1810.

"As no part of that plan has been as yet carried into execution, it will not be necessary for me again to speak of the general principle proposed to be adopted. I shall merely refer to the means which appear to me most proper for carrying it into execution.

"To convey fresh air into the House, I propose flues of single brick connected with the flues for sending hot air through the vaults under the floor, and I propose that this fresh air should be admitted by numerous apertures in the floor of the House, and supplied to the flues by pipes of copper or plate iron from the free atmosphere.

"The air in this case will be always fresh, and, by regulating the fire, may be more or less heated, according to the temperature of the room is low or high.

"To carry off the foul air, I propose two chimneys or tubes, made of copper, placed above the ventilators, and connected with wrought-iron tubes, which can be heated by a small fire, if a great draught is necessary, as in cases when the House is full.

"Should this plan be adopted, there would be no necessity for opening windows; the foul air would be carried off from above; warm air or cold air, whichever is necessary, may be supplied from below, and there would not be, as now, any stagnation of air.

"I shall subjoin a sketch which may be useful to the persons who may carry the plan into execution; I have already, I believe, made Mr. Davis,* Mr. Groves' clerk, understand it, and I shall be happy to give any other assistance in my power during my short stay in town.

"I regret that I was absent at the time your Lordship wished me to call at Fife House. It will be a matter of great satisfaction, if any thing I can suggest should be of use on so important an occasion.

"I have the honour to be, &c. &c.

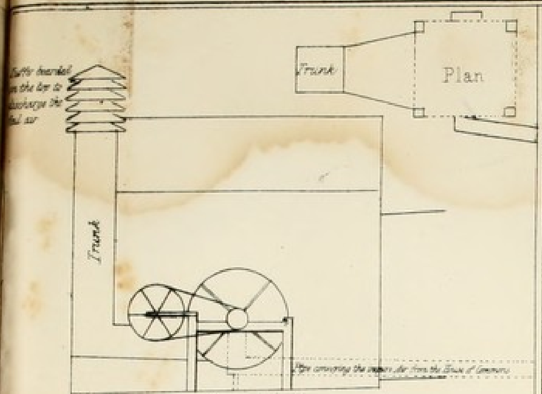
"HUMPHRY DAVY."

This plan appears to have been carried into effect. Plate 16 is a copy of the sketch accompanying the letter; the fire to warm the ventilator was placed in a fire-proof house constructed for the purpose upon the roof.

In June 1813, a Committee of the House of Lords was again appointed to consider on the ventilation of their House.

Mr. Adam Lee, at that time labourer in trust, in his official capacity made a Report to the Commit-

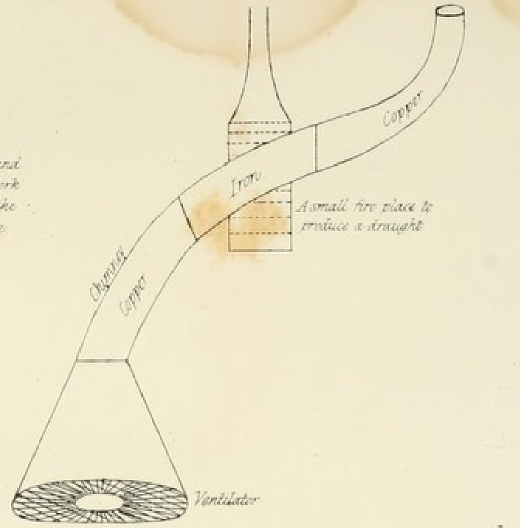
* Qu. a mistake, Mr. Adam Lee?




*Elevation of the Air Machine used for Ventilation at the House of Commons in 1791*

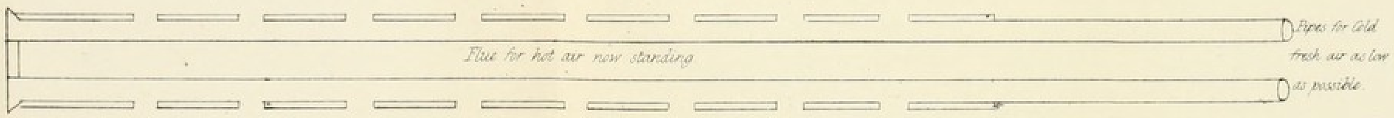
*The impure air enters at the Axis of the Wheel and is delivered at its Periphery*

*The other Ventilator is of the same kind both covered only with a thin wire work at Bottom, the part of the tube in the fire place should be of wrought Iron*




# *From a drawing by Sir Humphrey Davy*

*These Flues to be built on the side of the Flues now Standing*




*These are Flues of single Brick with apertures to let the air out into the Vault*

*Each of the flues from the furnace which are not to be altered to be furnished with two air flues running parallel to it and single Bricks to be left out at every three feet to admit of the escape of the Air this is the mode in which fresh air is to be introduced*

C. J. Richardson del.



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The Cowl on the ventilating
flue is fifteen feet in diameter,
runs upon rollers, besides being
supported upon a centre mast, &
weighs two tons. The bust of the
arrow which forms the vane is
made of cast-iron and weighs
170 pounds.

tee on the subject; and as this document describes the system afterwards introduced, and likewise the defects attributed to Sir H. Davy's plan, I shall quote at once from it:—

"My Lords,

"Having had the honour of superintending the ventilation of your Lordships' House for the last seven years past, I have repeatedly seen the great inconveniences resulting from the intense heat of the House, caused by the insufficient ventilation thereof; and I have from time to time made the most minute observations respecting the temperatures.

