Chas W Copeland
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HEATING BY STEAM.

ITS BEST APPLICATION IN WARMING AND VENTILATING

Public Buildings,

FACTORIES and PRIVATE RESIDENCES,

WITH

ILLUSTRATED DESCRIPTIONS

OF

An Improved Method of Piping,

FOR

BOTH DIRECT AND INDIRECT RADIATION.

WITH

SOME USEFUL TABLES.

By JOHN H. MILLS, Trustee,
"Mill's Steam Heating Trust Association,"
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PREFACE.

IT is not the writer's intention to attempt a "hand book" for the profession, or to enter on a discussion of the relative merits of the different methods employed for securing artificial heat and ventilation.

The superiority of steam as the best medium, being generally conceded a safe, silent and satisfactory application of it, to the varied and growing demands, remained (even after so many years use) still the desideratum.

Having devoted the time since 1867 to the study of, and application of steam for power and to heating, facts and figures are offered the reader; his object being principally to show what results may be obtained by a certain application of means and materials to the desired end.

The plans presented having been in use the last three years, in nearly all classes of buildings, render the statements and endorsements submitted, of value to the intelligent and progressive reader.

The tables embodied have been compiled from experimental data, and are introduced to make clear the inferences and results accomplished.

In the field of mechanics, the economy of material and better application of "means to ends," are fast being recognized as the true "science of progress;" and even now that machine which accomplishes a given work with the fewest parts and simplest movements, bears away the prize.

So in the application of the other sciences, that method or system which shall lead straightest to the desired end, will be sought after, approved and made the standard.

Therefore, to the owners of buildings, to Architects charged with their construction, and to the practical heating Engineers, these pages are addressed, with the hope that they may merit a considerate and candid perusal.

Respectfully yours,

JOHN H. MILLS.

BOSTON, January 1st, 1878.

"Ours is a scientific, progressive and practical age, withal, of discovery and invention; yet it is remarkable that the dry details and maxims of science have ceased to be the exclusive property of the learned professions.

We not unfrequently observe the humble Mechanic, and even unlettered individuals, making applications of the truths and principles of science, and deducing therefrom new and important results.

Hence it is that experience is teaching us not to be surprised when we are presented with new and valuable discoveries by those in the middle ranks of life, who have never been the recipients of college honors."

THE APPLICATION

—OF—

STEAM TO HEATING.

THE mightiest agent yet discovered by man, in enabling him to fulfil his destiny in subduing the Earth, is, *Heat conveyed through Steam;* that unwearied drudge of all work, which grinds our corn, weaves our clothing, forges our tools, drives our printing-presses, twists a massive cable of iron, or spins a gossamer thread of cotton, impels our steamships on their ocean routes, or whirles us through space when we journey on land.

Nothing furnishes man with greater cause for congratulation and even an excusable pride, than the feats of that mighty impersonation of brute force and human intellect, the Steam Engine.

Great however, as are all these exhibitions of the force and power of steam, there remains to be added another chapter on the incalculable benefits arising from the introduction of this same subtile agent, in modifying the rigors of our northern climate within doors, since no other agent is so adapted for the distribution of heat at long distances, and so efficient and certain of operation, enabling us also to secure that most vital of all our wants next to food—*pure air;* and when we consider with what rapidity steam, released in a room or building will control and subdue fire, and with what fidelity and success it guards from destruction the precious property intrusted to its keeping in safes and vaults, we are filled with astonishment and admiration.

But many regard steam as a mystery, and although they may employ it as a power for accomplishing work, still know but little of its character or capabilities. Steam can be understood and controlled as well as any other power; but if the laws which regulate its use are disregarded it reports itself in a way not to be mistaken.

Yet no one who desires to be really intelligent will rest satisfied with a simple result; it is not enough to know that certain results are produced from certain causes; we must go further and learn *why* the cause produced the result.

Considering how long steam has been employed as a medium for conveying heat, and what progress has been made in its application, it may at first sight appear strange that only at this late day should be announced a decided advance on the generally accepted ideas of heating and methods of piping, while the solution of so many difficulties, in the way of a simple and efficient apparatus, lie so near the surface and to the hand of the workman.

