one of these pipes could be closed at the top by suitable cut-out cocks. The gauge pipe was connected with a test gauge to show the pressure of the air entering the well. The water is always blown out of this pipe when starting the pumping operation. Another test gauge was placed in the air line to the well, so that pressures at top and bottom of air inlet pipe were noted.

The discharge pipe passed up through the roof of the cabin to the point of discharge. At this point the air and water lifted passed into an air separator, the air passing upward to the atmosphere, and the water falling by gravity into one of the two weighing tanks. Just under the roof of the cabin was a large three-way cock, by means of which the water was directed into either one of the tanks and weighed by means of the platform scales upon which they rested.

and the air required per gallon was slightly less than with the continuous flow, but the water delivered was considerably less. On the other hand, if the air pressure was gradually increased above that just required to give a steady flow, the quantity of water delivered would increase somewhat, but the air per gallon increases in a greater proportion, and, as the air pressure is further increased, the gain in the quantity of water delivered grows less until, at a certain point, it stops and from then on the water delivered **decreases** in amount.

It is very easy to regulate the air supply by the sound of the discharge. The point at which the flow becomes steady is quickly recognized.

Selection of Proper Ratios.

From the results obtained it would appear that for a given lift the further down in the well the submergence is

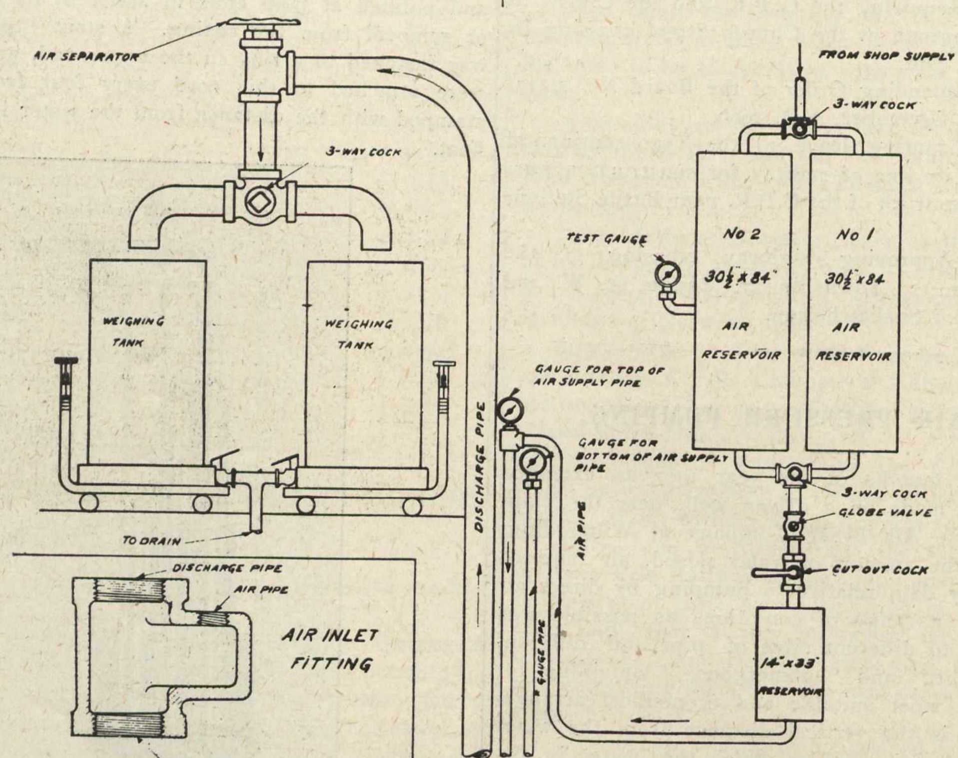

Diagram of Pipe.

The Tests.

Nearly eighteen hundred tests were made, covering from 350 to 400 different combinations of discharge pipe lift and submergence. From the figures obtained in these tests curves were plotted, showing the variation of cubic feet of air used per gallon of water raised and the gallons of water delivered per minute for the different ratios of lift to submergence. From these curves it was found that the cubic feet of air used per gallon of water raised and the gallons of water delivered per minute are practically the same for each ratio of lift to submergence for any submergence of a given size of discharge pipe. For example, a lift of 10 feet and a submergence of 20 feet will take the same amount of air per gallon, or lift the same number of gallons per minute, as a lift of 100 feet and a submergence of 200 feet, the size of discharge pipe being the same. In both these cases the ratio is identical, while the submergence in the latter is ten times as great as that in the former. Consequently, it is only necessary to consider the **ratio** of lift to submergence and the size of discharge pipe.

It was also found that, for a given size of discharge pipe, the gallons of water raised per minute decrease as the ratio of lift to submergence increases; also, the cubic feet of free air per gallon of water raised increase as the ratio increases for a given size of discharge pipe, and for a given ratio it decreases as the size of discharge pipe increases.

Air Pressure.

As regards the air pressure required, it was found that the smallest pressure possible that would give a continuous flow from the well was the proper pressure to use. It was found that, if the air pressure was choked down slightly below this point, the water would come out intermittently in spurts,

made the more economical the result would be. This is true as far as the well is concerned, but it must be considered that the greater the depth of the air inlet the greater the air pressure must be, and consequently the more horse-power must be employed to compress the air. The quantity of air required to operate the well decreases as the depth is greater, while the horse-power required to compress a cubic foot of air increases with the depth. A curve representing the horse-power per gallon of water raised for varying depths and constant lift will at first decrease as the depth increases until it reaches a minimum point, after which it increases. This point represents the most economical ratio for the given lift. To learn where this point would be some tables and curves were made, which gave the horse-power per gallon of water raised for the different lifts and different sizes of pipe, with various ratios of lift and submergence, from which it appears that the most economical ratios for a given discharge pipe decrease as the lift increases, and for a given lift they increase as the discharge pipe increases.

Tail Piece.

Concerning the use of a "tail" piece in the discharge pipe below the air inlet, it was found that this piece is essential when starting the pumping operation, as it tends to prevent the air from backing down into the well and rising in the casing outside of the discharge pipe.

Air Inlet.

The fitting used for entering the air into the discharge pipe was particularly well adapted to the purpose, because it offered no impediment to the free passage of the water. The results obtained indicate beyond doubt that anything