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Contents:

(Illustrated articles are marked with an asterisk.)

THE HEATING OF BUILDINGS BY STEAM.

Our articles, published on pages 55 and 88, current volume, appear not to have cleared up some points, connected with this important subject, in the minds of all our readers. Of the difficulty those not thoroughly acquainted with the theories of heat and steam find in comprehending these principles, the following quotation from the letter of a correspondent may stand as a fair specimen. He writes: "I am heating two drying rooms with about 2,000 feet of pipe in each. Am I to understand by what I read on page 55, present volume, that I get as much heat from 40 lbs. of steam as I do from 80? If not, how much do I gain by doubling the pressure? Is there any way I can bring the steam back into the boiler after it has passed through the drying rooms?" We propose to answer these questions in their order, not as to the single correspondent from whose letter we have quoted, but to numerous inquiries of similar import which we constantly receive.

The first question shows that our correspondent does not understand the difference, made by writers on steam, in the terms *pound of steam* and *pound pressure of steam*. Our assertion was that one pound of steam (saturated steam, of course), that is, one pound of water converted into steam,—one pound weight of steam—not one pound pressure, always contains the same amount of heat, at any pressure. The entire heat in a body of steam cannot be measured by its pressure, but only its sensible heat—its temperature—is so measured. Thus steam at 20 lbs. pressure has a temperature of 307° Fahr.; but this multiplied by the entire weight of steam gives a product representing only a little more than one fourth the entire heat the steam will impart before it congeals to ice, or less than one third the heat it will impart before condensing to water at 212°.

Now what we say is that, by taking the same weight of steam and increasing or lowering the pressure to which it is subjected, we shall not practically alter the amount of heat it contains, which is specific and constant at all pressures; and that the amount of fuel required to produce this amount of steam will be a constant, except that, in producing steam at high pressures and temperatures, there is greater waste by radiation from the furnace and boiler, and a larger waste through the uptake. This waste is more than compensated in the use of high pressure steam in engines, because of the increase of work obtained by using steam expansively; but in heating buildings it is an unnecessary waste, for which there is no recompense except that heat will radiate more rapidly from pipes carrying high pressure steam, and consequently a less extent of radiating pipe will be required to heat a given space. Hence the cost of the pipes would be less at the outset; but this would in most cases be offset by the increased cost of a boiler constructed to withstand high pressures. The use of high steam for heating is then a fallacy, which increases danger and lessens economy.

The third question is: How can I get the steam back to the boiler? We answer you cannot get it back as steam, unless you pump it or force it back by some other mechanical means, and this leads us to the consideration of another popular fallacy, namely, that steam circulates in pipes precisely as air does.

The difference between steam and hot air is this: Air is a mixture of gases that at any temperature known to science remains a gaseous mixture. Saturated steam is a gaseous compound, that *never loses any portion of its heat without a change of a part of it to water.*

Let us see if we can make this plain. A pound weight of steam, under a pressure of 60 lbs. to the square inch, contains 307 units of sensible heat, and 711·5 units of latent heat. Now, these quantities of sensible heat and latent heat being specific for steam at the pressure named, it follows that the subtraction by radiation of a single unit will result in the condensation of a portion to water, which can exist at atmospheric pressure as water with 966·5 less units of heat per pound weight than steam can. So if we go on subtracting heat we go on condensing; and if we maintain the pressure by new accessions, we are constantly condensing steam by robbing it of its latent heat; and the water thus produced gravitates toward the lowest part, which, if properly connected with the water space of the boiler, will allow the water in the system of pipes to seek and maintain the same level as that in the steam generator. Coming from the boiler as steam, it returns only as water. If the steam be used at atmospheric pressure, every 1,640 cubic feet will, by its condensation, be reduced to only one foot of water. This enormous reduction of volume creates, so to speak, a vacuum into which the live steam rushes with a velocity far exceeding that which could be created by the difference in the specific gravity of heated and cold air.

