by the displacement of water, which, in many cases, has not been made available by engineers. Two forces are required to counteract the excess of friction, namely, a lifting and pulling or pushing power, to effect the launching. Let there be a series of strong shores, *a*, fig. 2, placed along the inshore side of the hull *b*, and two or more large vessels *c*, be moored to the cradle by the hawsers *d*, and strong chains *e*, be attached to the cradle *f*, passing over the hull *c*, to be made fast to the opposite shore, where there are to be proper fixtures to take up the slack. At low water the floats *c* are allowed to sink to a certain extent, by letting water into their holds, and then all the slack of the chains are to be taken in and made securely fast, and the pump or other means to discharge the water from the hold set to work. As this is going on, and the tide is rising, you have a power acting on the nearly straight chains equal to the displacement of the hull restrained from rising; and this power will act both as a lifting and pulling force on the cradle, at the same time the "shores" *a*, are acted upon at their heels, producing a similar effect to raise and push the hull. The nearly straight chains *e*, from the hull to the shore, will, by their own weight, exert much force, and this could be increased at high water by a heavily loaded "traveler" *n*, being hauled out midway on the chains.

If one end of the hull moved too fast, the chains over the floats would slack and swag down, exerting but a slight force. If the hull moved parallel, no injury to it or the floats would ensue, for the weight of the swagging chain would keep the floats in advance, and the body of water between the hull and the floats would have to be displaced before they would come in contact; and it would act as a cushion, similar to the elastic balls used in lecture rooms.

For the Journal of the Franklin Institute.

On Boilers and Surface Condensers. By THOMAS PROSSER, of New York, Civil Engineer.

The very valuable experiments of Mr. Isherwood, elaborated in the last May and June numbers of this Journal, have a most important bearing on the subject at the head of this article. Taken in connexion with other well-known facts of a similar character, these experiments prove to me the necessity of using iron for condensers of the tubular surface kind, unless, using copper, we are prepared to go back to the same expensive material for tubular boilers also, notwithstanding the evident tendency among engineers to employ high pressure steam for ocean steamers.

The utility of experiments, such as Mr. Isherwood has frequently communicated with so much ability and care, are not easily overrated, and are entitled to more attention than they appear to have received. The experiments now referred to, were made at the steam flour mills of Messrs. Hecker & Brother, New York;* and I wish to be allowed to make a few observations on some parts, which have a very direct bearing on my

* Vol. xxxiii. (3d S.) pp. 278 and 370.

subject, and to correct some errors of calculation, which do not, however, affect the general results of the experiments, nor the deductions therefrom.

The condensing surface is very small, as compared with the recipient heating surface in the boiler, being about as 1 to 3·848; but, inasmuch as in practice, the grate and recipient heating surfaces bear no assignable proportions to each other, I prefer to compare the grate directly with the condensing surface, which is as 1 to 5·281; avoiding, by this method, all the numerous errors involved in calculating the heating surface of the boiler, and in fact all theories of any boiler whatever, having only to regard the quantities of fuel consumed and of water of condensation collected, together with that of the condensing water, and of course the temperatures of both waters. It is much to be regretted, however, that both quantities are given from calculations, instead of by actual weighing, particularly where so fine an opportunity occurred, during any definite number of strokes of the engines and pump, from which something reliable might have been attained. Instead of this, we have the fallacious method of calculating the weight of the water evaporated from the capacity of the cylinder and passages, after it has been expanded 1700 times, when, as I contend, we have no sufficient knowledge either of the absolute weight of water which has left the boiler in the state of steam, nor of the total heat carried with it, even if we had the weight of water, for some of it may have primed over, although, in this case, probably not much.