"I paid the most careful attention to the execution of Sir Humphry Davy's plan for the ventilation of the House, and to the operation of it afterwards, and have had the direction of the person who attended the fire to the ventilator.

"I have found on a very crowded night of business, that it was impossible by means of the present ventilators to draw off the heated air; the thermometer in the House has been up on such occasions to eighty degrees, and the windows were consequently obliged to be opened, otherwise it would have risen still higher; therefore, I consider that the ventilation pipe, which is only one foot in diameter, is quite inadequate to draw off the heated air from such a large room."

He proposed "enlarged pipes of three feet diameter, provided with registers to shut up the pipe to exclude the cold air from blowing into the House when the ventilation was not wanted, the pipes to be quite air-proof, being covered with leather at the joints.

These pipes "were conveyed in an oblique direction to the fire-proof house; they are capped at the top with a cowl head that will turn with the least gust of wind."

He likewise considered "the fire to the ventilator unnecessary, as there have been several complaints of the smoke getting into the House from the ventilation pipe." He proceeds, "I have at various times taken an opportunity of going on the top of the House, and have put my head over the ventilation pipe when the fire was at full heat, and have not perceived the hot air coming from the House. I have likewise tried at other times without fire, and have found a very strong current of hot air from the body of the House.

"I, therefore, consider the intended new pipes will answer the purpose without fire; and if the assistance of fire should be required, the new pipes are so constructed as to admit of fire-places agreeable to the present plan."

. . . . "I beg leave to suggest that a considerable improvement may be made in warming the House in the winter season—at present the flues are heated by coals, as they come from the pit; as the flues lie horizontally round the chamber of the House, one hundred feet in length and upwards, the smoke remains in them for a very considerable time, and consequently a great proportion of the unwholesome effluvia of sulphur, &c. which rises from the combustion of fresh coals, is at times perceptible in the body of the House; I have taken particular notice of this circumstance in the morning after the flues have had fire in them all night. . . . ."

The plan of Mr. Lee's for ventilation was not sufficient. In 1817 he recommended a machine or air-pump to draw the air out of his ventilators.

Mr. James Wyatt, the architect, was likewise consulted as to the better warming and ventilation of this House; and he placed the two enclosures, one in the Painted Chamber, before the Royal Robing-room, and the other at the door of the outward lobby at the lower end of the House. These were destroyed by the fire in 1834, with the rest of the building.

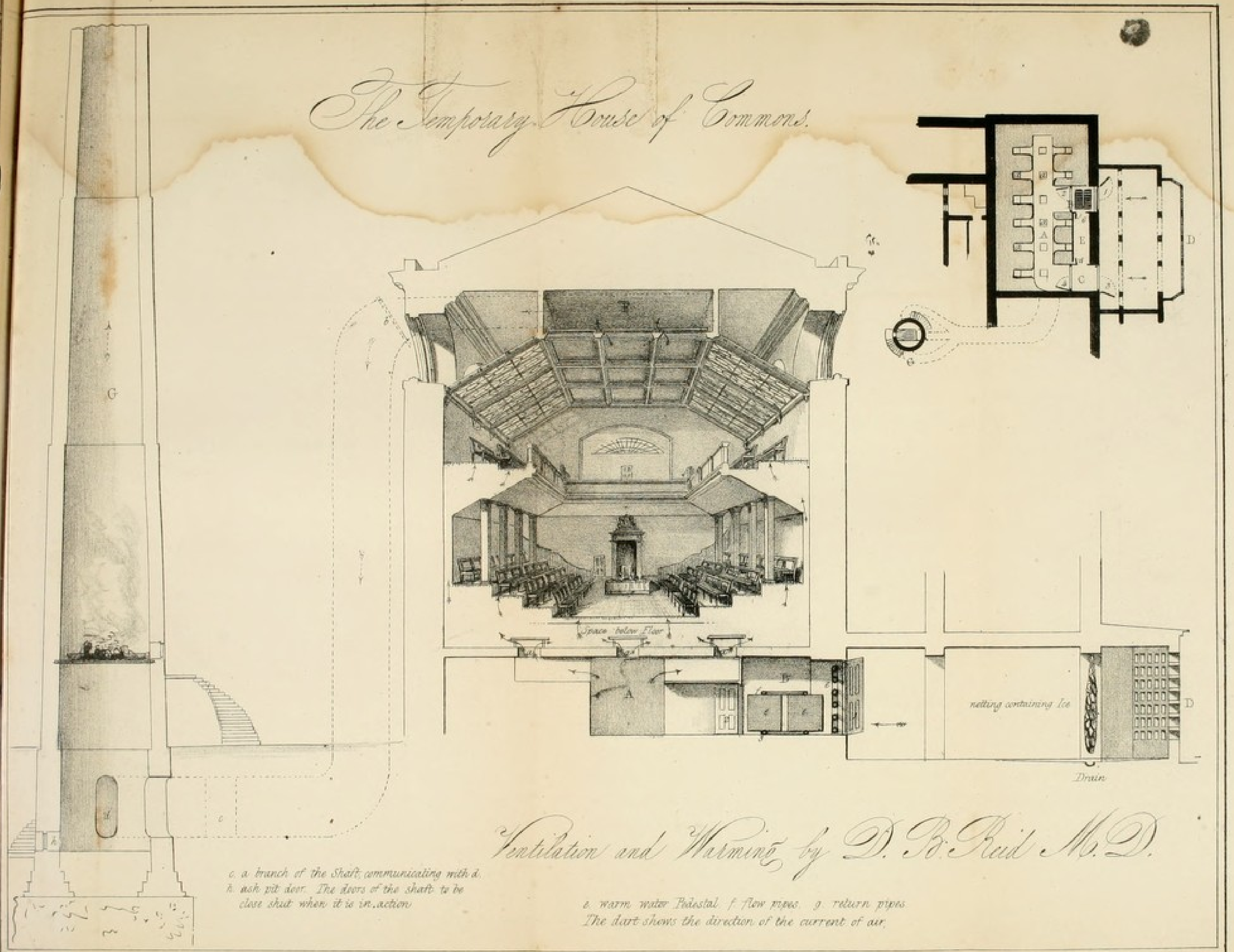
The present temporary House of Commons is warmed by the ordinary warm water system: the large flat tablets, through which the water circulates, are placed in a room under the House, and occupy a surface of about nine feet square; they are four feet in height.

