ducting a systematic series of tests, calculations, and investigations, to ascertain all possible information on this subject and in order to confirm the tests and deductions therefrom, and will illustrate some of the weaknesses that have developed in different forms of construction. He will also endeavor to show the cause for certain failures, and describe the problems to be met in the safe and economical design of grain bins, and will in connection therewith, illustrate and describe a number of designs of grain bin constructions.

Before proceeding to describe these tests, the author will briefly outline such different tests, calculations and discussions on this subject as it has been possible to obtain from any hitherto published records. In Great Britain in the year 1882, Isaac Roberts made a series of tests on both model and full-sized bins, which demonstrated that in a grain bin having a depth equal to 4½ times the diameter, the proportion of the grain weight resting on the bin bottom was very small, as also the lateral pressure. Mr. Roberts read a paper describing his tests before "The British Association for the Advancement of Science." The author, however, regrets that he has been unable to obtain a full copy of this paper. In 1895, H. A. Janssen, C.E., Bremen, Germany, made a number of experiments on small rectangular bins with a view to obtaining the proportion of weight of the grain contained in a bin that would rest on the bottom, and that would be carried by the bin walls. His bins were all of approximately the same depth but of varying horizontal areas. Briefly, his system of tests consisted in supporting bin walls on four jackscrews while in the bottom of the bin was placed a loosely-fitting board resting on a platform scale. By filling the bin with grain the proportion of weight resting on the bottom was recorded on the scale. When the weight previously placed on the beam balanced the weight of grain resting on the bottom, a record was taken of both the weight of grain in the bin and the proportion of said weight that was resting on the bottom. The bin was then slightly raised by means of the jackscrews, and owing to the friction of the grain on the bin sides this also relieved part of the bottom pressure and allowed the beam to drop; added weights were then placed on the beam and the filling of the bin proceeded with, the same procedure being followed until the bin was filled. Janssen's tests were thus carried out in four different sizes of bins, but were to obtain the bottom pressure only, as he found that having obtained the bottom pressures, it was quite simple to calculate the lateral pressure. By conducting a series of tests to obtain the co-efficient of friction between grain and the bin wall materials, he was enabled with the information thus gained to calculate pressures in different sized bins. His experiments seem to have been very carefully and scientifically carried out, and his apparatus well adapted for the purpose. The results which he obtained are almost identically the same as those obtained by the author.

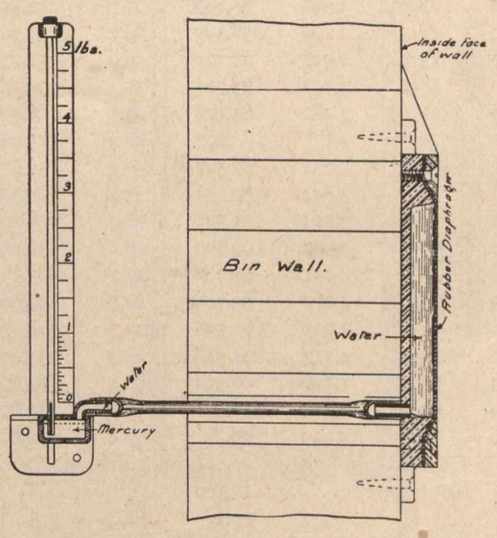
[The author then relates the investigation of Prante, at Bernberg, and of Airy in England, the latter being upon theory only.]

In 1897 the failure of a coal bin in Paterson, N.J., started a discussion in "Engineering News" on the pressures produced by coal and other granular materials stored in shallow bins. This discussion was started by the Editor, and a number of engineers contributed more or less valuable letters on the subject, but no records of actual tests were given, and since the discussion was confined almost entirely to shallow bins there is very little of it applicable to the deep bin problem.

About two years ago, or at the time of the controversy regarding the Montreal Harbor Commissioners' elevator, Dr. H. T. Bovey, C.E., Dean of Applied Science, McGill University, and John Kennedy, C.E., Chief Engineer, Montreal Harbor Commissioners, made a series of tests in the bins of the Canadian Pacific elevator, Montreal, and the Great Northern, Quebec.

At the beginning of the year 1900, it became apparent that wooden elevator construction must soon be replaced by buildings less liable to destruction by fire, and since this would involve entirely different materials of construction, the author realized that more accurate data was required to permit of intelligent and economical design of new construction. He therefore determined to conduct a series of tests with a view to gaining such information. There being no known appliance for making tests, the first and most difficult problem to be met was the design of the testing appliance to make the tests in a full-sized bin which would meet all requirements as to accuracy, decrease as well as increase of pressure due to the movement of the grain, and would record the pressures in different parts of a bin under all working conditions. Several styles of weight scale-levers and beams were first designed, all of which were open to serious objection and the difficulty seemed unsurmountable until the author conceived the idea of using a hydraulic diaphragm and a mercury or water column gauge, the first of which could be placed inside the bin at any given point either on the sides or bottom, with a tube leading through a small hole in the wall to the gauge, and therefore ascertain the pressure per square inch either vertically or laterally at any point of the bin. This appliance was immediately designed, care being taken to get the pressure face of the diaphragm, which was made of pure sheet rubber as large as practical, so that there would be no receding of the face by displacement of the water, owing to the pressure raising the mercury in the small gauge glass. When this appliance was manufactured and tested, it was found to be an accurate and sensitive weighing machine, and it is believed that no more suitable or accurate testing gauge can be found for the purpose. (See illustration.)

On the 10th of April, 1900, and following days the tests were carried out in the full-sized bins of the Canadian Pacific Elevator, at West St. John, N.B., tne inside dimensions of the bin being 12-ft. by 13-ft. and depth above the hopper bottom 67-ft. 6-in.; the grain being used was Manitoba wheat, weighing 49.4 pounds per cubic foot. The hopper bottom of the bin was first filled with grain and levelled off. To obtain the lateral pressure the diaphragms were then placed in position against the walls a short distance above the hopper bottom, with the face vertical, and on top of a small platform attached to the hopper bottom with face horizontal, to obtain the vertical pressure. The gauges were set up in an adjoining bin, a small rubber tube forming the



Grain Pressure Tests—Hydraulic Pressure Diaphragm and Mercury Pressure Gauge.

connection between the diaphragm and the mercury cup of the gauge, the diaphragm and tube being completely filled with water. The grain was then weighed and run into the bin in the usual manner, the first draft having a clear drop of 70 ft. Each draft weighed 30,000 pounds and gave a depth of 3-ft. 9-in. in the bin. The gauge was closely observed as the grain was running in, and the maximum readings taken and recorded as each draft was complete, until the bin was filled. The gauges and the grain were then allowed to remain for about eighteen hours, at the expiration of which time there was practically no change in the reading of the gauge. The grain was then drawn out of the bin and the gauge closely observed and the readings recorded as each 30,000 pounds were weighed out, the maximum readings dur-