In the last experiments, (p. 376,) the average pressure of the steam in the boiler was 91 lbs. per square inch above the atmosphere, the temperature due to which is about 336° Fahr., and its total heat about 1184° above 32°. Now, in the calculations on the "efficiency of the condenser," (p. 381,) the total heat of steam at atmospheric pressure is adopted, viz: 1146·6° Fahr., thus leaving 37·4°, (=1184—1146·6,) or more than three per centum of the total heat in the steam unaccounted for. It *may* be that just this amount of heat is lost by radiation, and is just sufficient to prevent condensation in the cylinder, and if so, then the calculation *may* be about correct, but, in point of fact, it is all mere guess work, for we know but little of that which we cannot see, and not much of that which we can see.

Another still less fortunate guess is, that the cold water pump discharged but "two-thirds of its capacity of water," or 17 lbs. to condense 1 lb. of steam at atmospheric pressure, which cannot be, for such steam requires nearly all the water which the pump can deliver to condense it, and $23·831 = \left(\frac{1048·6}{44} \right) = \left(\frac{1146·6 - (130 - 32)}{80 - 36} \right)$ lbs. is the least possible quantity of water which will effect it.

The equation (p. 381) " $\left(\frac{1146·6 - 130}{130 - 36} \right) 10·81$ lbs.," intended to show the difference between the quantities of condensing water required, by surface and by injection condensation, is erroneous to a small extent, and needs correction only on account of the comparison which I wish to make hereafter.

The total heat in atmospheric steam is 1146·6 above 32° Fahr., and that is condensed and reduced to water at 130° Fahr., or 98° above 32°, so that the formula should stand thus:—

$$\left(\frac{1146\cdot6 - 98}{130 - 36} \right) 11\cdot155.$$

Now, in this case, the condensing water gains 94°=(130—36,) while in the former one the gain is but 44°=(80—36,) and of course the quantities of condensing water required in the two cases are in the inverse proportions of 44 and 94, or as 23·831 to 11·155. This shows the danger of guessing, when other means are available, and also the danger in using a very awkward scale of temperature, instead of the beautifully simple, but very convenient and scientific centigrade.

Owing to the very low temperature of the condensing water, (36°,) these examples do not apply to ordinary cases by any method of condensation, for the condensing water of an air pump surface condenser seldom gains on the average more than 20°=(say 80—60,) if anything like a good vacuum is desired. In Hall's condenser, which is by far the best of its class, the vacuum is usually from 29 to 30 inches, but the condensing water only gains about 16° on the average, and consequently requires 67 lbs. of it to condense 1 lb. of steam.

The very low temperature of the condenser, and the consequent enormous condensation in the cylinder, requires 1·5 lbs. of feed water per minute, per horse power; consequently, *three tons per hour* for each horse power must be passed through the condenser. Need we be surprised, then, that, with such a torrent, the copper of the condensing tubes is carried into the boiler from the hot-well, and with it the elements of destruction? Add to this, the slightest leakage of salt water into the copper condensing tubes, and the case is completely made out, why surface condensers have never succeeded. Moreover, the machinery necessary to effect the operations, the space occupied by it, and the enormous dead weight carried, are together so enormous as to be almost incredible; nor is the boiler one whit less wonderful for the same qualities.

To return from this digression to the boiler mentioned at page 380, where Mr. Isherwood states, that "particular plates have been found deeply honey-combed, while others adjoining were nearly as sound as ever;" and "about these portions of the boiler," "salts of copper, were found, carried there from the copper pipes of the condenser." But "pure water is used in the boilers, and any deficiency is supplied by rain water." Again, he says: "The wasting of the metal appears to have been *about* equal on *both* sides the copper; that is to say, on both the sea water and distilled water sides." How is this? "Pure water" is generally supposed to have no effect whatever upon copper, whether hot or cold; but cold *sea* water has a very powerful effect upon it, and the difficulty of making a surface condenser perfectly tight, is far greater than is generally imagined, and particularly where the water is cold. That this condenser leaked,* as did also the one referred to in the 15th vol. (3 S.) p. 131 of this Journal, where the density of the water in the boiler

* Since writing this, I have ascertained that the condenser did leak sometimes, but is supposed not to have done so at the time the experiments were made.

increased without any assignable cause, is beyond a doubt; for nothing else that can be imagined will account for the facts.

