explanation of this evil and it occurred to him that the subsoil of Mexico, under a load, was acting more like a semi-solid or plastic body than like a solid material. After long researches, he found that Rankine had studied this problem in his Manual of Civil Engineering and Applied Mechanics. He also found the entire theory of the resistance of a semi-solid body to pressure in a book called "Théories des Potentiels," by Boussinesq, a French author.

The theory proves that the resistance of a semi-solid body to pressure varies from the perimeter towards the centre as the co-ordinates of an ellipse. The variation of resistance of a plastic body from the edges to the centre of a foundation can also be illustrated graphically. (See Fig. 1.)

We have assumed that the pressure due to a load follows an angle of friction of 45 degrees, but any other angle will give similar results. On the sketch we have taken into consideration four equal loads placed at equal intervals. It is seen that the pressure on the soil decreases from the centre towards the ends because, as we go down the loads merge one into the other, the pressure per unit of surface in the centre in this case and at a given depth being four times the pressure near the ends. When we

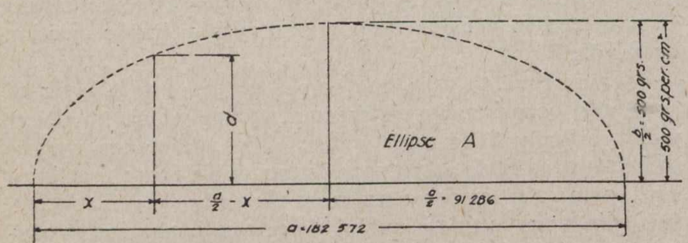

Fig. 2.—Ellipse A.

$a = 182.572$ $\qquad a^2 = 33{,}332.34$

$b = 1{,}000$ $\qquad b^2 = 1{,}000{,}000$

$$\frac{a^2}{b^2} = \frac{x\,(a - x)}{d^2}$$

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deal with good foundation material this effect is not noticed because a material which can resist a certain pressure per unit of surface without deformation will equally resist one-quarter of the same pressure; but, when we deal with semi-solid material or such subsoil as we find in Mexico, we recognize immediately that a pressure of one-quarter of a given load will produce less effect than the entire load will. It has occurred to us that if the concave effect is not oftener noticed in construction on weak subsoil it is because walls well built may act as a beam or perhaps as an arch in certain instances.

In preparing the foundation for the Palace, Senor Montiel first excavated a hole four feet below the street level, thereby removing part of the filling. After that, a cofferdam was built surrounding the entire site, said cofferdam being of reinforced concrete five feet thick and extending 24 feet below the floor of the excavation.

Then Senor Montiel proceeded to consolidate the ground; that is to say, to increase its bearing capacity. To accomplish this he drove sand piles in the bottom of the excavation; or, to express it more correctly, he drove holes eight inches in diameter from 10 to 14 feet deep and 20 inches centre to center and proceeded to fill these holes with sand which again was pressed into the ground, pressed down by the pile; the hole was then again filled with sand which again was pressed down into the ground, the operation being repeated two, three and sometimes four times. One hundred and fifty thousand of these sand piles were driven in or injected into the ground, and to give an idea of the quality of this ground, we will say that the holes were made with a wooden pile driven in by a small pile-driver and the pile went in four to five feet at a single blow. Besides, enough sand was injected into the ground to raise the level of the pit five feet, whereas it was found that it only had been raised about one foot. Underneath heavy walls and heavy column loads, long wooden piles were driven in between the sand piles.

After this, work was finished, a bed of loose broken stone about one foot thick was provided, covering the entire surface within the cofferdam. The loads brought on the foundations by the columns and walls were spread out by means of steel grillages. Under each grillage was placed a bed of concrete 20 inches thick, but these beds were isolated and not continuous though, naturally, sometimes these beds serve more than one column, depending on the necessities of the design.

The consolidation of the subsoil required two years of hard work, and no doubt the bearing capacity of the ground has been increased. Nevertheless, Senor Montiel thought that some sinking would still occur and consequently the structure was started four feet higher than required, to allow for expected settlement.

The assumption that the subsoil would still act as a semi-solid or plastic material was adhered to notwithstanding the consolidation, and consequently the ground was loaded unevenly, the unit pressure decreasing as the co-ordinates of an ellipse from the perimeter towards the centre of gravity of the building.

First it was assumed that the average uniform pressure that the ground could safely carry was 1,000 grams per square centimeter, equivalent to 2,048 pounds per square foot. Then it was decided that the pressure in the central zone, into which fell the entire foundation of the cupola, should be 1,947 pounds per square foot, and that the difference in pressure in adjoining zones should be 25 grams, equivalent to 51 pounds per square foot, so that in the second zone the pressure became 1,997 pounds and in the third zone, 2,048 pounds per square foot, etc.

Ellipse A was then constructed. For its semi-minor diameter we adopted 500 grams per square centimeter (1,024 pounds per square foot), or one-half of the average unit pressure, and for its semi-major diameter we adopted the distance from the centre of gravity of the building to the farthest corner of the cofferdam, or 299.51 feet. See Fig. 2.

It was then found that the dividing point between the first and second zones was at a distance of 93.51 feet from the centre of gravity of the building measured on the line running from the said centre of gravity to the corner of the cofferdam. Likewise the dividing point between the second and third zones is 130.55 feet from the same centre of gravity, etc. For a clearer conception of ellipse A it should be regarded as lying in a vertical plane passing through the centre of gravity of the building and the farthest corner of the cofferdam; the centre C of the ellipse coinciding with the centre of gravity and point D with the corner of the cofferdam. See Fig. 3.

Here the reader may well ask if ellipse A has been constructed in strict accordance with the theory developed and analyzed by Rankine and Boussinesq. The answer is that it has not. The researches of these authors cover cases of uniformly distributed loads, whereas at the Palace we have heavy concentrated loads very unevenly distributed. The selection of the major and minor diameters of ellipse A was arbitrary but served the object in view, *viz.*, to