ing department. The intention on the work was to do nothing by hand that could possibly be done by steam. The top of the bank was too narrow to allow the use of carts, and an 18-in. railroad was decided on as most convenient. A 65-ft. derrick with a 70-ft. mast and a 15-h.-p. double-drum hoisting engine for the operation of the derrick and railroad were set up on the floor of the reservoir for the removal of the spoil and for the placing of the concrete.

All of the concrete was mixed by hand with as great a proportion of water as could be used and not cause the material to slide when rammed in place. The lower layer was composed of 1 part cement, 2½ parts of sand, and 6½ parts of crushed stone from ¾ to 1½ in. in size. As this lean mixture could not be rammed enough to flush all over, the surface was finished where necessary by a thick mortar made of 1 part of cement to 6 of sand. Before placing any concrete, the bank behind the edge of the old concrete left in place was thoroughly rammed with iron railroad tampers, the edge of the concrete scrubbed with water and stiff brushes and then coated with 1 to 4 grout, which was allowed to fill the angle between the concrete and the slope.

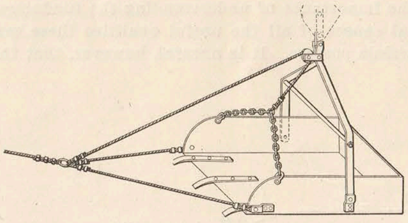
Previous to placing the concrete the earth bank was sprinkled so that moisture might not be drawn from the concrete while setting. In order to make the new lining as waterproof as possible two layers giving a thickness of ¼ in. of Venezuela asphalt, "Crystal Brand," were placed on top of the lower layer of concrete.

The upper layer of concrete was much richer than the lower, being composed of 1 part cement, 1¼ parts sand, and 1¼ parts stone dust, and 4 parts broken stone. On account of the steep slope very little ramming could be done and the concrete was laid as wet as possible. To make the lining more impervious, and also to obtain a smooth surface, a finish coat was applied by granolithic finishers, as soon as it was possible to work over the concrete layer, and at the same time have the concrete still fresh enough to allow a good bond with the surfacing. The coating was made in the proportion of 1 part cement, 1⅔ parts sand, and 3⅓ parts stone dust. The lower layer of concrete was placed in a continuous sheet; the upper layer being placed in alternate strips, 10 ft. long, the whole length of the layer, and 5 ft. wide. Plaster of 1 part cement and 4 parts sand was applied to the back of the block toward the bank to prevent any infiltration of water.

The total cost of the work was about $3,500, of which labor cost about 36 per cent., materials 35 per cent., plant and installation 23 per cent., and transportation and holidays about 6 per cent. As stated above, the work was designed and carried out under the direction of the engineering department of the Metropolitan Water-Works, of which Frederic P. Stearns is chief engineer and Dexter Brackett engineer of the distribution and Sudbury departments.

A Small Sea Wall and Breakwater.