Copper, under some circumstances, will doubtless stand longer than iron, on account of its greater homogeneousness, as well as flexibility and toughness. Iron tubes *under coercion*, will sometimes give out in an incredible short time, where each end is rigidly fixed, and the middle is subjected to violent changes of heat and cold, causing the scale to fly off, and exposes the clean iron to the action of sea water.

If we assume, in the experiments before us, that the condenser of copper and the cross-boiler of iron are each of the same value to renew, and also that no more danger attends the wearing out of the one than of the other, it does not appear to be of much importance which goes first. But, when the *destroyer* is of more than three times the cost necessary, and further, when, by reducing its cost in that proportion, by substituting iron for copper, it becomes the *destroyed* instead, it does appear surprising that copper condensers should be thought of in connexion with iron boilers.

It is but a few years since, that the fallacy of using copper boilers was exploded; and now we have to contend with a still greater evil and a more dangerous one too, (unless we are prepared to go back to copper boilers,) for so rapid is the destruction of iron boilers by salts of copper in sea water, that a boiler may be reduced to a most dangerous condition in a few weeks. I have known the boilers of a sea-going steamer almost destroyed by this means, in an incredible short space of time, where the bilgewater, with salts of copper in solution, was used for injection, and thus got into the boilers from the hot-well; so that more than 500 iron tubes and several plates of the boilers had to be removed, being completely honey-combed in the direction taken by the feed-water.

Another source from which salts of copper may get into the feed water of a boiler from a copper surface condenser is, the oil and fat in the exhaust steam, which remaining upon the copper when *cold*, rapidly absorbs air, becomes oxygenated, and attacks the copper.

Notwithstanding the great defects of the condenser experimented upon, Mr. Isherwood affirms that the results obtained are "very remarkable," and that "the uniform satisfaction it has always given must not be overlooked."

The defects I consider to be in the use of copper, and that too in the shape of large tubes, so that the steam has to expand itself enormously, to come in contact with the condensing surface. Next, the condensed steam being open to the atmosphere, necessarily limiting its temperature to a low point, and increased enormously the back pressure upon the piston.

In the "*New Method of applying the power of Steam and of Condensing the same*," which I had the honor of promulgating in the 31st vol., p. 343 of this Journal, I believe all the objections to this system of condensation are removed, and many improvements are introduced.

In the first place, the annular spaces between large iron tubes are used, so that the steam has to expand itself but little to come in contact with the condensing surfaces. Next, the condensing, *i. e.* the receding

steam alone gives, (or takes off, shall I not say?) its own back pressure to the piston; and, whatever that may be, the feed water is above 212° Fahr., for the phenomenon does really occur of a reduction of pressure without apparent cause. It happens, whenever a sufficient current is established in a gas-pipe ascending a hill, for a small puncture not only will not allow the gas to escape, but will absolutely draw the air in, and show the "*blue lights*" beyond; and I see no reason to doubt the same effect being produced by very rapid condensation of steam under favorable circumstances.

My system is essentially one of *centralization* and power; whereas all others are on the principle of dispersion, which is weakness. In the former case the steam is operated upon, while yet at a comparatively high but useless temperature, and it is *killed* on the spot, for it cannot travel more than 4 or 5 feet, after entering the condenser, before the full power of the latter is developed and in action. In the other case, the steam is allowed to expand enormously as soon as it leaves the cylinder, and then it goes on its travels to find a condensing surface, until it is so exhausted that there is nothing left to condense but dead inanition, which is dragged out by the air-pump.