This apparatus was found on the spot by Dr. Reid.

Two or three feet beneath the floor of the House, Dr. Reid has formed a second-floor, in which he has made about twenty apertures, each about eighteen inches square.

These apertures are marked *a, a, a,* in the small plan, Plate 17: on this plate, as with the others contained in this volume, it will be found that the same letters of reference indicate similar parts; beneath the second or lower floor runs a long passage A; opening into this are two others of an equal width, B and C; in the passage B, is placed the warm water pedestal. Large folding doors are placed before the entrances; and within these passages: they are marked in the plan respectively, 1 and 2; 3 and 4; 5 and 6. On the relative adjustment with each other of these folding doors, depends the temperature of the House above; fresh air, either warm or cold, according to the season, can be produced, and it can be changed from warm to cold, or the contrary, as the changeable external temperature of the day or hour requires; this will be understood by an inspection of the plate, and with the following description.

The fresh air enters from Old Palace Yard, through the perforated wall D; if the folding doors 1 and 2 are opened, and all the rest closed, the air will enter the passage A, passing through the pedestals placed in B, and warm air only will be supplied to the House above; if air moderately warmed is required, the doors 3 and 4 are opened as well, and two currents, one cold, the other warm, are then formed, they meet and blend together in the passage A, and then ascend: if only air of the temperature externally is required, the folding doors 3 and 4, are alone




C. J. Richardson Delt.

Plate 17

Printed from Zinc by Day & Haghe

opened : if required to be only moderately warmed, 3 and 4 are opened, 1 half opened, 2, closed ; the small folding doors 5 and 6 are then opened, and a slight current of warm air passes through the small passage E, and mixes with the cold current entering at C. The folding doors in this passage can likewise be opened when 3 and 4 closed, and a current of warm air will then be conveyed to one end of the passage A.

Through the apertures *a*, *a*, *a*, the cool or warm air rises into the space beneath the real floor of the house ; immediately over these openings, are placed large platforms like tables, sustained by short feet ; these have the effect of dispersing the great body of air admitted.

The air then enters through openings made in the actual floor of the House, perforations for which are made to the almost incredible number of 300,000. These lesser apertures are about the sixth of an inch in diameter on the surface of the floor, but expand downwards in order to prevent their being easily choked or becoming stopped. The sides of the House under the galleries are battened or brought forward five or six inches ; between the framing and the wall the air ascends, and passes out through the floors of the Members' galleries, pierced for the purpose in the same manner.

The floor of the House and galleries are covered with a thick horse-hair matting, the meshes of which are large, almost like those of a sieve; this allows the air to ascend through them.

The operation just described is ensured or rather forced at all times of the year by the action of the ventilating shaft G.

In Summer, when the air is required to be artificially cooled, various contrivances can be resorted to in the chamber immediately behind the perforated wall D. The air could pass into the chamber A, over wet surfaces, and be cooled by evaporation; the present intention is, I believe, to place ice suspended in netting between the piers in the chamber; this is shown in the Plate.

The alterations by Dr. Reid have, it is well known, been made principally with a view to the improved transmission of sound, for the obtaining of which, a new ceiling of novel construction has been placed a few feet below the former one; this is divided into three portions, the centre from one end to the other being perfectly horizontal; the other two compartments are inclined planes, each making, with the floor of the house, an angle of about thirty degrees; those portions of the ceiling which form inclined planes are glazed, while the centre is panelled in a manner to accomplish the ventilation of the House. An inclination has been likewise given to the ceiling beneath the Members' galleries, which corresponds exactly with the inclination of the lateral compartments in the newly constructed ceiling above.

