gas, destroys the lining of the stack and melts off the dampers as fast as they can be replaced. The grate bars, the manufacturers state, never burn out, and the puddler's tools last about three times as long as they did when coal was used. In furnaces where the water necks cannot be used, they are compelled to use a jet of steam to lessen the heat.

Their production has increased about thirty-three per cent since they began to use gas, and the iron made commands from $10 to $20 per ton more than the same class of iron manufactured at the Apollo works, where they use coal, the iron being made from the same class of stock. These facts were communicated to the American Iron and Steel Association.

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GAIN FROM THE USE OF FEED WATER HEATERS.

In an ordinary boiler, one pound of average coal will produce by its combustion between eight and nine thousand units of heat that are available for generating steam. Supposing the feed water to enter the boiler at a temperature of 32° Fah., each pound of water will require about 1,200 units of heat to convert it into steam, so that the boiler will evaporate between 6⅔ and 7½ pounds of water per pound of coal. Better results than these are often realized, especially in the case of tests, but the figures given above are believed to correspond with those of ordinary practice. The amount of heat required to convert a pound of water into steam varies with the pressure, as will be seen by the following table:

Units of heat required to convert one pound of water, at the temperature of 32° Fah., into steam at different pressures:

Pressure of steam in pounds per sq. inch, by gage.	Units of heat.	Pressure of steam in pounds per sq. inch, by gage.	Units of heat.
1	1,148	10	1,155
20	1,161	30	1,165
40	1,169	50	1,173
60	1,176	70	1,178
80	1,181	90	1,183
100	1,185	110	1,187
120	1,189	130	1,190
140	1,192	150	1,193
160	1,195	170	1,196
180	1,198	190	1,199
200	1,200		

If the feed water has any other temperature, the heat necessary to convert it into steam can easily be computed. Suppose, for instance, that its temperature is 65°, and that it is to be converted into steam having a pressure of 80 pounds per square inch. The difference between 65 and 32 is 33; and subtracting this from 1,181 (the number of units of heat required for feed water having a temperature of 32°), the remainder, or 1,148, is the number of units for feed water with the given temperature.

In the use of an ordinary non-condensing engine, in which the steam is exhausted directly into the atmosphere, each pound of steam, as it escapes, carries off the greater part of the heat that it has received in the boiler. This can be rendered plain by an example: Suppose the feed water enters the boiler at a temperature of 70°, that the pressure of steam is 90 pounds per square inch, and that the back pressure in the cylinder, under which the steam is exhausted, is 1 pound per square inch:

Temperature of feed water	70
Subtract	32
Difference	38
Units of heat required to convert 1 pound of water at 32° into steam at 90 pounds pressure	1,183
Subtract	38
Units of heat required to convert 1 pound of water at 70° into steam of 90 pounds pressure	1,145
Units of heat in 1 pound of steam at 1 pound pressure, from water at 32°	1,148
Subtract	38
Units of heat imparted to feed water, that are carried off by each pound of exhaust steam	1,110
Multiply this by 100	111 000
Divide by 1,145	96 941

which is the percentage of the heat, imparted to the feed water, that is carried off by the exhaust steam.

There remains, then, only about 3 per cent of the heat, imparted to the water by the combustion of the coal, that is utilized in the engine. This is a rather serious consideration for the steam user, who may figure up his account with the boiler and engine somewhat after this manner: One ton of coal costs $6.50, and evaporates, by its combustion, 15,000 pounds of water, at a cost for fuel of $0.00043 + per pound. When the steam resulting from the evaporation of this water is used in the engine, 96·94 per cent of the heat imparted to it by the fuel is exhausted into the air. This is the same as throwing away 14,541 pounds of the water that has been evaporated, leaving 459 pounds for useful work, so that really each pound of water used in the engine costs $0 014 +. There are very many engines running today to which this account will apply, engines that are sending into the air nearly all the heat imparted to the water by the fuel. We showed, in a preceding article, how considerable saving would generally result by attaching condensing apparatus to a non condensing engine. This cannot always be done, however; but there are means by which some of the heat carried off by the exhaust can be utilized. The most obvious method is to turn the exhaust steam into vessels through which the feed water passes, so that some of its heat may be imparted to the water, which will then require the consumption of less fuel for its conversion into steam. There are a number of heaters in the market which are guaranteed by their manufacturers to deliver the feed water into a boiler at the temperature of 212°, and we can state from our own experience that this is not an uncommon result, while a temperature of at least 200° should be realized from the use of any good heater. It may be profitable to consider the effect of attaching such a heater in the case previously cited. The feed water will then enter the heater at a temperature of 70°, and be delivered into the boiler at a temperature of 200°, having had its temperature increased 130° by the exhaust steam, which has lost a corresponding amount of heat. Each pound of water will require 1 015 units of heat for its conversion into steam of 90 pounds pressure, instead of 1,145 units, which were needed when the heater was not in use. This gives a gain of 130 units of heat for each pound of water evaporated, being 11 35 + per cent less heat than was required when the feed water was pumped into the boiler at a temperature of 70°. Each pound of exhaust steam, also, instead of carrying off 1,110 units of heat into the air, will only take 980, or 11 71 + per cent less than it formerly did. The account previously given will now figure up as follows:

The combustion of one ton of coal will evaporate about 16,900 pounds of water, at a cost of $0 00038 + per pound. In the engine, an amount of heat corresponding to about 16,300 pounds of the steam is thrown away in the exhaust, leaving 600 pounds for useful effect, at a cost of $0.0108 + per pound.

