CAUSES OF BREAKS IN WATER MAINS.

THE annual report of the City of Chicago for 1913 contains the results of an investigation made by Mr. Claude E. Fitch, assistant mechanical engineer, into the causes of breaks in the city's water mains. Many breaks have occurred during past years, but no attempt had been made, until 1912, to discover the cause. Mr. Fitch's findings are very interesting, and are abstracted below. The causes of breaks were ascribed to improper design, poor material, improper handling and installation, soil movements, jarring from traffic, frost, temperature changes, electrolysis, corrosion, excessive static pressure, excessive momentary pressure, periodic pressure waves and extraordinary causes. Explanations of these causes are given as follows:

Improper Design.—For the design of pipe there are numerous formulas giving very nearly the same results, as much the result of experience as theory, and generally considered satisfactory. For the design of valves and special fittings, theory and practice are not so far advanced, but there is not much danger of breaking and such as there may be is more likely to occur at the time the first test is made.

Poor Material.—All reputable builders and nearly all large users employ inspectors who may be reasonably depended on as conscientious in their work. Measurement, superficial inspection, pressure test, hammer test and the breaking of a test bar are the methods usually employed. Chemical tests have their value, but are not so universally used.

Improper Handling and Installation.—A pipe otherwise good may be badly damaged by mishandling in transit or in laying, and thus weakened so as to be unserviceable; or it may be improperly caulked.

Subsidence or Rise of Soil.—Assuming that the pipe has been properly laid, then the soil might be disturbed in one of several ways. Parallel trenches, heavy buildings nearby or the construction of tunnels and subways may so displace soil as to cause leaks or breaks.

Jarring from Traffic.—Where pipes pass through railroad embankments or under street railways or in streets subject to heavy traffic, there is not only displacement of soil from the weights above, but also jars are transmitted to the pipe. Where the displacement is considerable, the danger to the pipes is the same as described in the previous paragraph. The jarring may break a brittle pipe, but the more probable trouble is at the caulking, where the lead is continually deformed by the slight motion, until no longer tight. The resulting leakage causes softening of the soil, making further displacement probable.

Frost.—Under ordinary conditions, this is little to be feared in large mains, as the depth to which the ground freezes in severe winters has been determined by observations extending over many years. Further, the water is scarcely ever below 39 degrees F. in temperature, and if flowing will ordinarily not freeze solid. Troubles from frost are ordinarily confined to smaller mains and service pipes.

Temperature Changes.—The range of temperature of water in mains is not very great, probably 25 degrees, but this is enough to cause a measurable amount of expansion. Expansion or contraction of metals is exerted with great force; almost invariably enough to cause endwise motion of the pipe against the friction of the surrounding soil. This motion is undoubtedly taken up in the more loosely caulked joints, causing them to become more loose and to leak a little. This ability to move slightly at the joints is the reason for the use of the bell and spigot joints, rather than bolted joints.

A more serious phase of this condition may occur at a tightly caulked joint where the cast iron of the bell is first severely strained by the excessive caulking. Should this caulking be done in cold weather, the later expansion of the lead, being several times as great as that of cast iron, may cause sufficient additional strain to rupture the bell.

Electrolysis.—The evidences of damage by electrolysis are generally plain and are likely to be confused only with chemical action due to seepage of corrosive liquids through the soil.

Corrosion.—Pipes are made thicker than is necessary for resisting the physical strains imposed, in order to allow for rusting, and are painted within and without to protect the metal. So far as simple rusting is concerned, a pipe otherwise strong would outlive its usefulness several times in a country of rapid changes. Lead and iron in contact with water or moist earth will cause an electrolytic action on the iron, but experience has shown that this is not a serious matter.

Excessive Static Pressure.—In a small system, relatively new and tight, this might be a source of danger, but in a large system with numerous pumps, engines and mains, much cross connected and with some pipes old and leaky, the danger is not great.

Excessive Momentary Pressure.—Shock, or momentary pressure in the shape of a blow, is one of the most serious troubles to which water mains are subject. Its intensity cannot be calculated with any degree of certainty and therefore it cannot be provided for even approximately in the design. The blow is of the most searching character and is very severe.

Pulsation from pumps is one cause to be considered and may be classed under the head of water hammer. Under this name the effect has been extensively studied.

Periodic Pressure Waves.—Injury from this cause is comparatively infrequent, but may be quite serious, and its way of action is not so easily discovered. Should a pipe receive a set of pressure waves in tune with its natural period of vibration, it will vibrate with increasing force, possibly until it is ruptured, unless stopped by friction.

Extraordinary Causes.—These include explosions and blasting, earthquakes, lightning, intentional injury and possibly the breakdown of a heavy truck above.

An analysis of the list of breaks in Chicago during 1912 showed 42 joint leaks, 3 broken valves and 2 burst pipes. The valves were all three of an ancient type of poor design. No cause was discovered for the bursting of the pipes, although irregular cooling strains were indicated in one case. Of the joint leaks, one was under a railroad embankment and was probably due to the jar of trains and subsidence of the soil. Four were under street tracks where heavier cars have recently been run than previously. A large number were discovered in the spring and early summer after a very severe winter, and temperature changes may have been partly responsible.

But the majority of these leaks were within a mile or so of the Fourteenth street pumping station. This station differs from the Harrison street one only in one pump—the other pumps are exactly similar in the two stations. This pump has twice the rated capacity of the others, a relatively lighter flywheel, and only one air chamber, which is on the pipe line, while the other pumps have a