To provide for the egress of the foul air from the House, each panel of the centre compartment of the ceiling is raised by blocks several inches above their styles; this admits the passage of the air into the space marked F, between the two ceilings. To draw out with rapidity this foul air and to introduce fresh, has been effected in the following manner :—A large circular shaft G, has been erected in Cotton Garden, at a distance of about twenty feet from the eastern wall of the building; about ten feet from the surface of the earth is an exceedingly large coke or coal fire, the operation of which is greatly to rarefy the air within the shaft; a very high column of heated air is thus obtained, the importance of which for ventilation may be understood by the remark of Dr. Reid, that "the greater height to which you can carry your column of heated air, the greater the power."*

The space F between the two ceilings of the House opens at the north-end into a large square shaft; this is continued downwards, and opens under ground into the circular shaft G, just described: the result of these arrangements is, that when the air in the circular shaft becomes intensely heated, and, therefore, exceedingly rarefied, there is produced a downward draft through the square shaft, and the effect of that operation is the rapid withdrawal of the air within the House, and the substitution of fresh air in it from openings in Old Palace Yard.

* Made to the Ventilation Committee of the House of Commons in 1835.

A damper is placed at *b*, in the square shaft, which regulates, as it is more or less opened, this supply of air according to the number of members present.

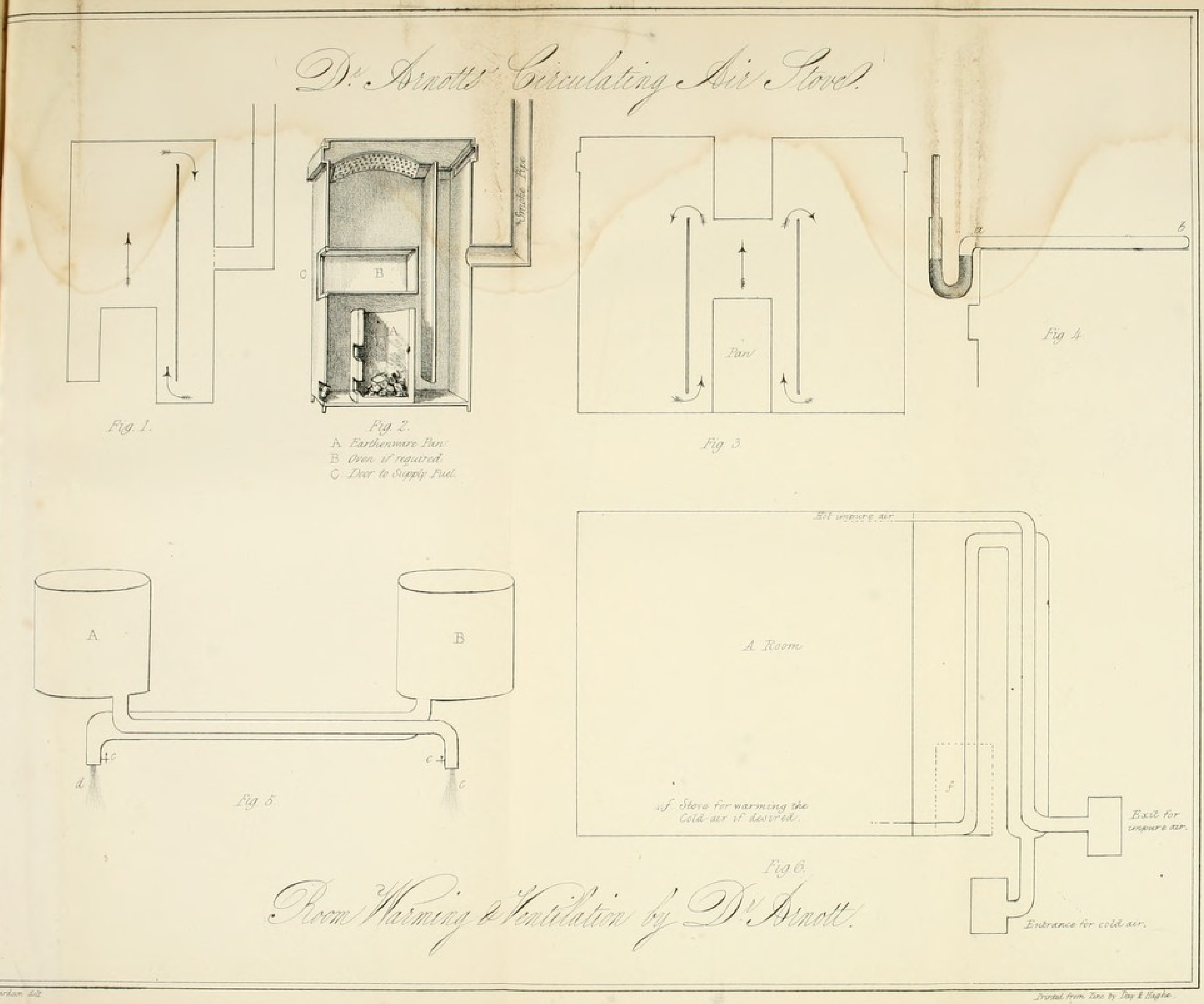
The height of the ventilating turret above ground is about one hundred and ten feet; it is twelve feet in diameter at the base, and about eight feet at top; it is constructed on a concrete foundation, as the ground for building about this part of Westminster is very bad. The reason of placing it on the ground is, as I should imagine, to get greater security of foundation; for if such an erection had been placed on the roof, the extra height, near sixty feet, would have rendered the foundations very difficult to form and very expensive.

