In addition to the surfaces located in the slips, about one-quarter of the entire heating surface is placed in boxes below the platforms and at other points, with a supply of pure air from without the church to take the place of whatever may be removed through the registers in securing proper ventilation.

A marked feature of this system is its sectional character throughout, the church proper being divided into three divisions, the vestry and school-room forming a fourth, each operating independently or in connection with the others, as may be desired. One of the chief points to be considered is the space of time in which the church or vestry can be made ready for use. By the old methods of treating the whole body of air before that required can be available, from twenty to twenty-four hours' application of the heating power is found necessary as a general rule; by this method the church may be entered with comfort in from *one* to *three* hours, with a *corresponding saving in fuel*, as the area or size of grate will be no larger for this one boiler than for the five furnaces, and *cannot be made to burn any more fuel in a given time under the same draft.*

The plan and arrangement of the piping has not the demerit of entire novelty. The Memorial Hall at Harvard University, a room 210 feet by 63 feet, 71 feet high, (over 900,000 cubic feet,) is heated from these plans differently arranged, and has been in operation two years to the satisfaction of all concerned; also several minor buildings in the city of Boston.

Suppose four furnaces of the largest capacity for the church and vestibule have combined not exceeding four hundred square feet of heating surface, while the steam surface for the same area amounts to one thousand square feet, and thus meets and deals with the air in one thousand places at the same time; now if a thousand feet of surface is required at the healthy temperature of 200°, what must be the temperature of the four hundred feet to do the same work? The surface of a furnace is not *equally* heated, and it is this excessive and unequal work which so soon brings furnaces to repairs and destruction; but if the same iron is protected on one side by water, no temperature is ever reached that will affect its structural condition or durability; neither

does it, as some suppose, deteriorate after years of use, except as it may be "fouled" by sediment within or soot without.

It is of course plain that radiators may be used, instead of the circulating pipes shown, with a like effect; they are so used at Memorial Hall, Cambridge, and whenever we desire to heat one floor, without showing any pipes on the walls, or "returns" on the walls below.

The *horizontal* application is also in order, in arranging the supply for "indirect" stacks of radiators below the floors, effecting a great saving in material and labor. All these plans have again and again been used, with a like uniform and satisfactory result.

With regard to the sizes of pipes, we would say that they are required no larger than in good work by the old method; and, taking a review of the work so far, they are not as large. As seen by the estimate, a line for the new method is about the same money as for the old, the gain being in *joints, fittings, valves and labor.*

While it was not my intention to enter on the somewhat "debatable" ground of aerology as applied to ventilation, yet the supply and removal of air to buildings, public and private, is so intimately connected with heating them that a few remarks may not be out of place.

Mr. L. W. Leeds, of New York, has made this important branch of engineering a specialty, and has furnished us with a key to the subject, and a solution at once clear and practical.

That no building or room can be successfully heated without ventilation is known to all heating Engineers and practical men.

When warming by the "indirect" method, the air being taken from without over the radiators to the rooms, only some proper outlets or escape is required; but when warming by "direct" application of steam surface in the rooms, a supply of air must be provided, or an unhealthy condition of the atmosphere will soon follow. That the amount of air required for each adult person (about 5 cubic feet per minute) cannot be obtained and removed at the small cracks around windows and doors must be apparent to every right-thinking person.

In Plate No. 2 this supply of air is shown as entering directly behind the radiators, controlled by a damper, by which means no cold drafts are felt, the removal being also provided for at the opposite side through ducts in the wall or through chimneys. But to insure a con-

stant and prompt delivery, steam surfaces should be placed either in the flue or at the top; this contained air being heated, rises and is discharged, regardless of the "wind or weather."

The surest method to supply efficient ventilation on an extended scale, as for Public Buildings, is by force applied to the air after being warmed, by fans driven by steam power, and may be arranged at no greater first cost, since, as shown in the table of Experiments, page 34, a given amount of heating surface in "stack" would warm twice the amount of air as when under the natural draft, besides delivering the air so warmed with certainty, not obtainable by any other plan; and *it is our opinion that the total first cost and cost of running would not exceed the old method, as the steam, after use in the engine, may be discharged into the heating pipes, since the* 80 *per cent. latent heat is not lost or yielded up until the steam is condensed.* "It must be remembered that, however much of the motion be utilized, all the heat remains, either in the waste water or steam, all the quantity only diminished in intensity. It can, therefore, be used for the purpose to which it is still applicable, or all the work it could have done before passing through the engine." (Tomlinson's Encyclopedia, page 709.) A machine for just this purpose, forced ventilation, has been invented; it is made of the best materials and workmanship, and is arranged for both the portable and stationary requirements.

