sary to keep the joint wet outside and inside, if possible, from 24 to 48 hours. If the joint is allowed to dry while setting, during the first few hours, shrinkage takes place, and this may or may not be taken up under pressure.

It is the custom of the Portland Water Department to test all lines to 50 lbs. in excess of the normal pressure before putting the line in service, and it may be said, for the cement joints and workmanship, that only one of those made in 1916 leaked under test.

The city of Portland has about 6 miles of 8 and 12-in. cast-iron pipe laid with leadite joints since 1912, and no leaks have ever been reported. Many of the joints sweat slightly when the pressure is first turned on, but they take up rapidly and become absolutely tight in a few days.

Most of the objection to the use of cement and leadite comes from workmen who have long been accustomed to the use of lead, but the writer has not heard of any complaint from engineers or foremen who have given either a fair trial. The Portland Water Department contemplates a very general use of cement joints in future work.

It is hoped Mr. Shaw's paper will bring out additional facts and opinions on this subject.

Walter Pearl, M.Am.Soc.C.E. (by letter).—In these days of Twentieth Century progress, and under the present duress of military requirements concerning our minerals and metals, this paper presents much matter for interesting discussion, in the way of economy, along the line of public work, as the latter must be continuous, and extend indefinitely, as long as civilization exists, regardless of whether the world is at peace or only striving for peace.

During several years of hydraulic engineering practice, embracing waterworks construction for municipalities, the writer has noted the rapid exchange or substitution of the baser materials, metals, or elements, for those of refined, or combination metals and construction materials; in the case of wood, timber, and lumber, more metal is being used in the constructive combination.

Recently, bids were received in the State of Washington for a steel highway bridge, but as it was afterwards found that a concrete bridge would cost only a trifle more, a bid was accepted for work of this class, considering the small margin in favor of the permanence of a concrete structure. There have been many similar instances lately, and as all branches of the government and all individuals must now practice economy, this paper offers suggestions along many lines.

The method of making the cement joints is described very clearly and concisely, including the method of breaking or loosening them, all of which would necessitate less time and expense, apparently, than is ordinarily required in melting, pouring, and driving lead joints, after caulking the joint with oakum or hemp in the usual manner, or the necessary expense and labor of melting the lead from the joints in disconnecting them; these elements of time and labor are favorable to the cement joint. However, more data and experience with the cement joint should be available before final conclusions can be reached regarding the relative cost of the two kinds of joints; former data cannot be used at the present time in making up a table showing the cost of lead joints.

It is a question with the writer whether the cement, as described, is sufficiently wet to fill all the joint space, and, certainly, great care must be taken in driving or caulking the cement, as the joint space is limited, and irregularities in the pipe often provide very small space, even for hot lead.

Table 5, showing the joint space, etc., in cast-iron pipes, is taken from the catalogue of a manufacturer of cast-iron pipes.

Table 5.—Some Dimensions of Cast-Iron Water Pipe.

(Thickness of shell proportioned for 100 lb. static pressure.)

Diameter, in inches.	Length, over all.	Thickness of shell, in inches.	Depth of hub, in inches.	Joint room, in inches.
4	12 ft. 4 in.	7/16	3	5/16
6	12 " 4 "	1/2	3	5/16
8	12 " 4 "	17/32	3	5/16
10	12 " 6 "	19/32	3	5/16
12	12 " 6 "	5/8	3¼	5/16
14	12 " 5 "	11/16	3¼	5/16
16	12 " 5 "	3/4	3½	3/8
18	12 " 5 "	25/32	3½	3/8
20	12 " 5 "	27/32	3½	3/8
24	12 " 5 "	15/16	3¾	3/8

The figures in Table 5 may be assumed as standard, but as the flask, mould, and pattern vary slightly with different manufacturers, the "joint room" may suffer. Table 5 shows what a limited space there is in the hub or bell for cement after the spigot end is entered, for a thickness of not less than ¼ to ½ in. of cement should be required throughout the entire joint. This thickness might prevent the possibilities of seepage or leaks in the joints of the pipe constructed under the author's supervision. The paper gives no information regarding the joint space. In laying a line of pipe such as described, great care would be necessary in securing, as nearly as possible, perfect alignment and grade, in order to have uniform joint space.

It would seem that cement joints could only be used with straight lines of pipe under low pressures. In a joint of a 6-in. cast-iron pipe, when laid straight, the space is 5/16 in., and on a curve of 250 ft. radius, the resulting space would be practically 3/16 in., or ⅛ in. on a curve of 166 ft. radius. Numerous ups and downs in grade could not be permitted, thus showing the necessity of laying such pipe according to the method of laying sewer pipe. This matter of joint space has been gone into at some length by the writer, as he realizes the difficulty of pouring the lead in a close joint, and more especially in caulking it.

Another question arises, as to whether cement joints in a cast-iron main will stand the strain and shocks due to the sudden closing of valves and hydrants (though not necessary, such things sometimes happen), causing water-hammer, ram, and vibration in the line of pipe, which might crack or injure the cement joints, causing leakage, expense, and annoyance. This is likely to occur in a gravity pipe line, and, in a pumping line, the constant vibration might cause seepage and leaks to develop in the cement in due time. It is well known that cement and concrete will crack and disintegrate where there are sudden shocks or continuous vibration, though it will stand great pressure due to head or weight, if not subject to disturbance.

The author has described cases where pipes with cement joints were laid in made or filled ground, and where settlement occurred without injuring the joints or causing leakage; also where a parallel trench caused the caving of the pipe trench, leaving the pipe hanging unsupported in the air for a time, without even causing seepage in any of the joints. The reason for this, doubtless, was the gradual giving way of the ground supporting the main. Had the shock been sudden, the results might have been different.

It may be conceded that no other base metal having the qualities of lead—so ductile and homogeneous—seems