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The Application of a Special Type of a Volumenometer to the Determination of the True Clay Volumes of Briquettes

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THE APPLICATION OF A SPECIAL TYPE OF A VOLUMENOMETER TO THE DETERMINATION OF THE TRUE CLAY VOLUMES OF BRIQUETTES

BY

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THESIS

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THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

Kenneth Edward Rockhold

ENTITLED The Application of a Special Type of a Volumenometer to the Determination of the True Clay Volumes of Briquettes

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

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The Application of a Special Type of a Volumenometer to the Determination of the True Clay Volumes of Briquettes.

Specific gravities of clays may be determined by one of three methods: By the Seger volumeter, using unburned specimens; by the pycnometer and by the chemical balance, using unburned specimens. All three of these methods determine merely the true clay volume of the brick and the specific gravity is expressed by the formula $\frac{w}{v}$; where w = wt. of clay and v= volume. The use of the Seger volumeter and the chemical balance requires that the brick be saturated with oil, if unburned bricks are used, and water if burned bricks are used.

"It will be noted by comparing the specific gravities in the tables, that those obtained by the volumeter are lower than those obtained by the pycnometer. This can be accounted for perhaps by the operators inability to completely saturate a brick, that is , to fill all the pore spaces with the oil or the water without resorting to the use of a vacuum pump to remove the air from the pores so that the oil or the water could enter. If the air is not entirely exhausted it will pass thru the oil or the water very slowly, requiring a period extending over several weeks in which to escape. In ordinary laboratory practise sufficient time can not be given to permit the complete escape of the included air. In the porosity and specific gravity tests here reported, no attempt was made to fill the pores completely. The bricks were simply soaked in coal oil for 48 hours, with one face exposed at the level surface of the oil. This incompleteness of saturation under these conditions is shown by the difference in specific gravity as determined by the volumeter and the pycnometer. Moreover the variation obtained by use of the volumeter is greater showing greater inaccuracy." 1

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1. Illinois State Geological Survey, Bulletin #9.

-Specific Gravity-

Clay	Seger Volumeter	Pycnometer
Alton, Ill.	2.54	2.665
Galesburg, Ill.	2.63	2.663
Streator, Ill.	2.62	2.716
Coffeyville, Kans.	2.51	2.706

The volume as obtained by use of the chemical balance is expressed by the formula, Clay Vol. = $\frac{D - S}{g}$ in which D is the dry weight, and S is the weight of the saturated brick in oil (or water if the clay is burned), and g is the specific gravity of H_2O at that temperature. Here again the difficulty in saturating the brick completely is met.

"Determination by Pycnometer:- A pycnometer or specific gravity bottle, as it is called, is a small flask of known capacity, usually 25 to 100 cc. When filled up to a given mark with air free water at normal room temperature its weight is noted. The flask is then partly emptied, a known weight of clay is added and the whole carefully boiled to exclude all the entrapped air, then cooled, filled up to the mark and weighed. By the formula, weight of dry sample (a) plus weight of bottle filled with cold air-free water (b) minus weight of bottle filled with sample and water (c), or a+b-c, will give the weight of water having the same volume as the sample or true total volume of the clay particles. Knowing the dry weight and true volume of the grains, their composite specific gravity is readily calculated by the formula (dry weight ÷ volume)." [2]

The true volume is $\frac{a+b-c}{g}$ where g is specific gravity of water at the temperature it was used.

2. Ill. State Geol. Survey, Bull. #9.

The pycnometer method, although the most accurate is rather tedious and is seldom used on testing clays especially after they have been burned since the brick must be ground to a powder.

The method of saturating a briquette with either oil or water is to place it in a filter bottle with the liquid and then reduce the pressure by means of an aspirator. Since it requires considerable time (usually about 24 hours) to saturate a briquette completely in vacuo, it was thought that the application of a volumenometer would eliminate this operation and save considerable time.

Ganot[3] describes a very simple volumenometer in his physics but as it is shown there it would be impractical and very inaccurate. Lo Surdo[4] describes a volumenometer which is claimed to be accurate to $\frac{1}{4000}$.

