The chief physical source of the heat which we enjoy is the sun, which, although situated at such an immense distance from us, warms the earth with its rays—of this source nothing is known. In addition to this external heat we have an internal source, whose product is known as terrestrial heat; this heat is very great, and it is computed by scientists that at the depth of a few miles it is capable of melting the most refractory substances. Though we are mainly dependent upon these sources for maintaining our temperature, there are mechanical and chemical sources which are of great importance to us, the most important being chemical action. Nearly all chemical combinations are attended with the production of a greater or less degree of heat, and it is the chemical combination termed combustion which we, as engineers, are mostly interested in. I will not touch directly on the subject of combustion, as that will be dealt with in a separate paper.

The temperature of a body indicates how hot or how cold it is, and should be distinguished from the quantity of heat in that body. For example, if a cup of water be taken from a vessel, the temperature is the same, but the quantity of heat varies as the weight in each vessel, the temperature or intensity being measured by the thermometer, but the quantity of heat is the temperature multiplied by the weight in pounds. The specific heat of bodies varies considerably, water being the highest of any (except hydrogen), it being the standard and considered as 1, while that of iron for instance is $.113 = \frac{1}{9}$ almost, so that the quantity of heat that would raise 1 lb. of iron through 9°, would only raise 1 lb. of water through 1°. These properties are taken advantage of by the engineer to ascertain approximately the temperature of bodies beyond the range of the ordinary thermometer, the uptake of a boiler for instance. Nearly all bodies expand by the action of heat, and the mechanic and engineer have ever to keep in view the fact, or disaster is the result, for instance, cracked boiler fronts and settings, broken steam pipes and leaky joints. At the same time this property is daily utilized in our workshops; cranks and pins are secured, locomotive tyres shrunk on, and many defects made good by the judicious application of heat. The transfer of heat from one body to another may take place in any of the following ways: Radiation, conduction or convection. Heat is given off from hot bodies in rays, which radiate in all directions in straight lines; this is the process of radiation. Conduction is the process by which heat passes from hotter to colder bodies: by contact the conducting power of bodies varies considerably. Iron and copper are good conductors, wood and some mineral substances are bad ones. The engineer uses good conductors to transfer the heat from the furnace to the water in the boiler, and the bad ones to prevent loss of heat by radiation from steam pipes, cylinders, etc. Convection or carried heat is that which is transmitted from one point to another by currents. The freer and more direct the currents the more readily is the heat transmitted. Steam boilers should be so constructed as to secure a free circulation of the water.

Before quantities of heat can be measured we must have a unit of heat, just as we require a unit of weight or length, as the pound or foot, and the unit of heat is the quantity required to raise 1 lb. of water through 1° F. But the all important point with the engineer is the conversion of heat into work. We will, therefore, consider the relation between the two. By the term work is understood the overcoming of a resistance through space, and the amount of work done is measured by the resistance in pounds overcome, multiplied by the distance through which it is overcome in feet: thus, if 7 lbs. be lifted through 10 feet, $7 \times 10 = 70$ F. lbs.

Thus it will be seen that work is not measured by the pound or foot, but by the product of the two, and the unit of work is the lifting of 1 lb. through a vertical height of 1 foot, and is termed the foot pound. It will also be noticed that the unit of work has no reference to the time taken, as the same amount of work is done whether it takes one second or one hour. The power of an agent is measured by the rate it can do work, and the unit of power adopted by engineers is the horse power, and is represented by the lifting of 33,000 lbs. 1 ft. high in one minute. In the case of pumping engines the work done is measured by the foot pound, and is termed "duty per lb. of coal."

We will now consider the effect of heat in producing a change of state in different bodies, as ice, water and steam. "The temperature of a body ceases to rise while it is melting." An illustration of this fact may be obtained in this way. Take equal weights of water at 32° and 174°, and mix. The temperature of the mixture will be the mean of the two, 103°; now take equal weights of ice at 32° and water at 174° and mix as before; the temperature will only be 30° instead of 103°; all the ice, however, will be melted; the 142° of heat has evidently been consumed in melting the ice and is now latent in the water. This heat would require to be given off again before the water could be transformed into ice, and were it not for this provision, as soon as any body of water had sunk to 32°, it would immediately become a mass of ice.

A simple experiment, which may be easily tried, will enable any one to determine exactly the quantity of heat which becomes latent when ice is converted into water or water into steam.

Procure a uniform source of heat and place a lb. of water over it to ascertain the exact amount its temperature rises in a given time. Assume it rises 10 degrees in one minute. Now remove and place 1 lb. of ice at a temperature below 32°; the temperature will rise to 32° and remain at that point until all the ice is melted, which will be in about 14 minutes. Now in this time the amount of heat would have raised 1 lb. of water 10° x 14 minutes = 140°; but the water is only 32°, then this 140° of heat has been rendered latent. Continue the heat and in 18 minutes it will have attained the boiling point, $10 \times 18 + 32 = 212°$. Still continue the heat, and in 95 minutes or about $5\frac{1}{4}$ times as long as it took to raise it from 32° to 212°, it will have all boiled away, and yet the temperature of the steam has at no time exceeded 212°. All this heat, nearly 1000°, has been rendered latent. It is this large amount of latent heat in steam that renders it so useful as a heating agent, and were it not for this property the moment water attained the boiling point would be one of extreme danger, as it would be immediately converted into steam with an explosive force akin to gunpowder.

A NEW process has been invented for obtaining aluminum from the oxide. The process includes chemical combinations hitherto supposed to be impossible. It is claimed that the metal produced by this process is cheaper than any other.