A second thought, however, furnished us with a reason, in the fact that every process connected with the generation and use of steam is a compound, or, so to speak, a chemical operation, in which science, philosophy and practical knowledge must unite to insure the best results.

What boiler can yield the proper evaporation, unless the chemistry of combustion in the fire-chamber is first attended to? What radiator can condense the steam supplied, releasing the stored-up heat, without a sure and easy circulation of the steam within the tubes and of the air without, to receive and convey away the heat to surrounding objects?

But of what avail are efficient boilers and radiators without good lines of communication, in the shape of proper pipes, to convey the steam and return the water of condensation to the generator, completing, what is found in all its phases, the triple nature of a steam-heating plant—Generation, Distribution and Return. This brings us properly to a brief review of the principles and operations involved, after which we shall find the knowledge to apply them much simplified.

Although it is generally conceded that steam is by far the best agent for the conveyance and distribution of heat, yet it is not so generally understood why low pressure steam is more desirable than high; but a few facts will make this clear, and that the apparatus should be constructed to operate under these favorable conditions:

"A cubic foot of water will contain more heat than any other known substance, and before it is converted into steam or vapor, at 212°, absorbs nearly six times as much heat as is required to raise it from 32° to 212°.

"This increase of heat would render a solid body of equal bulk red hot, and still the steam produced by it has only a temperature of 212° *sensible heat.* This quantity of heat is 20½ times as much as an equal weight of air could contain, and is capable of heating to the same point 20½ times its own weight.

"It is therefore apparent that the steam has absorbed nearly six times as much heat *in passing into a vapor* as the water absorbed in passing from 32° to 212°.

"That the steam really contains this prodigious quantity of heat, "stowed away," so to speak, hidden from the thermometer, and only recoverable on *condensation*, is a well-known scientific fact; and, also, that by the condensation and reconversion of such steam into water this enormous quantity of heat is liberated and becomes sensible heat, available to warm the surrounding air, both by radiation and conduction.

"A careful study of this beautiful law will render clear the fact, so mysterious otherwise, that a comparatively small radiating surface, heated by steam, will heat a large volume of air without itself passing through the limit of 212°."

And just here the peculiar value and desirability of a low pressure apparatus may be readily explained and understood.

Steam at the pressure of the atmosphere, = 14.7 lbs., contains the 212° of heat, which is rendered evident by the thermometer, and 966° that cannot be so measured, called latent, = 1178°, total.

At 6 lbs. above the atmosphere it has 230° sensible and 952° "latent heat," = 1182°, total, or simply a net gain of 4° for an apparent rise of 18°.

At 14 lbs. pressure we have 248° sensible and 939° "latent heat," = 1187°, total, or a net gain of only 9° for an apparent rise of 36°.

At 24 lbs. pressure we have 265° sensible and 927° "latent heat," = 1192°, total, or a net gain of only 14° for a rise in pressure of 24 lbs.; or, to increase the power of the heating surfaces about 1 per cent., we must raise the absolute pressure in the boiler and the whole apparatus 163 per cent.

"A pound of water, in passing from a liquid at 212° to steam at 212°, receives as much heat as would be sufficient to raise it through

966 thermometric degrees, if that heat, instead of becoming *latent*, had been *sensible*.

"If 5½ lbs. of water, at the temperature of 32°, be placed in a vessel communicating with another one (in which water is kept constantly boiling at the temperature of 212°), until the former reaches the temperature of the latter quantity, then let it be weighed, and it will be found to weigh 6½ lbs., showing that 1 lb. of water has been received in the form of steam through the communication, and re-converted into water by the lower temperature in the vessel. Now this pound of water received in the form of steam, had, when in that form, a temperature of 212°. It is now converted into the liquid form, and still retains the same temperature of 212°; but it has caused 5½ lbs. of water to rise from the temperature of itself. Now this heat was combined with the steam, but as it is not sensible to a thermometer, it is termed *Latent*."

It now becomes apparent why a low pressure apparatus, that will work efficiently and silently, is so much more desirable than one that requires pressure to circulate the steam and return the water of condensation to the boiler, since, to raise the pressure, we must also raise the temperature in the furnace, and, correspondingly, the heat in the flues, so that more heat escapes and is lost under high firing than at low; this is also true when the boiler is not of liberal size and power for the duty imposed.

