expression for the velocity of flow in the pipe due to the leak is:

$$w = \frac{\frac{P - P_1}{h}}{\left\{\frac{P + P_1}{2p} - 1\right\}^{0.5} - 1}$$

P is the amount that the pressure is increased due to water hammer, P_1 is the amount that the pressure at the valve is above the original pressure after the return wave from the leak reaches the valve; p is the original pressure at the valve; h is the water hammer coefficient.

The following values are taken from experiments made by the writer in 1906. The last two were measured from the second diagram shown in Fig. 4.

Calculated Distance. Feet.	Actual Distance. Feet.
64	72
70	72
371	381
385	381
375	381
262	265
265	265
116	113

A number of values have been computed from the equation, and the results have been plotted in Fig. 3. It was assumed that $P = 55$ lb. per sq. in., $p = 40$ lb. per

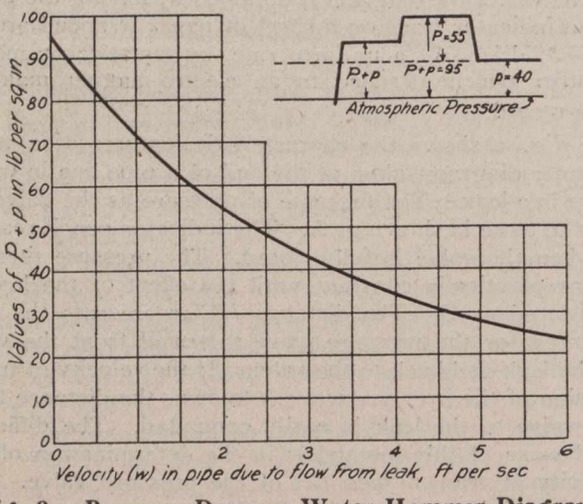

Fig. 3.—Pressure Drop on Water Hammer Diagram Due to Leaks of Various Amounts.

sq. in., and that $h = 55$. It will be seen from an examination of the curve that even small leaks will produce a noticeable fall of pressure on the water hammer diagram.

The first suggestion that the water hammer diagram could be used to determine the location of a leak was made by Professor Joukovsky as the result of a series of experiments made in 1897 and 1898 for the waterworks department of Moscow, Russia. He published a monograph (Stoss in Wasserleitungsrohren) in 1900. A translation of this paper, somewhat modified, was published in the Proceedings of the American Waterworks Association in 1904. Experiments were made by the writer in 1906 on a 2-inch pipe 730 feet long in the Hydraulic Laboratory of the University of Illinois. Fig. 4 shows two diagrams taken at that time.

In using this method for determining the location of a leak, the following suggestions are made. The quick-closing valve should be at the end of the section of pipe to be tested. This can be accomplished by tapping the main close to a valve, the valve in the main being kept closed during the experiments. The pipe leading from the main to the quick-closing valve must be large enough that a water hammer pressure at least as great as the static pressure can be caused by the sudden closure of the valve. The indicator should also be connected at this point of the main, or to the pipe containing the quick-closing valve. If possible, the method of proportional distances should be used. The distance to the source

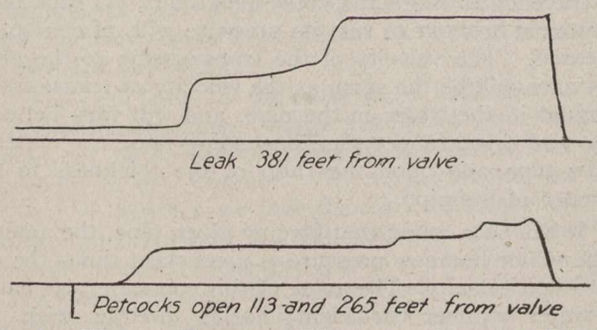

Fig. 4.—Water Hammer Diagram, Showing Effect of Leaks, Taken on a 2-in. Pipe Line, 730 Feet Long.

(large main) should be measured. A hydrant partly open will make a good reference point in case the main on which the experiments are being made is very long. When the method of proportional distances is used it is not necessary to know the speed of the paper. It is only necessary that the paper travel at a uniform speed while the diagram is being taken.

An apparatus called the "pulsograph," using the above principles for locating leaks, has been patented. It was described before the meeting of the New England Waterworks Association in September, 1913.

CONCRETE MATERIALS.

By R. O. Wynne-Roberts, Regina.

THOSE who have frequent occasion to prepare the estimated cost of concrete structures find it useful to have data as to the quantities of materials that are required to make one cubic yard of concrete of different proportions. There are tables given by various authors which are convenient for office use, but volumes are seldom carried about and consequently calculations, even approximate, are usually deferred until the engineer returns to his office. The author has experienced a need for a diagram which will afford the information as to the quantities of cement, sand and stone necessary per cubic yard of concrete in place and set to build one. The accompanying diagram is believed to be very simple and easily understood, and is applicable for concretes whose proportions range from 1:1:1½ to 1:3:8, which will doubtless suffice for practically all classes of work. The curves are derived mostly from tables in Taylor and Thompson's book on concrete and therefore no claim is made for originality of data, but the diagram is original. It is hoped it will be found useful by readers of *The Canadian Engineer*. In the top left-hand corner is given the volume of cement mortar produced by mixing various proportions of cement and sand. When any proportions of