"Fig. 1 shows a diagram of an apparatus designed by Lo Surdo. It consists of two cups A and E communicating with two vessels A' and E', of about equal volumes to A and E respectively, these being connected thru the taps R, S and N to the mercury reservoir M. A U-tube, which acts as a manometer is also inserted between A and E, and the connecting tubes between the vessels are marked at P, Q, P' and Q'. Then if, vol. A = vol. A' = V and vol. E = vol.E' = V' and A' and E' are initially filled with mercury up to P and Q, the air being under atmospheric pressure H, and the level of the liquid in the manometer being equal at KK', on lowering M until the mercury falls to P', Q', the pressure on the air in the vessels will be reduced to H/2 .

Returning to the initial condition and introducing into A a body of a volume X, the volume of air in A will be V-X, and on lowering M until the mercury reaches Q', still keeping the manometer liquid at KK', a quantity of mercury will remain in A' above the mark P' equal in volume to that of the body introduced into A, which may be either measured by having the tube above P' graduated, or, more accurately, weighed. Any slight differences in volume between A, A' and E, E', may be readily ascertained by carrying out a preliminary experiment with a body of known volume in A, and these can then be eliminated by introducing bodies of the required volumes to
(continued on next page)

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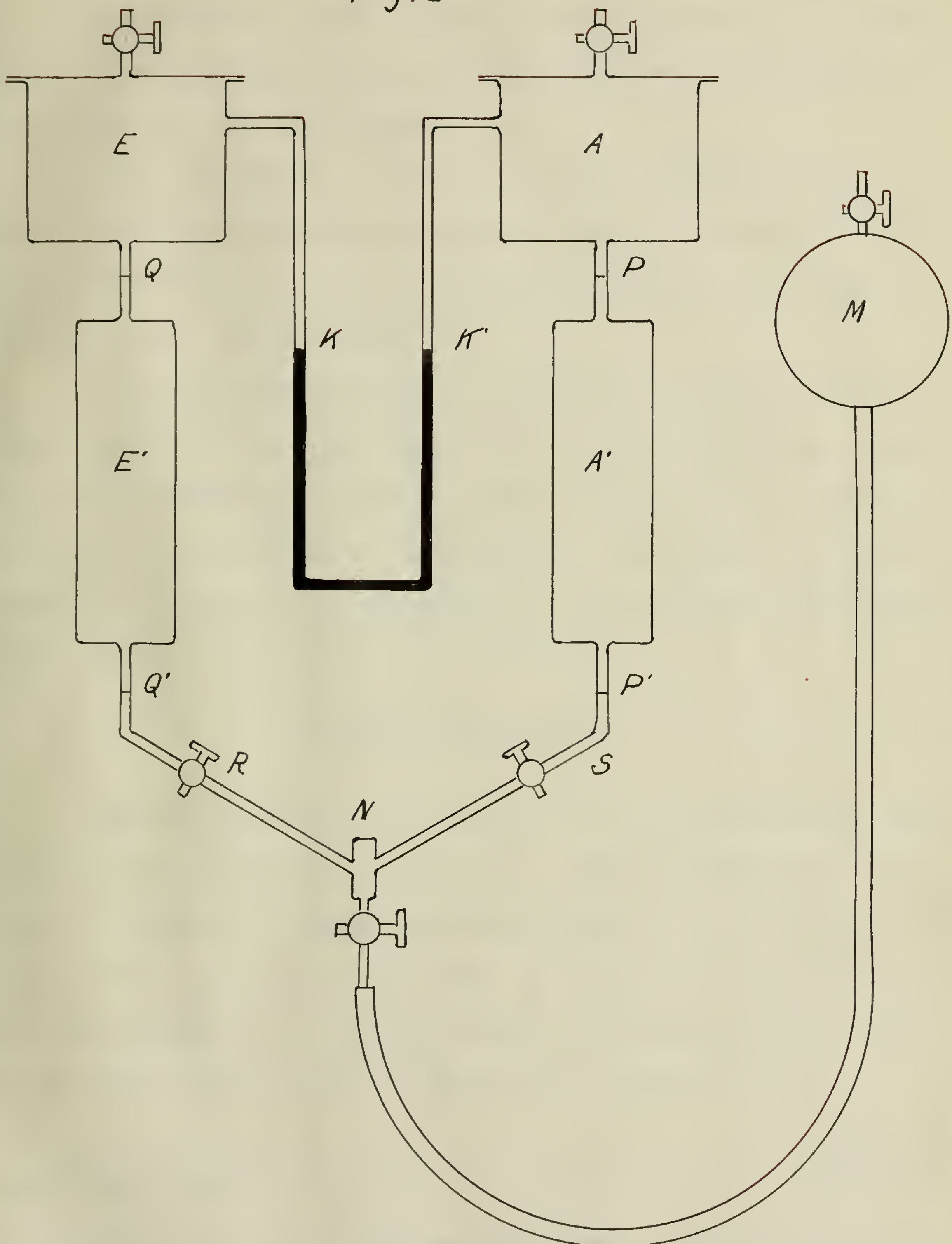
3. Ganot's Physic; Seventeenth Edition, 1906.