Plate 17 accompanying this description, is correct so far as the principles and construction of these excellent arrangements are is concerned.

Plate 18 illustrates Dr. Arnott's circulating air stove and his principle of room warming and ventilation.

The great object with the stove, was, that the external surface should always be of a low temperature, and therefore it should not be liable to the fault of the common hot air stoves, that of deteriorating the air in the room wherein they are used: another object was to obtain economy in fuel.

The stove, which is of sheet iron, has a contrivance inside like a double back; this extra plate, however, is six inches less than the whole height of the



Dr. Arnott's Circulating Air Stove.
Smoke Pipe
C
B
A
Fig. 1.
Fig. 2.
A Earthenware Pan
B Oven if required
C Door to Supply Fuel
Pan
Fig. 3.
a
b
Fig. 4
A
B
c
c
d
c
Fig. 5.
Hot impure air
A. Room
f
f. Stove for warming the Cold air if desired.
Exit for impure air.
Fig. 6.
Entrance for cold air.
Room Warming & Ventilation by Dr. Arnott.
Richardson delt.
Printed from Zinc by Day & Haghe.

stove, wanting three inches at top and the same at bottom; an earthenware pan containing a coke fire is placed inside the stove, immediately in front of this latter plate. The expanded air rises from the fire to the upper part of the stove, and the air at the back of the plate being of a lower temperature passes under it to the top of the pan, and thus a circulation of the air is caused; preserving as near as possible the whole of the heat generated by the combustion of the fuel.

Fig. 1, illustrates the principle; fig. 2, is a section of the stove complete; and fig. 3, a section of a double stove.

A small valve immediately in front of the fire, supplies it with air, and this opens in proportion as the fire is high or low in the pan; if too high, the valve closes; if too low, it opens; this operation is performed by the valve being connected with two small bars, one of which is iron, the other brass; these are rivetted together at one end, which is so placed that the heat of the stove affects it. The unequal expansion and contraction of these two bars at the other end communicate motion to the valve, and cause it to operate as desired.

The operation of opening and shutting this valve, can be performed several other ways; one is represented in fig. 4; this is a glass tube, which can be placed on the top of the stove; the space from *a* to*b* within it contains confined air, the bent part quicksilver; a small wooden peg floats on this; the heat of the stove causes the air in the glass to expand, which presses on the quicksilver, and this raises the wooden peg; if this is connected with the valve, when the heat of the stove is too great and the peg very high, it easily shuts it, and prevents any further supply of air.

Fig. 5, illustrates the principle of room ventilation and warming, by Dr. Arnott, and fig. 6, its application. Suppose A, fig. 5, 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 in A, and the water at *e*, will be one degree less than the water in B.

The application of the principle is explained by Dr. Arnott, in the following extract from his report on "Warming and Ventilating Infirmaries, Workhouses, Factories, and Domestic Apartments," given in the Appendix to the Second Annual Report of the Poor Law Commissioners.—"In rooms where the mechanical mode of ventilation already described, (by means of fanners) and now common in factories, have been adopted, an addition might be made to the apparatus for extracting the impure air, which would drive fresh air in, and which, by causing the two currents to pass each other in contact for a certain distance in very thin metallic tubes, would cause the fresh air entering to absorb nearly the whole heat from the impure air going out, and would thus render it at once both pure and warm air; and would consequently save, after the room was once warmed, any further expense of fuel for the day, and would avoid, how rapid soever the ventilation, all the dangers from draught and unequal heating."

The above idea is extremely ingenious, but as to its practical sufficiency I will venture, with deference, to add my opinion, that the temperature of a warm room, even if it was 65°, would be much too low to produce the action described.

The diagrams in plate 18 were copied from the drawings exhibited by Dr. Arnott at a lecture on warming and ventilation, delivered by him at the Royal Institution, in March, 1836.

## APPENDIX TO SECOND EDITION.

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*Sessions House, Old Bailey.*

THE apparatus for warming and ventilation at the New and Old Courts of the Old Bailey Sessions House was introduced with the view to secure to each Court, during all the changes of external temperature, a plentiful supply of air, either warm or cold, as might be desired, to be admitted under an easy regulation.

The New Court is represented in Plate 19, and exhibits the arrangements made for the purpose.

Under the Court is a close chamber *c*, divided in the middle by a partition. On inspection of the figure, it will be seen that the partition is provided, above and below, with doors or flaps; they are so united that one opens as the other shuts; the iron rod connecting them is placed outside, and readily permits their management. One of the divisions intended for the supply of warm air, contains a coil of 500 feet of pipe; the other is for the passage of cold air: in connexion with the bottom of the chamber is a cold air flue *d*, which supplies it with air.

