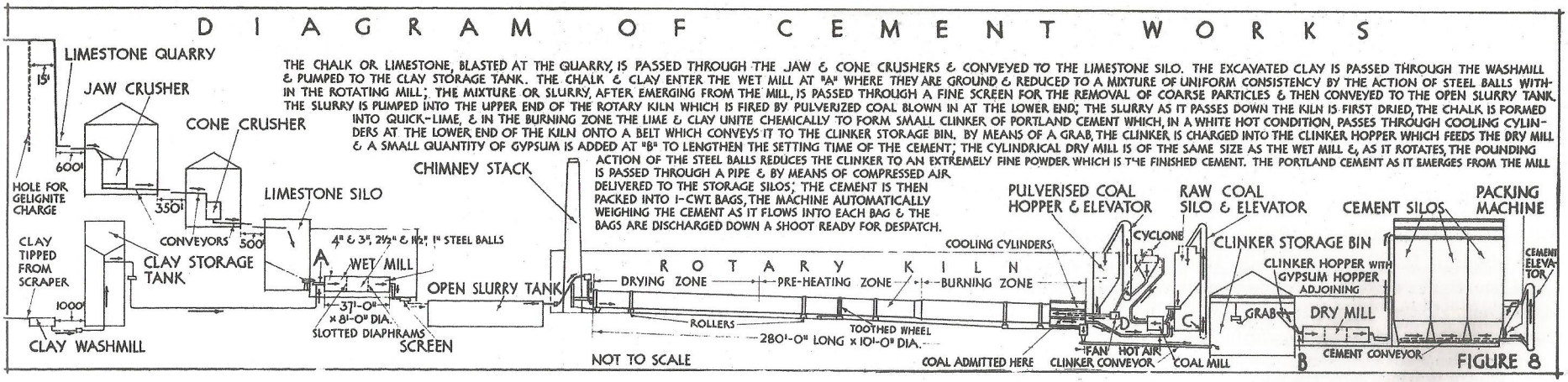

The following may be considered as an approximate analysis of a typical Portland cement :—

	Per Cent.
Lime	64
Silica	23
Alumina	5
Iron oxide	3
Magnesia	2
Sulphuric anhydride	2
Soda and potash	1
	100

The whole of the lime should combine with the silica and alumina. Any excess, called *free lime*, may produce unsoundness (see p. 24). A deficiency of lime may produce a weak cement.

The presence of iron is responsible for the grey colour of cement (resembling that of Portland stone). If excessive, the iron oxide increases the difficulty of grinding the clinker.

Excessive quantities of magnesia and sulphur compounds cause unsoundness.

An excessive quantity of soda and potash may cause efflorescence in the cement, and these alkalis should therefore be kept to a minimum.

(c) *Strength.*—The specification requires that cement shall pass tests to determine its strength in tension or compression.

Tensile Strength Test.—The cement has to be mixed with sand to form a mortar composed of 1 part (by weight) cement and 3 parts of Leighton Buzzard sand (a very clean, white and well graded sand obtained from Bedfordshire) to which a specified amount of water is added. The mortar is formed in a brass mould of the shape shown at B, Fig. 9, the cross-sectional area at the " waist " of the briquette being 1 sq. in. The mould is carefully filled by consolidating the mortar with a standard steel spatula (knife) until it is flush with the top ; the mould is reversed and the broad blade of the spatula is used to pat the mortar until water is brought to the surface, after which the surface is smoothed over and brought flush with the top of the mould by a trowel. The briquette is stored in a damp atmosphere and kept for twenty-four hours at a temperature of 58° to 64° F., when it is removed from the mould, submerged in clean water and left until required for testing.

It is required that twelve briquettes shall be prepared and stored in this manner, and that six of these shall be tested at three days after moulding, followed by the remaining six at seven days. The average minimum tensile breaking strength of ordinary Portland cement shall be 300-lb. per sq. in. at three days and 375-lb. per sq. in. at seven days after moulding.

One type of tensile testing machine is shown at A, Fig. 9. This has a pair of jaws of standard size and shape in which the briquette is placed. The lower jaw is fixed and the upper jaw is suspended at K to a system of levers consisting of lever R, pivoted on a knife-edge at J, and connected by a rod (having knife-edges at L and M) to lever Q, pivoted at N. A bucket is suspended at P to receive the load in the form of *shot* (lead pellets) fed from the container.

The testing is carried out in the following manner : A briquette is placed in the jaws, the spindle T is lifted to release the shot, which passes in a steady stream through a valve down the nozzle of the container into the bucket. This load is transmitted to the briquette through the system of levers and ultimately causes it to break across at the waist. Immediately this occurs the flow of shot is automatically stopped as the bucket falls on the pedestal below, depressing arm S, which in turn causes the spindle to drop and close the valve of the container. The bucket containing the shot is placed on some scales and weighed. A direct reading of the breaking load in pounds is obtained from the scales, as they are calibrated in accordance with the ratio of the levers after the weight of the empty bucket has been allowed for. As this breaking load is applied on 1 sq. in. of the briquette, it becomes the breaking stress in pounds per square inch.

A line diagram of the lever system of the apparatus is shown at C. The ratio of the lengths J'K' and J'L' in the lower lever is as 1 : 5 and that of M'N' and N'P' is as 1 : 10. Hence the magnifying ratio is 50, *i.e.*, the stress on the briquette is 50 times as large as the load in the bucket. Thus, if the weight of the shot in the bucket when the briquette fails is 7-lb., the load acting on ML equals $\frac{7 \times 10}{1} = 70$-lb., and this multiplied by 5 equals 350-lb. This is the breaking load, and is that which is read directly from the scales.

Compressive Strength Test.—If required by the purchaser the above tensile stress test may be substituted by a compressive strength test. The latter is applied to 2·78 or 3-in. cubes of a 1 : 3 mix, the mixing and compacting by vibration in a machine being specified. Three cubes are tested in a compression machine (see p. 32) at three days after moulding, and the average minimum compressive strength (calculated from the crushing load) for ordinary Portland cement shall be 1,600-lb. per sq. in. Three cubes are similarly tested at seven days, when the average minimum compressive strength shall be 2,500-lb. per sq. in. (see Table II, p. 34).

(d) *Setting Time.*—When cement and water are mixed to form a paste, the mass