This is the secret of the rapidity with which heat is carried by steam to long distances from the boiler, a rapidity so great that we once saw, in a large dyeing establishment, sixty hogsheads of water in one vat raised to the boiling point in five minutes. No possible application of heated air, circulating by virtue of differences in specific gravity, could accomplish such a result in five hours, if indeed it could do it at all. The fact is, that there is no vehicle for heat known to science that, in rapidity, can at all compare with steam. But there is for this purpose no need of high pressures. So long as we have *steam*, it is enough. Condensation will produce the partial vacuum, which the steam will expand and swiftly fill, and thus the circulation, of steam outward from the boiler and water returning, will be steadily maintained. This is true, of course, for all cases where the temperature of a substance, to be heated or dried by steam pipes, does not require to be heated above 212°. If higher temperatures than this are needed, the pressure of the steam must be increased accordingly.

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SUBSTITUTING OTHER VAPORS FOR STEAM.---ETHER AND BISULPHIDE OF CARBON.

The consideration that the latent heat of watery vapor is greater than that of the vapor of any other substance (see the table, page 5 of the current volume), and that, consequently, more heat is consumed by the evaporation of water than by the evaporation of any other fluid, has given rise to the idea that it would be more economical to use another fluid than water for the production of steam and the transformation of heat into power. Thus the amount of heat required to evaporate one pound of turpentine is scarcely one seventh of that required for water, but then the boiling point of turpentine is so much higher that the advantage might be counterbalanced by the stronger fire required; but it is especially alcohol and ether which have attracted attention, as these liquids, besides requiring for evaporation respectively only about one third and one sixth of the latent heat required by water, combine with this property that of possessing the low boiling points of 176° and 95° Fah. As ether in particular appeared very advantageous in this respect, it has been extensively and thoroughly tried; and we remember to have seen, among other attempts, a very large ether engine, built at the Novelty Works, New York. The execution of this undertaking was as thorough and perfect as can be expected only from a workshop possessing the superior capabilities of that excellent establishment, now, alas! suspended by the results of our unwise legislation on shipbuilding. The engine worked, of course, on the condensation principle, as ether is too expensive not to be used over and over again; and the method of surface condensation was here especially advantageous. Experience proved that there was no advantage in the supposed lesser amount of latent heat consumed, the only advantage being the lower boiling point, and this was largely overbalanced by the disadvantages in the practical working of the machine, the ether being a powerful solvent for the fats and oils, used for lubricating, and the ether vapors would pass through seams, cracks, and stuffing boxes which were perfectly steam tight, so that it was found next to impossible to keep it any length of time in the boiler; and, last but not least, anywhere this hot vapor escaped it was in great danger of taking fire, and would cause local heat, generate undue pressure, and become totally unmanageable; and it alarmed the experimenters repeatedly to such a degree that finally they threw up the ether experiment in utter disgust, and sold the machine for old iron.

The reason that there was found to be no advantage, in the fact that ether vapor contains less latent heat than water vapor, was simply in overlooking that these amounts of latent heat are always given by weight and not by volume; as, however, in driving a piston by means of a vapor, we have nothing to do with the weight of the vapor used, but only with its volume (for, by every stroke, we must fill the cylinder, whatever be the weight of the vapor), we see at once that, in order to come to a correct conclusion in regard to the economy of the latent heat consumed, we must compare this latent heat for equal volumes, and not for equal weights. In order to do this, we may reconstruct the table (given on page 5) for the latent heat of equal weights, into one for the latent heat in equal volumes of vapor; and this we may easily do by multiplying the latent heat of each vapor with its specific weight. The figures contained in the third column of the following table representing the relative amounts of latent heat in the vapors of different substances which are there reduced to the standard of water=1000, by dividing each of these products by 0·433.