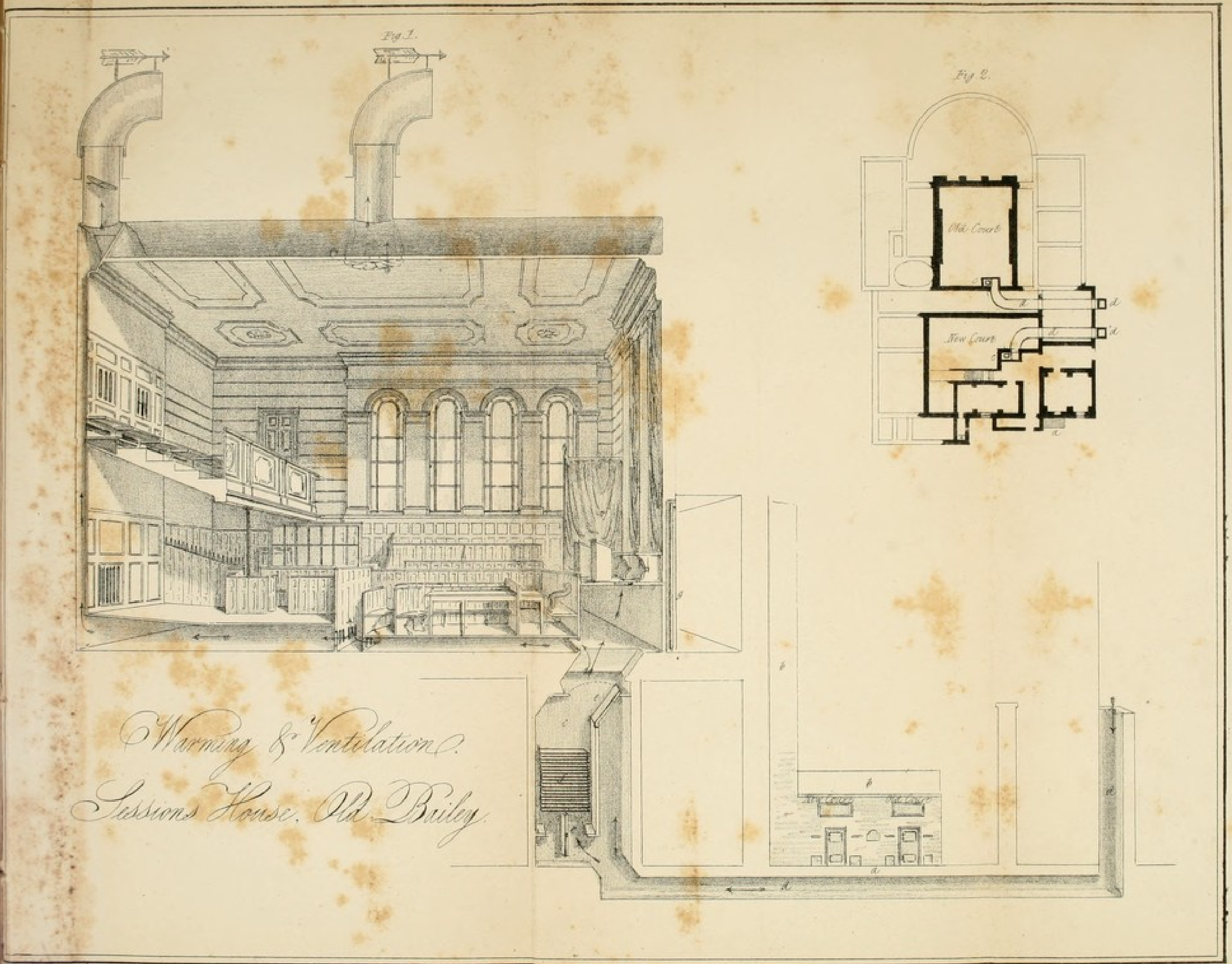



Plate 10

Day & Haghe Lithrs. to the Queen

The ventilation of the Court is spontaneous; the partition behind the dock is brought forward and pierced; the current is intended to take the direction shown by the arrows.

After the Court is sufficiently warmed, the hot-air chamber is closed, and the other opened, which is managed by turning the two valves.