Fig. 1



The apparatus used to test the application of a volumenometer to the determination of clay volumes was of a somewhat more simple design but not so accurate.

Fig. 2 shows its construction. It consists of the specially constructed glass part shown in Fig. 3 connected to a long glass tube which in turn is connected to the levelling bulb and the measuring tube as shown.

The glass stopper must be ground so as to fit into the container air tight when moistened with a little vaseline. (The excess vaseline should be removed.) The function of the stopcock in the stopper is to relieve any pressure which might be caused by crowding the stopper in. The fluid used to create the difference in pressure is mercury.

-Method of Operation-

The manipulation is done first with the apparatus empty. The stopper is put tightly in place and with the stopcock open the mercury is made to stand at A by raising the levelling bulb. The stopcock is then closed and the levelling bulb lowered until the mercury stands at B. The difference in heights of the two mercury columns is then read. Denote this reading by h_1.

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Continued from page 3.

render A = A' and E = E'. With an apparatus in which V = 55 cm^3. it is possible to determine volume up to about 45 cm^3. with an approximation of $\frac{1}{1000}$."

4. From "Science Abstracts, Vol. 10, Sec. A, No. 2 (1907)" Nuovo Cimento, Vol. 12

Fig. 2.

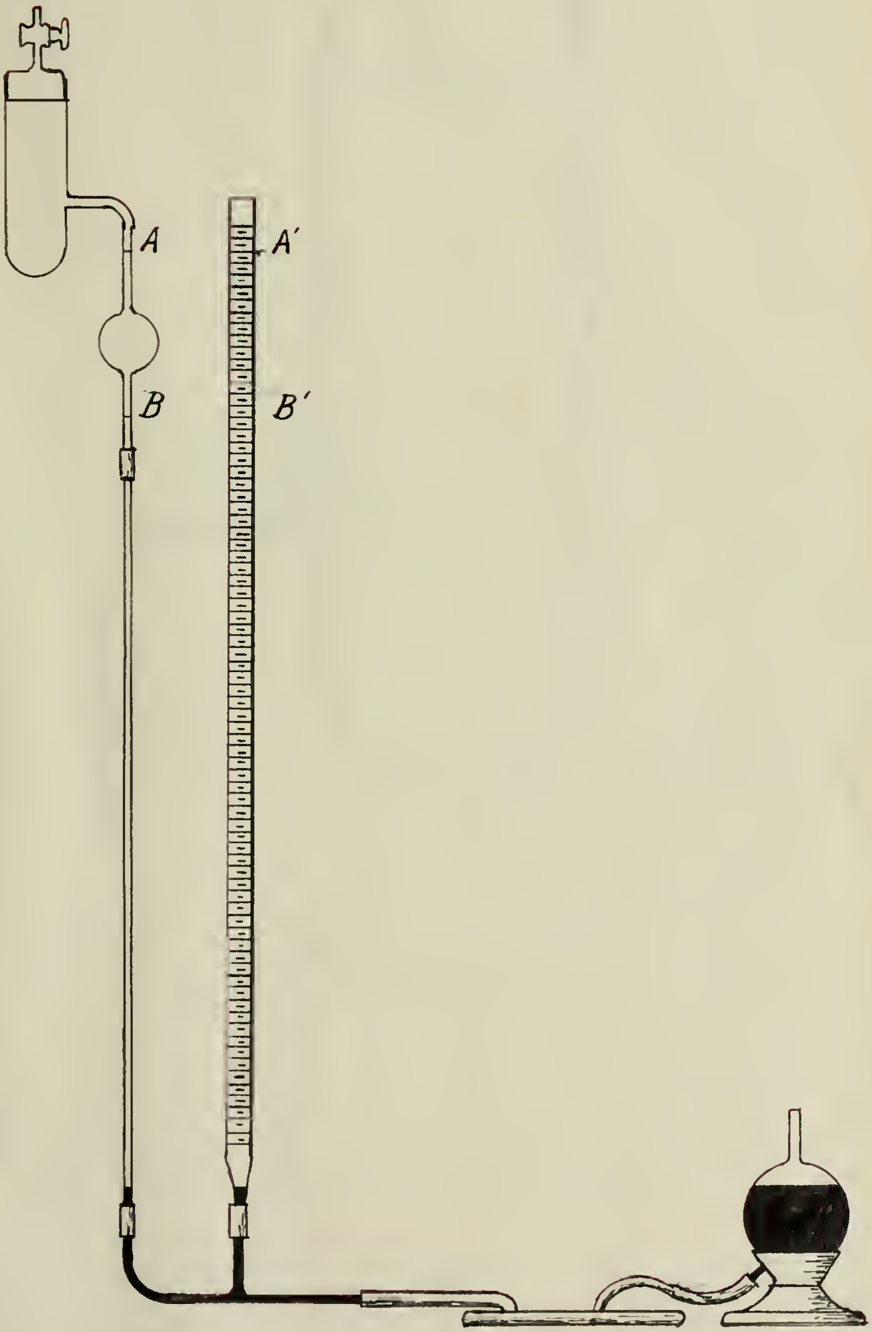
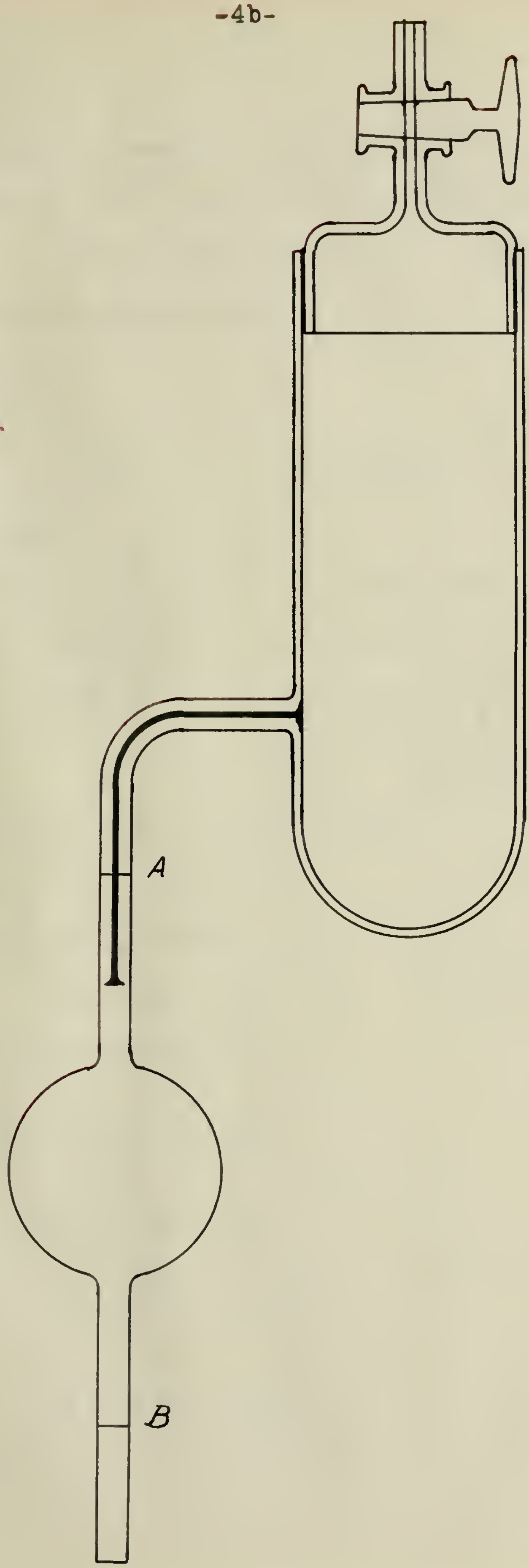


Fig. 3.



Then with an unknown volume X in the container the operation is repeated and the difference in heights of the two mercury columns is found. This difference is denoted by h_2.