TABLE OF LATENT HEAT OF VAPORS FOR EQUAL VOLUMES

Name.	Units of latent heat of vapor. for equal weight.	Spec. grav. of vapor. (Air = 1.)	Product of latent heat with spec. gravity.	Units of latent heat of vapor for equal volume. (Water=1000.)
Water	962	0·45	433	1000
Alcohol	385	1·25	481	1111
Ether	162	2·26	365	840
Oil of Turpentine.	133	3·21	487	1125
Bisulphide of Carbon	210	2·60	546	1261
Ammonia	900	0·59	531	1226
Carbonic Acid	300	1·53	459	1060
Chymogene	140	4·00	560	1293

It is seen from this table that, in consequence of the fact that the vapors which possess the least latent heat are the heaviest, and therefore possess, for the same weight, the smallest bulk, the relative amounts of heat for equal bulk do not differ materially; or at least it is seen that the difference of the extremes, in place of one being more than seven times the other, as is the case with ether and water, are inconsiderable, when we compare equal volumes, differing less than one third part in the most extreme cases; in fact they are so small that some investigators have come to the conclusion that in all cases the same volume or bulk of vapor is produced by the same expenditure of latent heat, and consequently of fuel, whatever be the liquid which is evaporated, asserting that the differences in the figures of the last column are only due to the errors of observation consequent upon experiments of so delicate a nature as the determination of the specific gravity of gases and vapors, and of the latent heat absorbed by their evaporation—a conclusion of a cognate nature to that in regard to the same amount of specific heat, which the atoms of all elementary bodies appear to possess, and which was spoken of on page 389 of our last volume.

A liquid as volatile as the ether being thus almost uncontrollable over fire, in a steam boiler, the next question is: Can it not be heated in another way, say by means of the escaping steam of a high pressure engine? Or may it not be inclosed in a tubular boiler, through the tubes of which, in place of the flame and heat of coal, the exhaust steam is passed before going to the condenser? There is no doubt that in this way we may utilize the exhaust steam, without producing any back pressure, as has been the case with most other contrivances suggested for this purpose. As the exhaust steam may have a temperature of some 240°, and must have at least 212° (otherwise it can be no more steam), we may develop considerable pressure in a boiler containing ether, heated in this manner. According to Régnault, the pressure of the ether for different temperatures is as follows:

TABLE OF REGNAULT FOR THE PRESSURE OF ETHER AT DIFFERENT TEMPERATURES.

Degrees Fahrenheit.	Degrees Centigrade.	Pressure of ether in atmospheres.
240	116	9·25
230	110	8
212	100	6·50
194	90	5
176	80	4
185	70	3
140	60	2·5
122	50	2
104	40	1·33
86	30	0·8
68	20	0·6
50	10	0·33

It is seen from this table that the heat of exhaust steam is amply sufficient to develop considerable pressure by the intervention of ether in a separate condensing engine; but as ether is a quite expensive substance, being a product of chemical action on organic growth, the next question is: Can it not be superseded by another cheaper ingredient? And the answer is affirmative. We find in the table, on page 5 of this volume, bisulphide of carbon mentioned; this substance being simply a product of the combustion of charcoal in an atmosphere of sulphur vapor, CS_2, as carbonic acid is a product of charcoal in an atmosphere of oxygen, CO_2, can be, and is now manufactured very cheaply, while its boiling point (113° Fah.) is only 18° higher than that of ether. The above table, given for the pressure of ether, is approximately correct for that of bisulphide of carbon, if we add 18° Fah. or 10° Centigrade to the temperatures mentioned.

We are happy to find that the idea has been realized, and that at present, in the city of Boston, a steam engine* is successfully in operation, in which the heat of the exhaust steam heats bisulphide of carbon, and so originates a new pressure in another boiler even surpassing the first pressure, that of the steam in the boiler heated over the fire. Such a bisulphide of carbon engine may, of course, be separated from the steam engine, or may be so connected as to act on the same shaft and to form a single engine, in which the great problem, of changing as much of the heat as possible into power, will be much nearer to solution than was ever the case before.

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THE INDIRECT INFLUENCE OF INVENTION UPON MANUFACTURES, ARTS, AND COMMERCE.

In a recent editorial, we spoke of the direct beneficial influence of patents upon general business. We propose now to notice some of the ways in which business is indirectly benefitted by invention, the latter having undeniably been greatly stimulated by our patent system.

In the first place, business is helped by the increased facilities for its transaction afforded by such inventions. Communication, transportation, printing, all of these have been

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*This engine is fully described and illustrated on page 31 of the current volume.