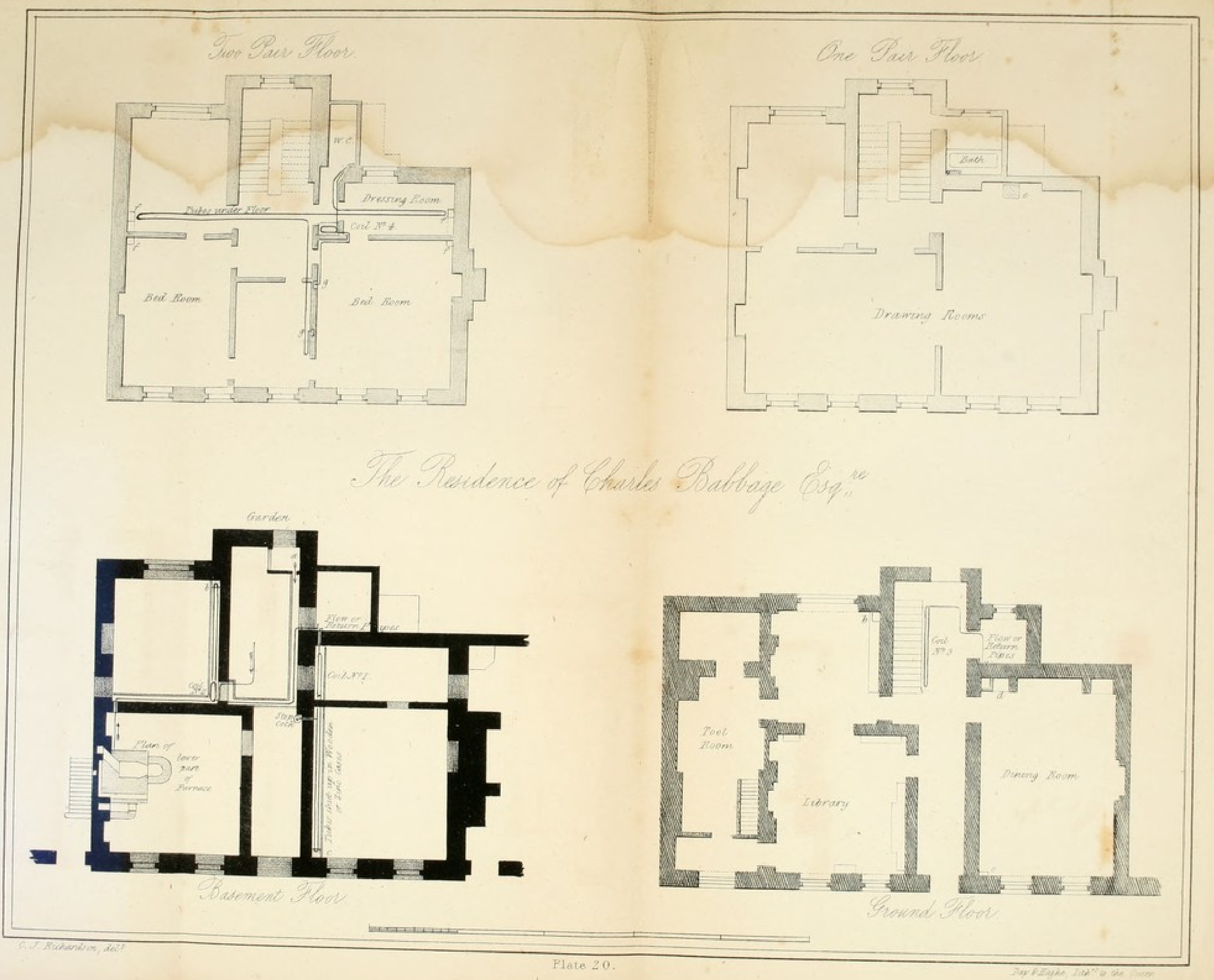
It has been found that if the atmosphere of the Court be raised to a temperature of 56° when the external atmosphere is at from 32° to 52° it will rise in the course of a few hours to from 60 to 68°, according to the number of persons in Court. It is generally observed that the internal temperature, notwithstanding the Court may be crowded, is kept to within ten to fifteen degrees of the temperature of the external atmosphere.

The object most desirable to be obtained, is to produce one degree of temperature in the court, whatever may be the variations externally; a thing *almost* impossible to be obtained without artificial means of cooling as well as heating.

A similar warm and cold air chamber to that just described, is placed under the Old Court. Fig. 2 shows the situation of them, *c, c;* the cold air flues, *d, d;* the furnace for both, at *a;* the smoke-pipe is marked *b;* the expansion tube, *g.*

The ventilation of the old Court is not attended with any difficulty; it is of large area, seldom crowded, has no projecting galleries, and the ventilating flue connected with the cowls on the roof is an upright tube of twenty or thirty feet in height, which is of great importance for effectual ventilation.

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 formerly resulting from their old hot-air systems.




C. J. Richardson, del.t

Plate 20.

Day & Haghe, Lith.rs to the Queen

*The Residence of Charles Babbage, Esq.*
*Dorset Street.*

The following Plates, Nos. 20 and 21, with which I intend to close the present collection of examples, illustrate an apparatus which I consider more important than any of which I have yet given an account. It has been made, by skilful mechanical contrivances, to produce some of those conveniences and luxuries which I hope to see much more generally applied than they are at present in the dwellings of this country.

At the commencement of the winter of 37-38 Mr. Babbage introduced Mr. Perkins' 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 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 20; the basement, where the furnace is placed, is made the darkest: 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.