By applying Boyles Law, a formula can be deduced giving the unknown volume x.

$$P_1V_1 = P_2V_2$$

P= pressure
V= Volume

With container empty

$$B(V-v) = (B-h_1)V$$

$$\cancel{BV} - Bv = \cancel{BV} - Vh_1$$

$$(1) \qquad B = \frac{V}{v} h_1$$

B= Barometric Pressure
V= volume of container down to mark B
v= volume of container between A & B.
h_1=difference in levels of mercury

With container containing an unknown vol. X.

$$B(V-v-x) = (B-h_2)(V-x)$$

$$\cancel{BV} - Bv - \cancel{Bx} = \cancel{BV} - \cancel{Bx} - Vh_2 + h_2x$$

$$Bv = Vh_2 - h_2x$$

x = vol. of piece to be determined
h_2= difference in levels of mercury

Substituting B from equation (1)

$$v\frac{V}{v} h_1 = Vh_2 - h_2x$$

$$h_2x = Vh_2 - Vh_1$$

$$x = \frac{Vh_2}{h_2} - V\frac{h_1}{h_2}$$

$$x = V\left(1 - \frac{h'}{h_2}\right)$$

V is a constant and was determined by weighing the amount of water required to fill that part of the apparatus.

h_1 will vary with the barometric pressure and it is necessary only to determine once on any given series of determinations which may be completed on the same day.

A series of determinations were made on briquettes burned to different porosities and on solid glass rods. These determinations were checked by finding the loss in weight when the briquette was saturated and weighed while suspended in water.

Trial Piece		Volumeter	Chemical Balance	Difference	Percent Variation
Glass rods	(1)	39.63 cc.	39.78cc.	0.15 cc.	0.38%
	(2)	38.80 "	39.78 "	0.98 "	2.46%
Briquettes					
Cone	010	24.69 "	25.36 "	0.67 "	2.52%
Cone	08	25.25 "	25.76 "	0.51 "	1.98%
Cone	06	28.66 "	29.39 "	0.73 "	2.48%

The accuracy of the instrument seems to be within 2.5%. This is, of course, too high, but by making the volume of expansion that is the volume between A B (Fig. 2) equal to the volume of the container the accuracy would be increased to .12%. This can be proven by the following example.

The measuring tube measures the pressure to within 1 mm. Therefore, assume that the pressures in two different determinations of the same object showed a difference of one millimeter.

h_1 is assumed to be 1/2 barometric pressure or 35.0 cm.

