mixture of heat and water, and the power to be got out of it is proportionate, not to the amount of water it contains but to the quantity of heat, the water being but a vehicle for the transmission of the heat, and the steam boiler a machine in which to mix the water and heat.

The object aimed at in the use of the boiler is to bring the heat of the furnace into contact with the water. The loss of heat in doing this is necessarily great. A large quantity is required to produce the draught in the chimney, and heat is radiated in all directions, from the furnace front, boiler, pipes, etc. Boiler rooms are usually much hotter places than there is any need for, and it should be understood that this uncomfortable heat costs money and is a waste, some of which might be saved. Another cause of loss arises from the fact that while iron is a very good conductor of heat, mud and scale, so frequently found inside boilers, are bad conductors of heat, and where these are allowed to cover the plates and tubes they retard the passage of the heat into the water, and increase the quantity which escapes up the chimney. Leakage from boilers, pipes or valves, apart from the mischief it causes by corrosion, is a positive waste of fuel, and is worse than money thrown away.

After the steam is produced inside the boiler, how is it to be converted into power? No engine has ever yet been made which can do this without great loss, and most of the engines in actual use are much more wasteful than there is any necessity for. If the man who can make two blades of grass grow where but one grew before is to be considered a public benefactor, what shall be said of him who makes one ton of coals do as much work as two tons?

Steam engines are in use which require 10 lbs of coal per hour for each horse power given off, while others do the same work with 2 lbs. It has not yet been found practicable to reduce the consumption of fuel to 1 lb of good coal per hour for each horse power, but suppose an engine is actually doing this, how much of the heat produced by each pound of coal is converted into power? Not more than 15 per cent., while 85 per cent. goes up the chimney, heats up the boiler-room, and and escapes with the exhaust.

It is not beyond the range of possibility that steam engines may yet be built, capable of working on 1 lb. of coal per H. P. per hour, and surely within the future something better will yet be discovered. But, without waiting for that, much can be done to make engines as we now have them more economical. The most common sources of loss in an engine are condensation in the pipes and cylinders, leakage at the valves and piston, improper setting of the valves, excessive back pressure, &c. How are these to be discovered and corrected? A well conducted test of the amount of fuel consumed, quantity of water evaporated by the boilers, and amount of power given off by the engines as shown by indicator diagrams, will usually discover the real condition of the engine, &c. An engine giving off a total of 60 horse power was found by the indicator diagrams to be using 25 H. P. to get rid of the exhaust steam from the cylinders, and had been working in this condition for years, the loss of so much power never having been even suspected till the indicator diagrams revealed it. Many engines are running in this country, close beside streams of water, and exhausting the steam into the air, when, by the addition of a condensing apparatus a large increase of power could be obtained, or a saving of fuel effected. In an engine taking steam at 60 lbs. pressure, and cutting off at half stroke, the gain of power by condensing would be about 32½ per cent., of which 2½ per cent. would be required to drive the air pumps.

Instead of adding a condensing apparatus it is sometimes more profitable to use the exhaust steam for heating purposes, either work rooms, drying rooms, or water; and the question comes up, how much heat is available from exhaust steam? More than 100 years ago it was observed that steam at the temperature of boiling water gave out a large quantity of heat while being condensed into water, which still showed the same temperature. It was also clearly established that water of 212° temperature could not be converted into steam of 212° temperature without the addition of a large amount of heat, and to this was given the name "latent heat."

More modern experiments have shown that, while the addition of 152 units of heat to a lb. of water at 60° will make it water of 212°, other 966 units must still be added to make it into steam of 212°. Nearly the whole of this quantity, and indeed often much more, remains in the exhaust steam, and is released from the steam while it condenses into water, and ought not to be allowed to go to waste, where it can be put to any useful purpose. Sometimes the attempt to use exhaust steam for heating purposes has proved a loss instead of a gain, owing to the unskilful manner in which it was done, the loss of power from increased back-pressure having been greater than all the gain of heating: but where the apparatus is properly constructed there need be no increase of back pressure. Another source of loss in factories arises from imperfect arrangement of shafting. It gets out of line, or the pulleys run out of balance, or the belting is defective, and power is lost or used for a useless purpose. Manufacturers should look out for all such leaks in their factories, and when found it will pay to stop them.

UTILIZING EXHAUST STEAM.

There is only one general method of accomplishing this efficiently. The exhaust steam can be made to give up a portion of its heat to some fluid of lower temperature which in turn utilizes it in performing some useful function. This is the principle of all binary engines. The steam of a temperature above 212° F. transfers a portion of its heat to some fluid of lower temperature which evaporates or expands at a lower temperature than that of the exhaust steam. The fluid is then utilized in a cylinder separate from the steam cylinder, but may form a part of the direct power system which includes the steam engine. In other words the two engines may drive the same shaft, though this is by no means a necessity. Again the exhaust steam may be made to transfer a great portion of its heat to the water fed to the boiler. This is partially accomplished by a condenser and by a feed water heater. But the only way in which the heat in the exhaust steam can be utilized is by transfer to some colder body than itself, and it is time that this be generally appreciated. Of course exhaust steam can be used to create draught in chimneys, but in this case, though the direct action results from the velocity of the escaping steam, the temperature of the steam is lowered accordingly.—*American Engineer.*