would probably take place at the instant preceding rupture, and the ordinates represent the strains in percentages of the total maximum strain at the same instant.

In the light of this curve it is conceivable that the parabolic theory of stress distribution may possibly be sufficient. It is also conceivable that this may not be the case. For instance, suppose we assume that a plane section before bending becomes after bending a curved section through which an imaginary plane passes and touches three principal parallel lines in the curved section, viz., a line in the plane of the

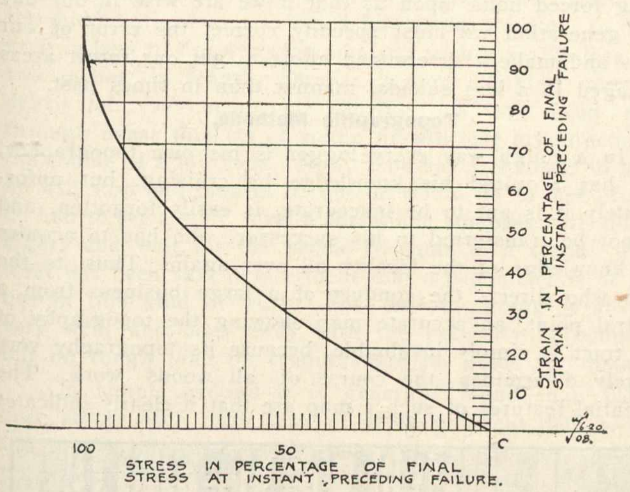
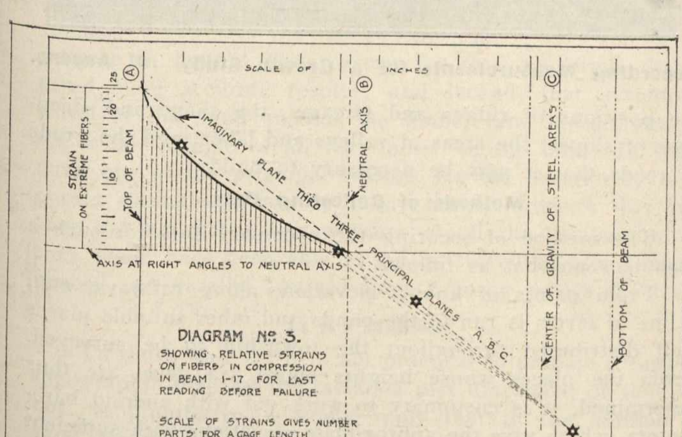



**Diagram No. 2, Stress-Strain Curve For Concrete in Compression.**

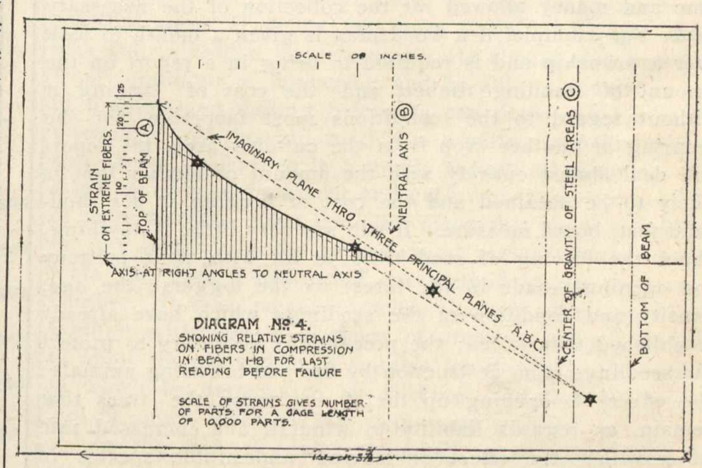
top fibres of the concrete; a line in the plane of the centre of gravity of the areas of the steel reinforcement; and a line in the plane of the neutral axis. If this latter assumption be true the distribution of stress on the cross section will vary according to the strains indicated by this curved section. Further assume that the fibres in this curved section are strained so as to give a distribution of stress on the cross-section that follows the straight line law. We will thus have two curves to represent the boundaries within which experimental values of strains may be expected to fall. Both assumptions may be wrong but an investigation of them along these lines will bring us nearer the truth than we could arrive if we were to accept either one without further investigation.

There are very little data that throw light upon the question as to whether a plane section before bending remains a plane section after bending. However, the tests of Professor Lanza, as published in Volume VI., of the Proceedings of the American Society for Testing Materials, do throw some light




upon the subject. In these tests "the strains were measured at four points in the depth of the beam on each side. The points at which strains were measured were respectively 1 inch and 5 inches above and below the centre of the depth of the beam; those 5 in. above and below the centre being determined on a gauged length of 27 in., and those 1 in. above and below the centre being determined on a gauged length of 12 in." These test beams had a cross-section of 8 x 12 inches and 11-foot span. They were supported at the ends and loaded transversely, the load being applied in each case at two points each 22 inches from the middle of the span. The concrete had the proportion of 1 : 3 : 6 measured by volume These proportions being such as would theoretically, a little more than fill the voids in each case. The quantity of water used varied from 6 to 7½ per cent. The reinforcing rods extended longitudinally throughout the length of the beams and the centres of their cross-sections at the ends were two inches from the bottom with a sag of from ⅛ to 3-16 of an inch at the middle of the span. They were tested at the ages of 2 month and 14 months, but the beams tested at 14 months were chosen as likely to give a more perfect stress-strain relation. It was not considered necessary to present an analysis of more than two of these beams. Beam 1-17 was reinforced with four ¾-inch twisted bars, and beam 1-18 with plain bars of the same size.

A separate diagram has been drawn for each of these beams. The abscissas represent the position of the fibres throughout the depth of the beam, the ordinates represent the positive and negative strains on these fibres. The four stars indicate the strains given by Professor Lanza for the last reading preceding the breaking of the beam. (The strains for the last reading are cited by the writer because they represent a stage in the stress-strain relation that always produces the greatest difference between theoretical expectations and experimental data). In the case of beam 1-18 the position of the neutral axis is taken to be indicated by the projection of the line passing through the two lower stars, whilst for beam 1-17 it was assumed to be on the line bisecting the angle 3-1-2. A plane through these lines at right angles to the sides has been assumed to intersect the true




strain-curve in the plane of the top fibres of this beam, and the intermediate values of this strain-curve were obtained from the values in Diagram No. 2 on the assumption that the indicated value for the strain on the extreme fibre was 90 per cent. of the strain at the instant preceding rupture. In both cases this strain-curve practically passes through the ordinates found by Professor Lanza, thus indicating that Proposition 1, is true for these beams. It also indicates a straight line distribution of stress on the cross-sections, giving for beam 1-17 a probable maximum fibre stress at rupture of about 4,100 per square inch, and for beam 1-18 about 3,600—values which may be expected from concrete at the age of 14 months. The modulus of elasticity indicated by these strain-curves for the stress on the extreme fibre is about 1,500,000 per square inch for beam 1-17 and 1,350,000 for beam 1-18.

In the light of these investigations and other evidences in experimental data, it is assumed by the writer that in general a plane section before bending bcomes a curved section after bending; (See Figure No. 1). And that the stress on any fibre varies directly as the distance from the neutral axis. This is also assumed to be true for wood, steel or concrete.

A word in regard to the use of extensometers: They have usually been attached on the sides of the beams with the lower screw fixed in the plane of the steel reinforcement and the top screw from 8 to 32 per cent. of the distance between