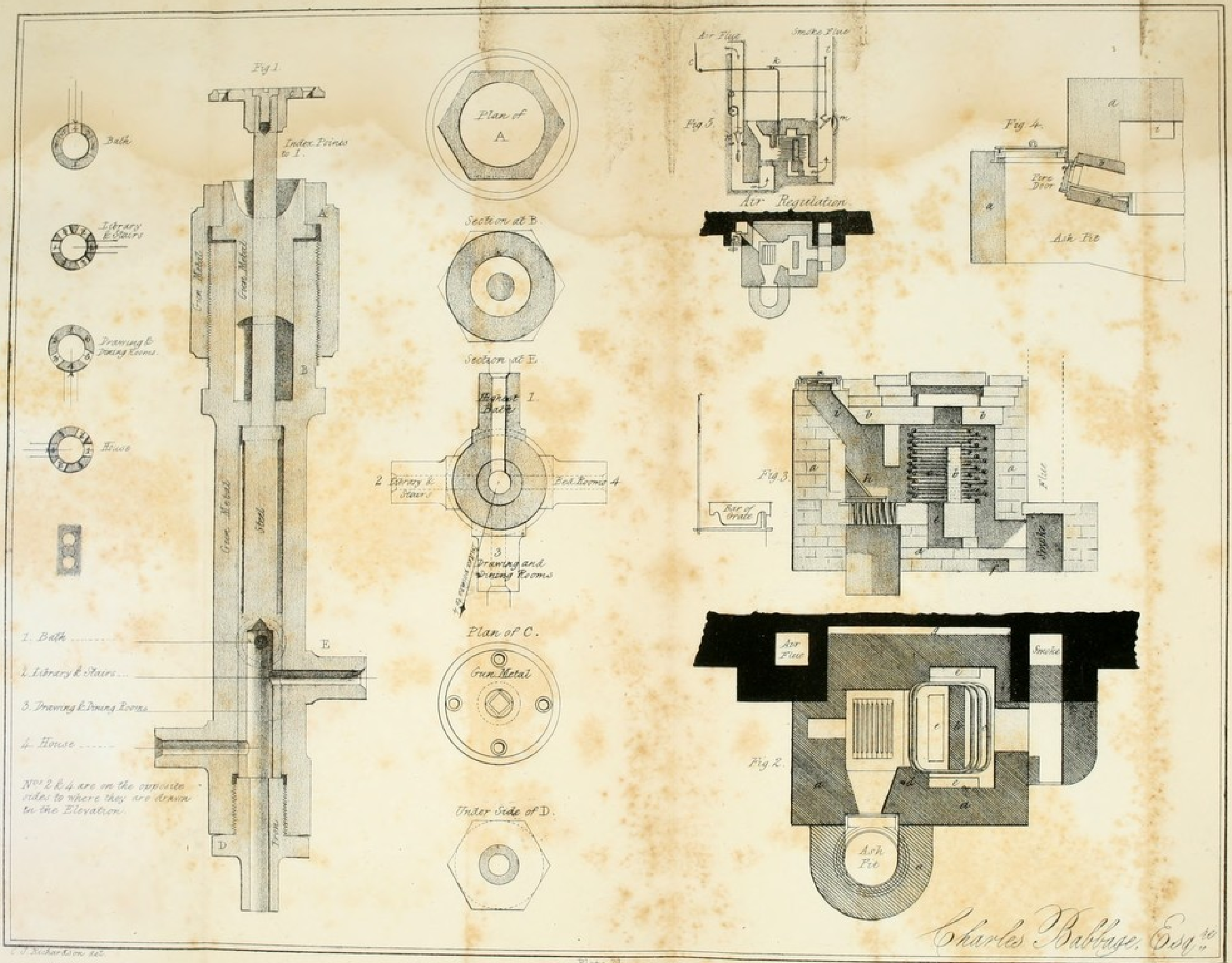
On an inspection of the plan, these inclosures will be seen in four of the rooms; at the point *a*, in the direction of the arrow, the current of fresh air for the flues is obtained from the garden; the supply is shut off at night.

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 stair-case; 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 50° to 54° 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




C. J. Richardson del.

Plate 21

Day & Haghe Lithrs to Queen

tool-room is sufficiently warmed for its purpose. It may, however, be proper to remark, that the room has a double sky-light; the stair-case in it leads down to the wine-cellar.

On the right of the principal stair-case 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 it is proposed by these means to warm slightly the air which passes into this channel from the stair-case, and to introduce it 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 2¼ baths.

The cistern serves also to heat the dressing-room; it is of copper tinned, and the top i  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, cleaning 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 21, 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°. 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°, 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 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.*

Fig. 2, 3, and 4, Plate 21, are sections and plans of furnace:—*a*, represents brick-work; *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° 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, stair-case, 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, 3d 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 30 | 249 | 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° 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°, when that in the flow-pipe equals 240°.

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.

Bed-rooms, 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 gasses 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.

Hitherto Mr. Babbage has only made experiments at about 250° F., and with this low heat the dining-room and bed-room circulations have not been effective: some alterations are contemplated, which will probably improve their action.

But the library, the tool-room, the stairs, and the bath have fully answered his expectations.

The servants' room in the basement, where the furnace is placed, has at present too large a supply of heat: by placing the fuel inside a square coil, and putting a cover over the furnace to conduct the heat away, this may be remedied.

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