Tensile strength, lb. per sq. in.	49,000
Elastic limit, lb. per sq. in.	32,000
Elongation in 8 in., per cent.	18

while those of the steel constituting the lap-welded tubes tested by the writer and at the Watertown Arsenal were

Tensile strength, lb. per sq. in.	58,000
Yield point, lb. per sq. in.	37,000
Elongation in 8 in., per cent.	22

13. These data show that the material of the angles and tubes tested by Mr. Christie as compared with those of the tubes tested by the writer and at the Watertown Arsenal had average physical properties less by 15 per cent. in tensile

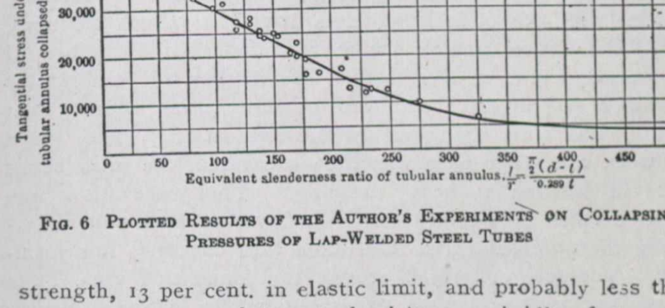

Fig. 6 Plotted Results of the Author's Experiments on Collapsing Pressures of Lap-Welded Steel Tubes

strength, 13 per cent. in elastic limit, and probably less than 10 per cent. in modulus of elasticity, or rigidity factor. It should be remembered while comparing the results of these experiments, that these differences in the physical properties of the materials, which it will be noiced are comparatively small, will be more or less offset for two reasons: (a) the tubular annulus at the point of failure varies somewhat more from being truly circular than does the strut from being truly straight; and (b) there is a small bending moment on the wall of the tubular annulus directly due to the action of the external fluid pressure on an annulus that is slightly out of round, for which there is no counterpart in the equivalent column.

14. Fig. 6 represents the plotted values of the results of the writer's experiments on the collapsing pressures of lap-welded steel tubes. These results are plotted to a horizontal

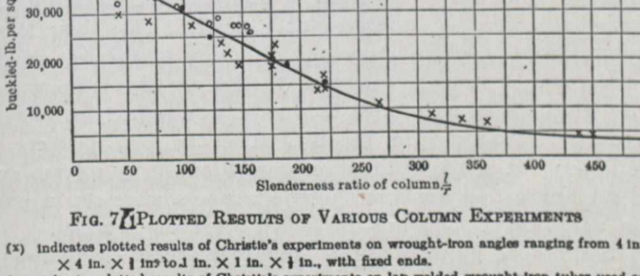

Fig. 7 Plotted Results of Various Column Experiments

(×) indicates plotted results of Christie's experiments on wrought-iron angles ranging from 4 in. × 4 in. × ½ in. to 1 in. × 1 in. × ⅛ in., with fixed ends.
(•) indicates plotted results of Christie's experiments on lap-welded wrought-iron tubes used as columns with fixed (flanged) ends.
(o) indicates plotted results of Watertown Arsenal experiments on lap-welded steel tubes, 5 in. outside diameter, used as columns with fixed ends.

scale representing the equivalent slenderness ratio of the semi-tubular annulus considered as being under the same conditions of stress as a column with ends fixed in direction (Figs. 2, 3 and 4). Since the mean semicircumference of the tube annulus equals $\frac{\pi}{2}(d-t)$ and the radius of gyration of the section equals 0.289t, this slenderness ratio will be

$$\frac{l}{r}=\frac{\frac{\pi}{2}(d-t)}{0.289t}.$$

The vertical scale represents the apparent tangential stress T (Fig. 2), under which the tubular annulus actually failed.

15. Fig. 6 represents the plotted values of the group averages of Series 2 of the author's experiments on the collapsing pressures of lap-welded steel tubes, 3 to 12¾ in. outside diameter. The straight portion of the line represents the writer's column formula [K] plotted to the same scales, while the curved portion similarly represents column formula [L].

16. Fig. 7 represents the plotted values of all results of tests on commercial struts and columns with ends fixed in direction known to the writer. It should be noted here that practically all tests of commercial columns and struts have been conducted under the condition of flat, pin, or round ends.

ENGINE AND MACHINERY FOUNDATIONS.*

By A. E. Dixon.

The first and most important purpose for which foundations are employed is to insure that any settlement which occurs will be uniform; the second is to provide an anchorage. The last purpose may be accomplished in combination with the first, but an anchorage is only necessary where the energy developed in the machine is not absorbed or utilized in a direct-driven machine, as in the case where the power is taken off by or delivered to the machine by belts or ropes. Anchorage is also required by reciprocating machines which are improperly balanced or in which the direction of motion is reversed abruptly, the mass of the foundation serving to absorb and dampen vibration. There are some classes of machines which can be safely set without either foundations or holding-down bolts, as rotary converters and turbo-generators or similar combinations mounted upon rigid bed-plates. The only requirement in these cases is that the supporting structure shall have sufficient rigidity and be capable of meeting the concentrated loadings imposed.

Rock bottom is most desirable where piers supporting heavy machinery are to be put in, but it may introduce complications in getting rid of vibration. Rock has a tendancy to transmit shocks or vibrations to all surrounding structures resting upon the same bed, and where there is any chance of vibration a bed of dry sand from 6 to 12 inches thick must be placed between the rock and the foundation. This sand bed can be made within a pocket excavated in the rock or, where a flat bed exists without natural retaining walls, by building a pocket of concrete to hold the sand in place. Mineral wool and felt cushions have been utilized under light foundations, but they do not possess the lasting qualities of sand.

There are many different grades of rock and the natural bed of the stone may be at any angle between the horizontal and the vertical. The most favorable conditions are those in which the rock has a horizontal bed and does not disintegrate upon exposure to atmospheric influences. Some rock is called "rotten" because it deteriorates and softens upon exposure, while in other cases beds of rock are found which upon their first exposure are soft enough to excavate with a pick and shovel but harden rapidly and must be blasted after exposure. Many other outcrops require blasting, while in

* From Power.