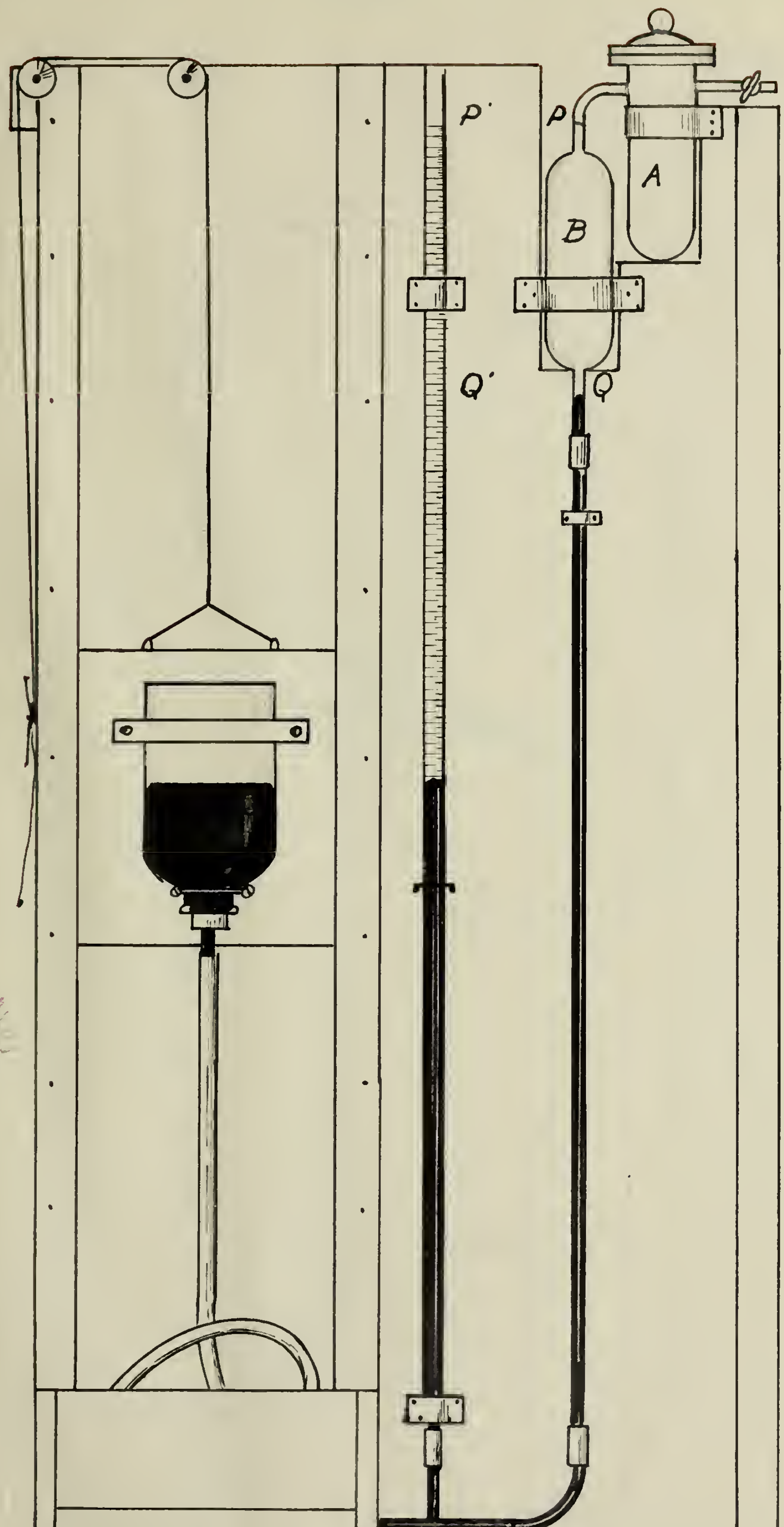
	h_1	h_2	x
1st case	35.0 cm.	75.0 cm.	48.95 cc.
2nd case	35.0 cm.	75.1 cm.	49.01 cc.
			.06 cc.

This shows an accuracy of .12%.

All of the determinations made by the volumenometer are lower than those obtained by saturating the briquette. This shows that the air in the pore spaces must expand in the same manner as the surrounding air. The volumenometer, then, can be used in finding the true clay volumes of briquettes. In a more accurate form it would be substituted for the pycnometer in determining specific gravities.