That the generator and radiators are the main requisites of a heating apparatus, and of the first importance, is true; but we designed only to discuss the principles and elements involved in heating, leaving the several details to another time and place, yet a few remarks on these essentials may not prove out of place. That *safety* should be the first requisite of the generator, other things being equal, is a "truism," economy and simplicity following in their proper order.

Absolute "*safety*" in the generator of steam for power or for heating can alone be secured by discarding the large shell and adopting some form of sectional boiler. Much time and money has been expended to produce a satisfactory machine having all the virtues of the old "shell," with none of its defects. As might have been expected, there were many failures to one success, for but few mechanics are also enough "philosophers" to reason and work out this compound prob-

lem, at the bottom of which lies a "science" but little understood, viz.: the Chemistry of Combustion.

In our Plate No. 2 we have shown a sectional elevation of a practical and successful machine of this class, whose work has been fully tested and approved.

Of radiators, we may explain that three feet of inch pipe is the standard for a foot of heating surface, and will generally yield more heat and condensation than most of the other forms and materials offered for sale, not but what cast iron may, under the best conditions and arrangements, do equal duty, *foot for foot*, but so few of the devices now on the market really have the 144 sq. in. *live surface* to the foot, as advertised and sold.

A radiator, besides having an easy circulation of steam inside, must also have an unimpeded circulation of air over the surface outside, in order to take up and carry away the heat. See table of Experiments on page 33.

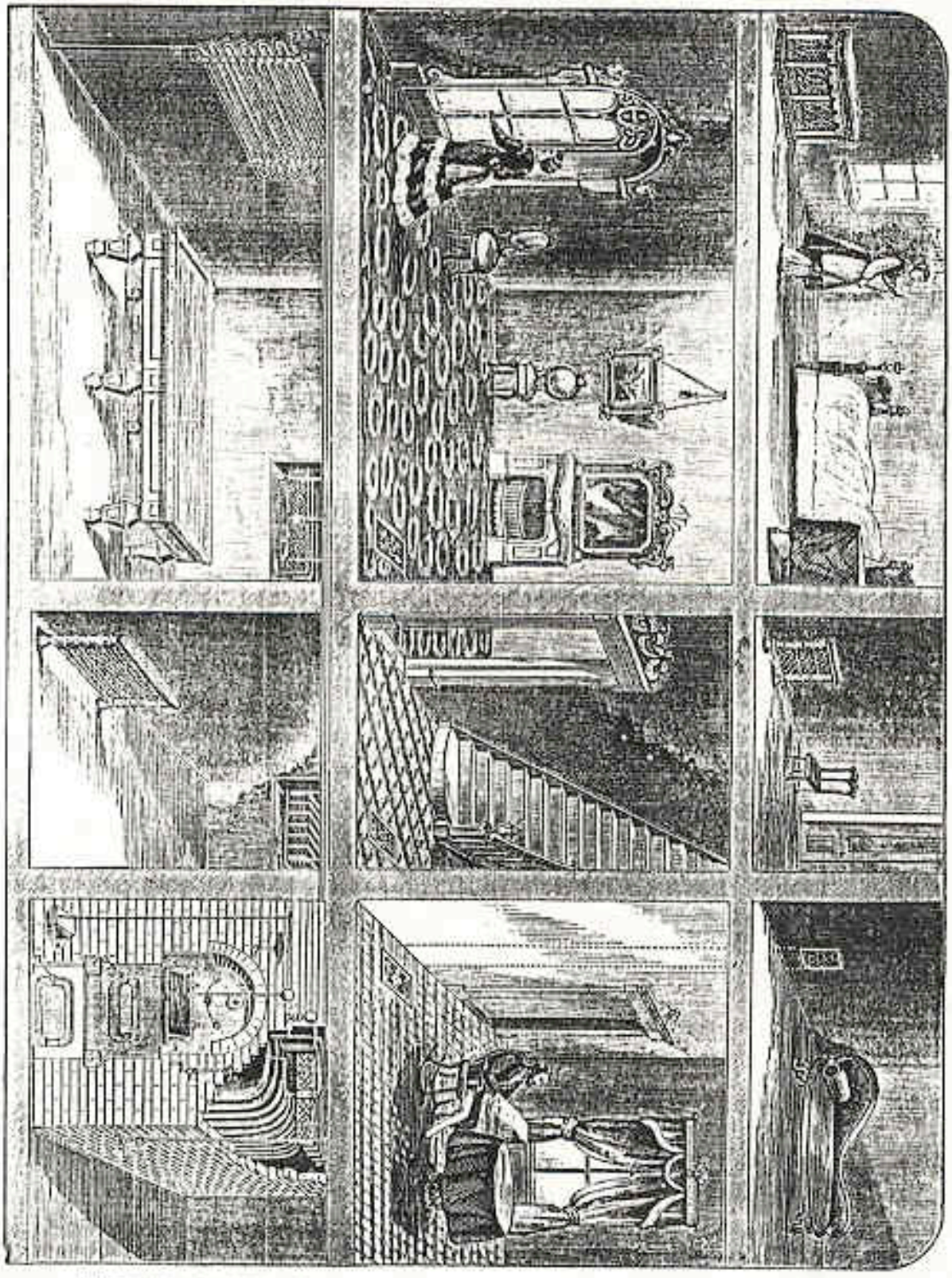
We introduce a Plate, No. 4, showing the general arrangement and detail of a first-class steam-heating plant for a private dwelling. The arrangements would be essentially the same if water was used in the place of steam, which, being much more silent and steady, yielding a uniform degree of heat under various conditions, is steadily growing in favor, especially where the price of fuel is an object, the cost of warming a given space being much less by water than by steam, without any danger whatever from explosions or complications.

