AN APPARATUS FOR DETERMINING SOIL PRESSURES.*

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FOR many hundreds of years, engineering structures have been built whose safety to a large extent has been dependent on the physical behavior of the adjoining or the underlying soil, and although these centuries have elapsed with their records of disastrous failures, our ideas of the laws governing the action of soils and the pressures which they exert are still indefinite, and are based mainly on mathematical theory rather than on adequate experimental data. Certainly the present vagueness of our knowledge is not due to any lack of effort, for many attempts at an experimental solution are recorded in engineering literature. The very fact that there are now no satisfactory laws concerning earth pressures evidences the inadequacy of the existing data for the formulation of such laws, and is suggestive of the difficulty and elusiveness of the problem.

Measurements of the pressure of earth against or under a wall or other structure are rendered difficult, because the location at which the measurement should be made is almost impossible of access without disturbing the soil, and such measurements have not been accomplished because no apparatus seems to have been designed for this use, whose action does not have some influence on the very pressure it was constructed to measure.

Then, too, the many variations in the condition and character of fills make the problem very complicated. It has been the aim of the authors to develop an apparatus that will be applicable to the measurement of earth pressures against structures, as well as for use in the laboratory for the study of the laws of pressure distribution through particular kinds of materials, under different conditions of compaction, moisture content, load application, etc.

Soils are made up of granular particles of various sizes, together with very finely divided material, generally containing moisture. The action of pressures is to cause motion of some of these particles with respect to others, and the manner of transmission of pressures is influenced by the mobility of the mass or the ease with which the particles move with respect to one another. It is evident that several factors must control this movement, such as cohesion and friction, and these factors are in turn governed by the physical characteristics of the soil, such as the grading, moisture content, kind of fine material, degree of compaction, etc. It is probable that all of these characteristics should be known so as to make any experimental data obtained applicable to similar cases in the future. In view of the fact that friction and cohesion between the particles exist, it is evident that an apparatus employed for the measurement of soil pressures should be so constructed that no movement of its parts will take place against or away from the soil during the measuring process. If the measurement requires a movement against the soil, a higher pressure than actually exists will be indicated. On the other hand, should a movement away from the soil be necessary, an indication lower than the true pressure will be obtained. The authors have, therefore attempted to develop an apparatus which will measure the pressure of an earth fill with practically no disturbance of its natural condition, and in considering such an apparatus it was deemed advisable to develop the idea of a portable cell of small size, capable of indicating at some remote station the value of any pressure coming upon it.

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Description of Apparatus.—After a great deal of experimenting, a diaphragm cell has been developed as shown in Fig. 1. A cast-iron base *g* is fitted with a brass diaphragm *j*, held in place by the annular ring *c*. On each side of this diaphragm are disks, *a* and *b*, securely and rigidly held together by means of Bakelite cement and machine screws, as shown. These plates have an annular clearance from the ring *c* of 0.03 in., thus allowing only a small annular portion of the diaphragm *j* to be the flexible element. The diaphragm *h* serves the double purpose of protection and of stiffening the plates *a* and *b* against side motion and eccentric loads. In the base *g* is placed a slightly crowned contact support *f*, held in place

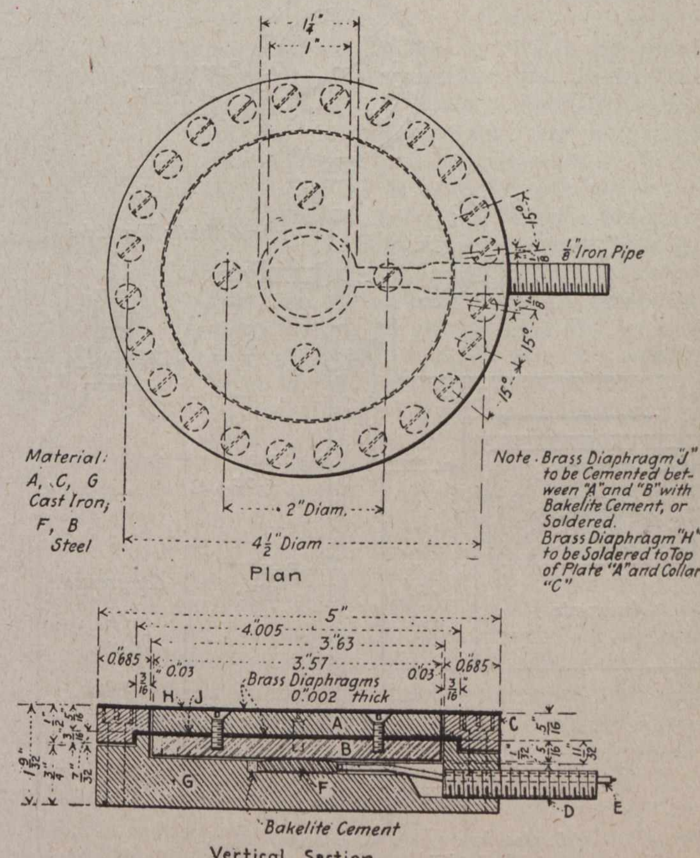

Fig. 1.—Diaphragm Cell for Determining Soil Pressure.

and electrically insulated from the base by Bakelite cement. An insulated bell wire *e* is soldered to the support *f*, and passes to the outside connections through the ⅛-in. pipe *d*.

In the use of this apparatus the cell is buried in the soil to the required depth, and, by means of the ⅛-in. pipe and the bell wire, is connected to the remote control and indicating instruments as shown diagrammatically in Fig. 2. Air pressure is slowly admitted from a compressed-air supply until the air pressure within the cell equilibrates the external pressure on the disk *a* (Fig. 1), and causes the contact between disk *b* and support *f* to be broken, as indicated by an ammeter or a telephone receiver.

In the development of this cell an attempt was made to reduce the movement of the disks and diaphragm to the very smallest possible value, for as previously mentioned, any movement of the disks against the soil fill introduces stress conditions which will no doubt vitiate the results. It was found that a movement of 0.001 in. or