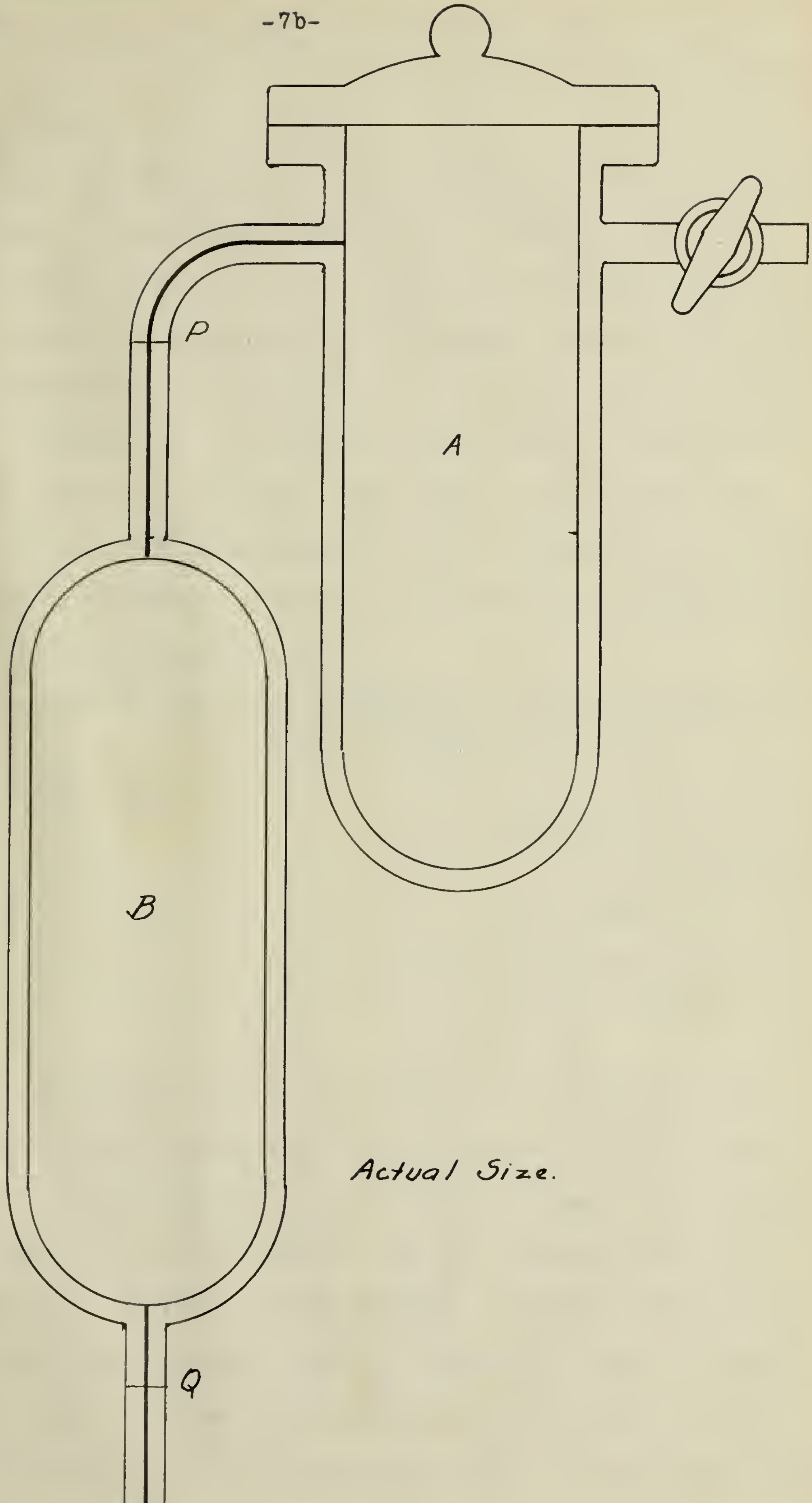
Fig. 4 is a design of an apparatus especially applicable to the determination of the clay volumes of trial bricks which are about 3½ inches long and have a diagonal dimension less than 1½ inches. The apparatus consists of two cups A and B of about the same size connected by the capillary tube as shown in Fig. 5. The cup A has a cover like those used on dessicators and is made so as to fit air tight when moistened with a little vaseline. (The excess vaseline must be removed). The stopcock is to relieve the air pressure in the cups without removing the cover. These cups are connected to the measuring tube and the mercury reservoir as shown in Fig. 4. The mercury reservoir is raised by a cord attached to the board on which the reservoir is fastened. This board slides in grooves and the cord passes over two pulleys at the top and can be

Fig. 4.



One Fourth Actual Size.

Fig. 5.



Actual Size.

fastened on the side.

To make a determination: The manipulation is done first with the cup empty. The mercury reservoir is raised until the level of the mercury stands at P, and P' under atmospheric pressure. The cover is then put on cup A and the stopcock closed. The reservoir is then lowered until the mercury in the cup stands at Q and the distance, h_1, which is the distance the mercury in the leveling tube stands below Q' is noted. The point Q' is at the same level as Q on the cup. The operation is then repeated with a brick in the cup A and the height h_2 below Q' is found to be the pressure required to lower the mercury to Q.

The volume of the brick then can be calculated from the formula:

$$x = V\left(1 - \frac{h_1}{h_2}\right)$$

in which x = unknown volume

V = Vol. of reservoir down to mark Q.

h_1 = height of mercury with cup A empty

h_2 = height of mercury with unknown volume x in the cup.

V is a constant and may be determined by weighing the water recuired to fill that part of the apparatus or may be calculated from the formula when a solid of known volume is in cup A.

The advantages this design over the apparatus used in the experiments are: First, the dessicator cover eliminates any change in volume of cup A which might be caused by such a stopper shown in Fig. 3. The stopper shown in Fig. 3 is liable to crowd down more or less each time it is put into place. Second, by mak-

ing the cups A and B equal in volume the readings of h_1 and h_2 were increased so that greater accuracy could be obtained. Third, the method of raising and lowering the mercury reservoir is such that the height of the column can be more easily adjusted and the apparatus is more permanent.