Hall's condenser has about 39 feet of surface to 1 foot grate surface, but then he has almost a perfect vacuum. Others have less surface, but a less perfect vacuum, and of course the less air-pump the higher the temperature of the feed-water. Messrs. Hecker & Brother's condenser had no air-pump, but the feed-water was only 122° . Now, in my system, the feed-water need never be as low as 212° , by several degrees, while the back pressure, I have reason to believe, is always below that due to the temperature, for the exhaust steam is in rapid motion, and of course, being *drawn off from the piston, must and does* draw off the pressure from it.*

I know that iron tubes, when properly put together to form condensers, will withstand the action of sea-water for a considerable time, provided they are not too long, but, even if it should be found that they corrode rapidly, there is no doubt, if the statements in the English papers are to be believed, that *Howell's* homogeneous metal will last many years.

Under any circumstances, however, the mere tubes being inexpensive, and the facilities for replacing them very great, there does not appear to be any objection whatever to their use. And now, what is the national stake at issue in connexion with this subject? It is doubtless very presumptuous in me to say that I believe, unless *my method*, or one equally efficacious, is adopted, for condensers of ocean steamers, we must entirely (we have almost done so already), abandon the foreign carrying trade. The monstrous space now occupied with machinery in ocean steamers, together with their first cost, and the enormous expense of working them, are all against this country. But the fuel and its concomitants form by far the greatest evil; and yet, in point of fact, with a system of centralization in the boiler as well as in the condenser, that fuel should be our

* See Dr. E. Alban's work on "The High Pressure Steam Engine," translated by William Pole, C. E., London, note 31, p. 56.

greatest good, for there is no fuel that can be used in such a system equal to the anthracite; and instead of evaporating 6 lbs. of cold water with 1 lb. of it, I have no doubt that 12 lbs. of boiling hot water may be evaporated with that quantity. I am supported in this opinion by the January number of this Journal, p. 58, from which it appears, that in the north of England 12·27 lbs. of boiling water has been evaporated by one pound of coal. One cause of the greater proportional efficacy of the fuel, in operating upon boiling water, probably arises from the water not assuming the spheroidal condition, or, if it does assume it, on coming in contact with the hot iron, it is in a very advanced state of that condition, necessarily so, because, if otherwise, cold water could never be got out of it at all; whereas we know that the water will dance about for some time, and then evaporate pretty quickly at the last, when it has sufficient heat, which it obtains with great difficulty when cold. The fuel, then, is the thing to be operated upon; for, if we can reduce that and its concomitants to one-half, although foreigners may take advantage of our improvements, yet, with a superior fuel for the purpose, and the adoption of those methods of economy which the peculiar nature of our facilities require, instead of following in the wake of foreign improvements, which, in many instances, are not applicable to our wants, the per centage of saving on the whole expenditure will be greatly in our favor.

I may now be allowed to say, that, before I penned the "*Memoir*"* on my new method of using and condensing steam, I had pretty well satisfied myself, by practical experience, that it was correct; and having been engaged upon it ever since, until I have fully worked out the problem, I feel fully justified in pronouncing the air-pump of a surface condensing engine a great mistake. I make this declaration, in full view of the handle which it gives to call hard names, but, as that is and must be the turning point, I prefer to meet the issue so, and thus I throw down the *gauntlet* to all comers to disprove my theory, if they can.

* Vol. xxxi, Third Series, No. 5, May, 1856, p. 343. See also vol. xxxiv, Third Series, No. 3, September, 1857, p. 199.

*The Original Locomotive Engine of Trevithick.**

SIR,—Whilst employed at the Penydarren Iron-Works, I had frequent opportunities of seeing the principal parts of the original locomotive which was made by Trevithick, as described by Mr. Thomas Ellis in last week's Journal. Some years ago I recommended the late Mr. Ald. Thompson, and also Mr. Forman, to preserve these interesting relics and put them together, as a memento of the original locomotive. I am truly happy to find my old friend Mr. Ellis has taken up the subject, and that the fitter and the driver are still alive, and are able to assist him in the task he has undertaken to perform.

October 27th.

EVAN HOPKINS.

* From the London Mining Journal, No. 1158.