THE DETERMINATION OF HIGH TEMPERATURES.

(By A. A. Watson, B. Sc., Vernon, B.C.)

THE determination of high temperatures is a subject of great interest in smelting operations and in the numerous experiments carried out by scientists upon blast furnace smelting and upon the use of various kinds of fuel a good method of accurately estimating high temperatures has been eagerly sought after. Various methods have been used to this end, and to describe some of these, together with the scientific principles involved is the object of this article. One of the first methods to be applied, and one which would naturally occur to anybody, was that of measuring the expansion of a bar of some metal, difficult to fuse, when placed in the furnace with one end passing through one side. The principle involved is the same as that of the ordinary mercury thermometer. We measure ordinary atmospheric temperatures by the expansion of a thread of mercury, reading off the degrees on an arbitrary scale; applying the same principle, only using a bar of iron instead of a thread of mercury, the temperature of any furnace could be obtained up to the melting point of iron, in terms of the centigrade or Fahrenheit thermometer. The iron bar was carefully measured at a temperature of zero centigrade and placed in that part of the furnace where the temperature of zero was desired to be determined. One end of the bar projected through the wall of the furnace. The increase in length was measured and the temperature calculated from this. Theoretically this instrument should have been satisfactory, but the difference of temperature of that part of the bar which was in the wall of the furnace gave rise to inaccuracies. The temperature was obtained by considering the equation for determining the coefficient of lineal expansion of iron, that is to say the fraction of itself which iron expands for every degree of rise in temperature. This fraction is .000012.

For example let L be the length of an iron bar at a given temperature. Let M be its length at 0° centigrade. Let T be the temperature. Let the coefficient of expansion of iron be .000012, then its length at any given temperature will be the multiple of its length 0° c., and unity plus the coefficient of expansion multiplied by the given temperature.

$L = M (1 + .000012 T)$.

Suppose an iron bar measured 100 inches at 0° c. and when placed in the furnace increased to 101.107 inches, we obtain the temperature of the furnace as follows:

$101.107 = 100 (1 + .000012 T)$.

$T = 922°$ c.

The barometer of the furnace then is 922° c.

A more accurate method was found by placing an iron and a platinum bar side by side in the furnace with the ends projecting and measuring the difference in the expansion of the two bars. Iron expands about half as much again as platinum for every increase per degree centigrade. The coefficient of expansion of platinum is .0000086. The greater the temperature therefore the greater difference will there be in the length of the rods and so by using the same equation as before first applied to iron and then applied to platinum we can easily obtain the temperature of our furnace. Suppose our rods each measure 100 inches at zero and the difference in their lengths in the furnace is .314 inch.

For iron $L = M (1 + .0000120 T) = 100 (1 + .000012 T)$.

Platinum $P = M (1 + .0000086 T) = 100 (1 + .0000086 T)$.

By measurement $L - P = .314$ inch.

$.314$ inch$= 100 (1 + .000012 T) - 100 (1 + .0000086 T.)$

$.0012 T - .00086 T = .314$.

$T = 923°$.

The temperature is found to be 923° c.

Another method which has met with considerable success is the calorimetric method. A platinum ball of known weight is suspended in that portion of the furnace of which it is desired to know the temperature and is then quickly ejected and placed in a water calorimeter. The rise in the temperature of the water is then noted. But first it will be necessary to explain to the lay reader what a calorimeter is and for what purpose it is used. A calorimeter is, as its name implies, a heat measure, that is to say, an instrument used for the purpose of estimating quantities of heat. The quantity of heat required to be put into a gramme of any substance in order to raise its temperature one degree, is called the specific heat of that substance. The specific heat of water is that quantity of heat required to raise a gramme of water one degree centigrade and this quantity of heat being taken as unity the specific heats of other substances are always taken in terms of the specific heat of water. Thus the specific heat or iron is 0.114, because the quantity of heat required to raise the temperature of a gramme of iron one degree centigrade is 114-1000 of the heat required to raise a gramme of water one degree. It is in measuring the specific heats of metals that the water calorimeter is used. It consists of a small breaker-shaped copper or brass vessel of known weight packed inside another brass vessel, the space between the two being lined with asbestos or more often non-conducting material to prevent the escape of heat from the inner vessel.

Suppose, for example, it is desired to measure the specific heat of brass. A piece of brass is weighed and placed in boiling water to bring it to a temperature of 110° c. In the meatime, the calorimeter is filled with water and weighed so as to obtain the weight of water, and the temperature of the water is registered. The piece of brass is next quickly removed to the calorimeter which is kept stirred and the rise in temperature of the water noted. We now have all the data for determining the specific heat of brass.

Supposing the weight of the brass to be 177.6 grammes, the initial temperature of the brass to be 100° c.,the final temperature 18.6 c. The fall in temperature of the brass is 81.4 c. The quantity of heat evolved by the brass in cooling is (177.6×81.4×specific heat of brass) heat units and is by natural law equal to the heat taken up by the calorimeter and water.

Now the weight of water in the calorimeter was 657 grammes and the amount of water equal to the instrument itself by previous determinations was 11 grammes, therefore the amount of water the whole calorimeter was equal to was 668 grammes. The initial temperature of the water was 16.6 and the final 18.6°. The water therefore was raised through 2° c. The heat taken up by the water was therefore 2×668 or 1336 units.

Now the amount of heat taken up by the calorimeter must be equal to the amount of heat given out by the brass, for energy is never lost, therefore $177.6 \times 81.4 \times$ specific heat of brass $= 1336$.

Specific heat of brass = .094 heat units.

It will be readily seen that, applying the same prin-