Having now reviewed in detail the several advantages connected with the new plans, a recapitulation will not be out of place. Our "*system*," *then, consists in conducting the steam directly from the boiler in one or more supply pipes, without cutting, to a point above or near the highest radiators, which are then connected to the return pipe by a single valve. Thus arranged, the steam, air and water of condensation travel together in the same pipe, forward and downward, towards the boiler, the air finding vent in the basement, but above the water-line.*

That this entire change of plan at once simplifies the whole heating problem, reducing the first cost and that of maintenance, is apparent to most persons at once; that the plans are practical, and have been thoroughly tested, the following letters and indorsements will convince all

Plate No. 4.

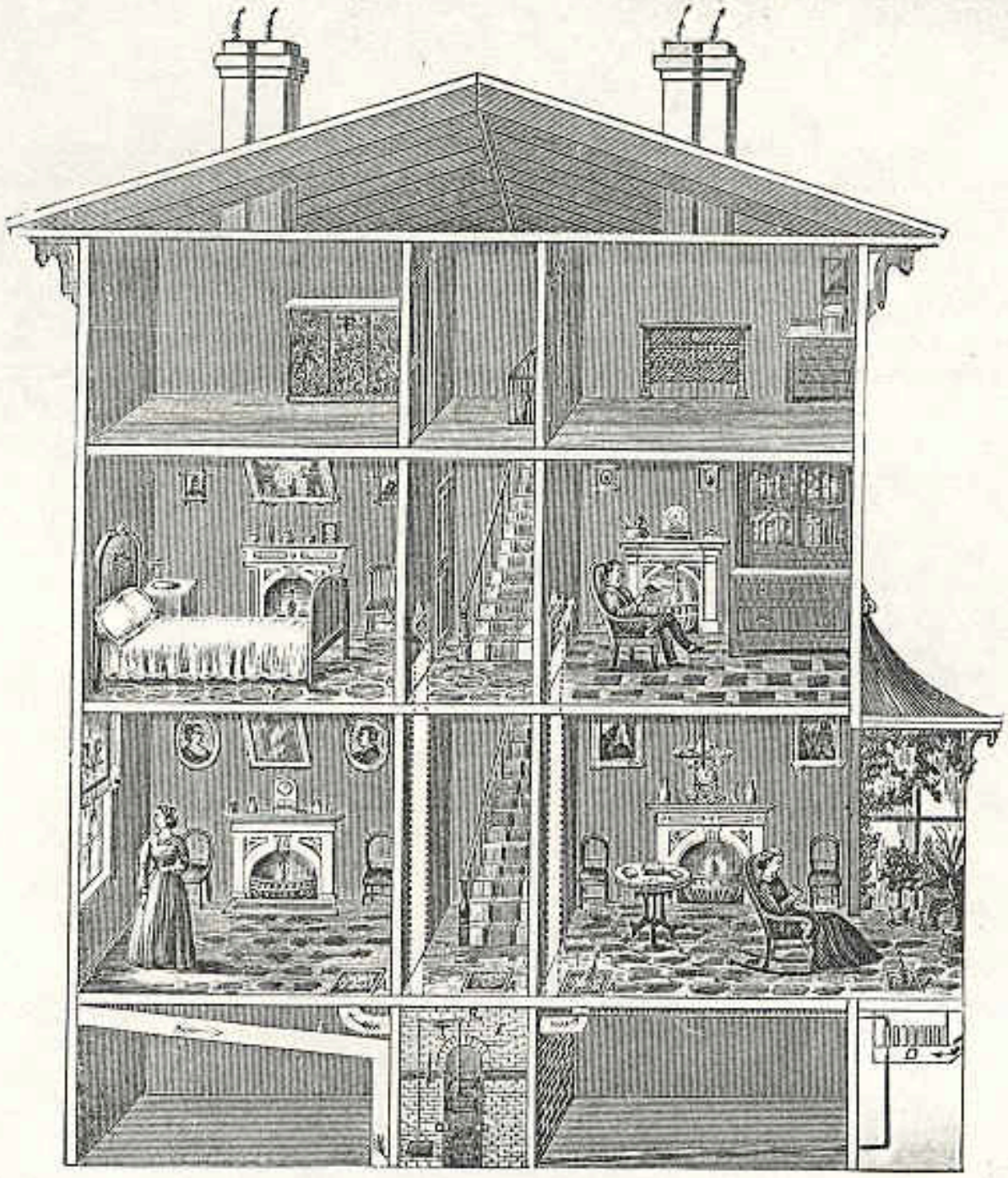
HEATING BY STEAM.