That many heating "plants" will not work efficiently without several pounds' pressure on the gauge leads many to suppose that the radiators are so much more efficient when worked under pressure, because they then get the result desired; in fact, it only proves that some or all parts of the apparatus have not been properly proportioned.

In the early use of steam for heating factories and mills, with a pressure of 50 or 60 lbs., but with no returns to the boiler except by pumps, little was required of the workman except a fair mechanical knowledge and some judgment as to the best way to get "round a building;" the pressure at the boiler being relied on to produce a circulation, the "music" in the pipes and coils incident to this forcing arrangement being considered a necessary "accompaniment."

This crude and wasteful practice was continued for years before a return of the water of condensation to the boiler was attempted, and

still more time was required with many changes in the piping and coils used for radiation, with a reduction of the pressure, before this valuable economy, a *natural* return by gravity, was established. It is a matter of regret, however, that the name of the Philosopher who first applied Newton's discovery of the law of gravity in the falling apple to the heating problem is not even known. Doubtless the steps to this advance were so gradual, and made by several workers about the same time, that no one of them felt entitled to lay claim to what has proved the key to this important science.

Afterwards, for various reasons, chiefly danger of explosions, came a demand for less and less pressure, necessitating larger pipes, better radiators and a higher standard of workmanship. The workman could no longer be sent out to *cut* and *fit* his uncertain way to favor, nor could he be expected to supply intelligent plans, with detailed estimates of materials and labor; nor could the Architect, burdened with the many details of his profession, meet this demand. Thus it came about that a class of educated Mechanics, generally Engineers in other branches of industry, saw the importance of this opening, and turned their attention and talents exclusively in this direction.

From this period of time, say ten or twelve years ago, the advancement has been marked and rapid, until to-day the plans for heating and ventilating compare favorably with the Architect's plans, and often form a part of his specifications.

Considered simply in the light of so much pipe, fittings and labor, the erection of a steam-heating apparatus would not appear to involve or call for much brain power in its successful arrangement; and certainly in many instances but little thought has been expended, such imperfect results and so much dissatisfaction have followed, causing in the minds of many a distrust of the agent employed.

However, when we look deeper and consider the nature of the elements brought together, it will not be difficult to understand that both science and philosophy must be brought to bear before we have any right to expect efficient and economic results.

The elements with which we have to deal in the operations of heating are steam, air and water, each of which has a certain weight, which must be considered and provided for before they will work harmoni-

ously together; relatively, they stand as Steam 1, Air 2, Water 1700, for equal volumes.

The steam and air, both being gases, do not conflict, as some suppose; the noise and snapping in the pipes is caused by the steam coming in conflict with the water, *when there is a wide difference in their temperatures;* such noise generally occurring when steam is first made or turned on, the cold pipes absorbing the heat of the water, which at some point meets the steam, which, being condensed, forms a vacuum, and more water then rushes in, and the snapping follows. Some times, owing to defects or depressions in the piping, the water does not readily escape, and this impeded circulation breeds a chronic disturbance.

Being constantly reminded of this fact, the effort to separate the two elements, steam and water, was most natural, but at the same time resulted in a complication, from which the Engineers even could not extricate themselves or the apparatus.

This division of the work into two separate and distinct channels, which must, nevertheless, lean constantly on each other for support, demands a far too nice "balance of power." This "balance of power" consists in so proportioning the pipes, the "supply" and "return," *that there shall always be an equal pressure on both, regardless of the forces that are constantly operating to weaken them*, especially the "return," which does not receive at the start so much pressure as the supply, and yet cannot return its water to the boiler until, in some way, the lost pressure is made up. Now the pressure in the return is mainly acquired through and *after* the demands of the radiators and piping are met, and is dependent on the excess of steam so transmitted; and the further and further we go from the boiler the weaker will be the pressure in all the return pipes.

Therefore, to heat a large building with steam of only 3 or 5 lbs. pressure at the boiler, and return the water of condensation, requires not only skill in arrangement, but large pipes, both supply and return.

An examination of these arrangements in detail, Plate No. 1, will enable any practical person to readily understand our argument. On the right is shown the pipe, fittings and valves to supply 4 radiators of,