These examples, which correspond well with cases in ordinary practice, will enable our readers to estimate with tolerable accuracy the results that will be realized from attaching a heater in any given instance. It will be observed that, in the case supposed, no allowance was made for increased back pressure by the use of the heater. This was because the hypothetical heater was properly designed. A good heater does not increase the back pressure in the piston. There are many forms of the apparatus, however, that offer so much resistance to the escape of the exhaust steam, as to more than neutralize the gain that would otherwise be derived from their use. It is easy to see, for instance, that if the introduction of a heater increased the heat of the feed water 10 per cent, but also increased the back pressure so as to call for the expenditure of 12 per cent more fuel, the arrangement would be anything but economical.

A SPECIAL EDITION OF THE SCIENTIFIC AMERICAN.—ONE HUNDRED THOUSAND COPIES.

We shall, during the coming month of December, issue a special edition of the SCIENTIFIC AMERICAN, aggregating one hundred thousand copies, which will be gratuitously circulated among manufacturers of all kinds, machinists, mill owners, and, in brief, representatives of all industries in the United States and in Canada. At considerable outlay of time and expense, we have procured a list of one hundred thousand names, embracing the leading business men of the above important classes; and to each individual a copy of the SCIENTIFIC AMERICAN, enclosed in a separate wrapper and prepaid, will be mailed. The item of postage alone will thus cost the large sum of two thousand dollars, and the issue will find its way into every post office in the country.

Our motive for printing this extra edition, at an outlay of some six thousand dollars we do not desire to conceal, nor could we do so even if such were our wish. Our aim is to increase our subscription list; and in pursuance of this object, we take such means as will enable others beside ourselves to derive benefit from the enterprise, in direct proportion to the amounts they invest in its furtherance. To this end, therefore, we propose to admit a few advertisements. It will readily be apprehended that, since the publishers are distinctly pledged to print the large special edition above noted, and to mail the same (pre paid) to names selected with care and judgment, every person having goods, productions, or ideas to bring to the notice of the class above mentioned is here furnished with the means. Moreover, it should be remembered that the names to which we refer are not those of our regular subscribers, but of business men not accessible through the ordinary newspaper channels.

We would direct especial attention to the fact that, although a circulation of 100,000 copies is guaranteed, there is every probability that this will be greatly exceeded. Our offer of last year included a circulation of but 60,000; but before we had supplied the demand, 120,000 copies were printed and mailed. For this immense excess, we imposed no extra charge upon our advertisers. The same course will be adopted this year. The extra benefit is given freely to those firms who send us advertisements for the special edition.

To the enterprising manufacturers and inventors who advertise in our regular columns, and indeed to everybody at all conversant with the advantages of a good medium, we need not point out the benefits to be derived from our proposition. For further particulars, see advertisement on another page.

COST OF TUNNELS.

"Among the various plans for disposing of the Jones' Falls stream or improving its channel, which have been presented to the council committee, is one by J. E. Sudler, civil engineer, proposing to divert it by a tunnel from a point beyond the city across to the valley of Gwynn's Falls, and thus throw its waters into the middle branch of the Patapsco, or Spring Gardens. This tunnel would pass in good part under Druid Hill Park, and through a rock formation which, it is believed, lies beneath all the hills in that quarter. Never having looked to diversion in that direction, and without pretending to have examined into or formed any judgment in the premises (the plan lately suggested by the mayor in his special message to the council for improvement within the city being still pending), it may yet be worth while to inquire into what has been the cost of like tunneling, accomplished in other parts of the world. The aggregate cost of this tunnel for Jones' Falls, the length of which is 16,000 feet, is put by its author at $2,800,000, or $145 per lineal foot, which is a fraction over $2 per cubic yard. With regard to other tunnels already in existence, their cost is given as follows: The great Mont Cenis tunnel cost about $360 per lineal foot, including equipment of road, etc. The Kilsby double track railroad tunnel (England), in the construction of which very great difficulties were encountered from the tapping of quicksands, cost $262 50 per lineal foot. Bletchingly tunnel, for a double track railroad in England, cost $120. Terre Noire, on the Paris, Lyons, and Mediterranean railroad, cost but $50 per foot; and the very difficult Hauenstein tunnel, between Basle and Berne, Switzerland, cost $133 per lineal foot. The Hoosac tunnel, through a formation of mica slate and quartz, with working shaft upwards of 1,000 feet in depth, cost $360 per lineal foot.

These tunnels were all completed several years ago, and the cost per cubic yard of material excavated varies from $1 50 to $14. The difficulties met with in their execution have led to the invention of improved apparatus, by the use of which the cost of boring, drilling, etc., is reduced from 100 to 300 per cent. The diamond boring machine was thoroughly tested by Captain Beaumont, R. E., in Lancashire and Cumberland. At Stoughton, the borer reached a depth of 689 feet in two months, that could not have been got at in less than two years by hand labor. In the Clifton tunnel, Bristol Port and Channel Dock Railroad, in hard mountain limestone, the drills advanced at the rate of two inches per minute—outside diameter of boring, two inches. The machine advanced at about five times the speed that could be attained by as many men as could find room to work at a heading. The motor is compressed air. Dynamite is used for blasting, and found to answer admirably. With the aid of these machines the work of tunneling through the hardest rock presents no difficulties of any extraordinary character, and may be executed at a cost very little, if any, greater than the excavation of the same material in open cutting."—*Baltimore Sun.*

To the above, may be added the cost of that portion of the Underground Railway, in New York city, now nearly completed, on Fourth Avenue, between 44th street and Harlem

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