dated without infringing on the capacity or use of the drain, this should be done.

The lines for the drains should be run as straight as possible, at the same time the line of the drain should follow the lowest depression. The engineer is one of the commission to appraise the damages in a drainage district. The damages asked for are sometimes a great deal more than will be allowed by this commission. The commission on damages should use judgment, and not allow any more than is fair and just.

The assessment of benefits is a very hard proposition. The drainage district should be examined very closely, each tract by itself, and all of the facts weighed and sifted until an equitable apportionment can be made by these commissioners. If this apportionment of taxes has been made in a just and fair manner, the board of supervisors should not change it. A great deal of trouble has resulted by boards changing the assessment.

The engineer and contractor should be on good terms always. The engineer should use judgment and have the contractor work to the line, but should not unnecessarily hamper the work of the contractor, who often has a very hard job before him. The drains should be laid out and constructed upon the best lines and no deviation made from them, and they should be constructed in such a manner as to do the most benefit to the land. The people are paying for it, and they expect the construction of these drains to be such as will be a benefit to them.

ACTION OF WATER ON LEAD PIPES, ETC.

Before the Chemical Section of the British Association, Dr. F. Clowes presented a paper on the action of distilled water on lead. When some years ago it was proposed to bring large volumes of soft water from Wales to London, the possibility of the action of this water on leaden pipes had to be investigated. Dr. Clowes had experimented with large sheets of very pure commercial lead. This lead was not acted upon by distilled water in a vacuum nor in an atmosphere of hydrogen; at any rate, the action, due probably to the last traces of oxygen, was infinitesimal. But supply waters always contain oxygen and also other gases. Of these gases, oxygen when alone present attacks the lead worst; carbon dioxide has a very slight effect; in equal mixtures of oxygen and carbonic acid the effect is quantitatively that of the oxygen, and when more CO_2 is present the action becomes less pronounced. The corrosion of the lead is hence primarily due to oxygen; the carbon dioxide acts in the second place by forming a carbonate with the oxide first produced. The action is rapid at first, and a white deposit is formed, while some lead passes in solution; the deposit in some hydroxycarbonate of variable composition. It has been suggested that the presence of bacteria was required to start the attack, or would hasten it; but heated lead corroded as quickly in water which had long been kept boiling as under ordinary conditions. These experiments demonstrated, however, the inhibitory influence of certain salts in the water. When water is distilled with the aid of a glass condenser tube, some silicate passes into the distillate, and this silicate protects the lead against corrosion. The water was therefore distilled from copper vessels and passed through copper coolers in some experiments. Sulphates also protect the lead, carbonates and carbonic acid are less efficient, lime is doubtful, and may even increase the corrosion if sufficiently concentrated. It is also due to this protective power of salts that distilled water does not acquire its full corrosive activity on subsequent aeration by exposure.

PROTECTION OF STEEL PIPES.*

By Alfred D. Flinn.

One of the siphons of the aqueduct under construction to supply New York City with water from the Catskill mountains was described in our issue of August 23. At that time the steel work of the siphon had not been completed, and consequently only a brief description was given of the protection, both inside and out, which was contemplated. In a paper before the New England Water Works Association, Alfred D. Flinn, Department Engineer of the Board of Water Supply of New York City, described the methods employed for furnishing inside and outside protection to this siphon and to the others along the line of the aqueduct. Of these siphons there are fourteen, ranging in length from 608 feet to 6,671 feet, the total length of all the siphons being 33,031 feet. About one-fourth of the total length has a finished inside diameter of 10 feet 11 inches, about one-fourth a diameter of 9 feet 5 inches and about one-half a diameter of 9 feet 2 inches.

While preparing the plans, investigations and experiments were conducted to determine the material and method which it would be best to adopt for protecting the steel. Apparently none of the pipe coatings commonly used possessed qualities giving it more than a few years' useful life when in contact with the water and soil which had to be considered in this case. One or two cases of the use of Portland cement mortar on a small scale and wide experience in reinforced concrete construction suggested the use of cement for this purpose; and after some study it was decided to jacket the siphons outside with rich concrete, with a minimum thickness of 6 inches and line them with Portland cement mortar 2 inches thick. An effort was then made to find the most economical and practical methods for the various steps in covering and lining the pipe, with a view also to obtaining intimate, complete and permanent adhesion in spite of the unavoidable changes in shape and the elastic distortions of the pipe.

Mortar lining experiments were made on a steel pipe 9 feet in diameter and 12 feet long. This was lined by plastering with metal reinforcement of several styles, by plastering with terra cotta and cement blocks or tiles, and by pouring grout or very thin mortar into the space between a cylindrical steel form and the interior surface of the pipe. These experiments seemed to show that no combination of plasterer's skill with various kinds of cement mortar, reinforced or unreinforced, gave linings that were adequate; besides which this method was expensive. Bedding tiles of terra cotta or mortar, about ¾ or ⅞ inch thick and 6 by 8, 6 by 12, and 8 by 12, on mortar applied directly to the pipe surface, and, after setting, building up the lining to the required thickness with successive coats of mortar troweled on, was much more satisfactory, but also expensive. The grouting method proved by far the most satisfactory and least expensive and was made the basis of the specifications. It had the advantage of producing a monolithic lining, which was considered desirable, especially as it avoided layers or laminae, since it is well known to be difficult to cause one layer of Portland cement mortar or concrete to adhere absolutely and permanently to another without expensive and troublesome precautions. This method also gave promise of being feasible in actual construction, and was adopted for the work.

The specifications as adopted provided that the pipe should be tested by filling with water, should be made tight

*Abstract of paper before the New England Water Works Association.