HEATING OF A PRIVATE DWELLING SHOWING GENERAL ARRANGEMENT OF BOILER, AND HEATING SURFACES

PLATE NO. 5.

HEATING BY STEAM.



HEATING BY INDIRECT RADIATION, ALSO THE REMOVAL OF THE VITIATED AIR THROUGH THE CHIMNEYS.

except those who, whatever the evidence, "are of the same opinion still;" and as some will naturally be curious to see what protection could be secured by these improvements, I submit the patents in full. The examination at the Patent Office discovered no applications or patents for any *system* or *method* of applying steam to heating purposes.

It may here be explained that this was not apparent at first in 1873, and the patent was surrendered and reissued to cover this broad ground in 1874. The first patent also showed two connections to the circulation or radiator; another patent, Sept., 1874, covered the ground of the single valve.

It is a well-known fact that the Patent Office, after having passed upon a case and issued the patent, can do no more towards protecting the Inventor and his improvements, which, if valuable, will often excite the cupidity of the unscrupulous, who openly steal or secretly infringe the principles of the invention.

Only a good business organization, and a support that is tangible, can render a valuable invention secure. Such an organization has been effected. It being seen that the steam-heating people and firms would the best understand the principles and value of the improvement, the stock of the "Mills' Steam-Heating Trust Association" is offered and divided only among first-class firms, under an arrangement that is at once simple and satisfactory. At this date, two-thirds of the 1000 shares are already provided for; the remaining shares are ready for location, but only limitedly, in States and cities, designated as "Local Agencies." Thus the stock and all accruing benefits will be divided among and absorbed by the heating profession, to their advancement and the benefit of their customers throughout the country.

Many persons about to build, or intending alterations, would be much benefited by having a plan of their heating and ventilation perfected before-hand, with a detailed estimate of stock and labor. Omitting this essential feature until all other matters are completed, it can only then be arranged imperfectly, and often at an increase of cost.

Again: many persons competent to put in the work have not the time and ability to make proper plans. To meet this want and facilitate business, we will furnish complete plans, specification and estimate for both stock and labor, at an average cost of about one per

cent. on the amount of the estimate, or about two per cent. on the smaller and ¾ per cent. on the larger calculated costs.

Much more might be said in favor of this new "departure" in the heating line, but we designed only to call the attention of persons directly interested, who will not fail — as they have not — to see the needed reform, and that the plans offered are in harmony generally with their experience and the fitness of means to secure the much-desired end.

If anything important has been omitted or not fully stated, it should be remembered that the author only claims a place as an "amateur" in the sciences, only "an earnest worker" offering the results of his experiments for what they may be worth to those who have kindly given their attention; at the same time he does not shrink from a fair, candid and honest criticism, and would be pleased to correspond with persons who, from a different standpoint, think they have discovered different results.