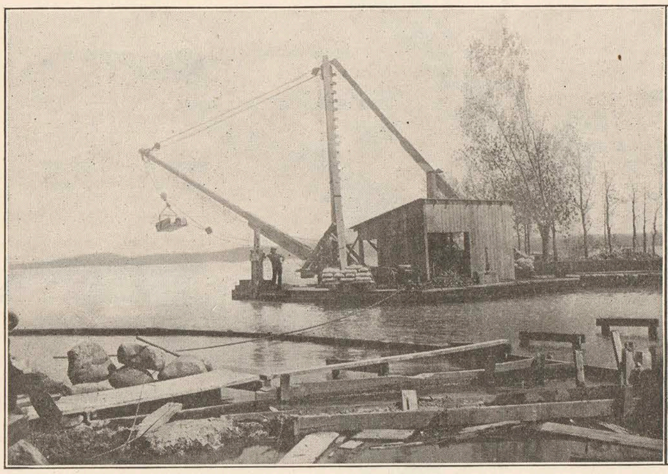
A sea wall of concrete and rough glacial boulders, which serves as a retaining wall and a harbor breakwater, was completed the past season at Green Lake, Wis. The site is a point exposed to the full action of the wind, behind it being a bight or cove, which it only partly sheltered. It was necessary to build a very substantial wall on account of the destructive surging of the ice in winter. The wall protects the end of the point and runs from there back along the shore around the cove, having a total length of about 2,400 ft. Lying close inside the point is a small island, which was also surrounded with a wall, and a projecting jetty or tiger-tail was built on its inner side, thus greatly increasing the shelter of the cove. The dimensions of the wall vary from 4½x2½x8 ft. in the cove to 5x4x9 ft. on the point. Two feet of the wall is exposed above the water. It is built of concrete and large granite boulders, which abound in that locality. The Universal brand of cement, manufactured by the Illinois Steel Co., was used, and the sand and gravel were dug and screened on the spot. The concrete was mixed very wet on a small portable platform, in the proportion of 1:2:4, and formed the core of the wall, the boulders being set as a facing. Two stairways, each 12 ft. wide, were built in the wall for landing and bathing purposes, and ten posts or mooring bitts were set at intervals along the wall. These posts, which were of 6-in. cast iron pipe, were filled with concrete and finished with a cast-iron pipe cap.



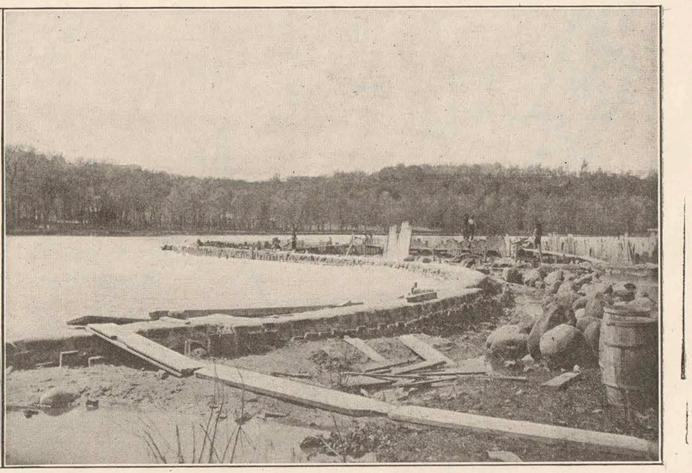
Page Bucket Dredge.

The cofferdam was built in 150-ft. sections, Wakefield standard sheeting being used on the outer or lake side and plain two-lap sheeting on the inner or landward side. The sides were then lined with 2-in. dressed and matched sheeting. A waling strip 2x2 in. in size was placed at the water line, and another about half way down the sheeting. At intervals of 7 ft. these were braced with 4x6 in. timbers. This construction successfully stood the autumnal gales. A force pump and jet of water were used to sink the sheet piling.

As the shore rises abruptly in a steep, wooded hill at this point, a level esplanade was made by locating the wall some two rods out from the original shore line. The intervening space was then filled with the spoil obtained from dredging out the cove some 5 or 6 ft. in depth. The ground is of a very compact character, a light covering of sand overlaying a glacial drift of hard packed marl, clay, gravel and Lake Superior boulders. Dredging was very difficult. The first attempt was made with a centrifugal pump mounted on a scow, and meeting with absolute failure. Then an orange-peel bucket was tried, and it did not bring up more than 30 lb. of stiff material at a trip. Finally an improved Page bucket dredge was put in service. This proved equal to the work, handling boulders of over a yard in size without difficulty, although the wire cables and their fittings showed the severity of the service in a marked manner.



Bucket Dredge Mounted on Scow.



Completed Portion of Sea Wall.

One of the illustrations shows this bucket, which has been recently patented by Page & Schnable, of Chicago. Only two lines are required to operate it. One is an ordinary hoist to raise and lower the bucket, and the other pulls the bucket through the loading movement, and also controls the dumping action. The latter line divides at the bottom into three ends, two of which merely fasten to the corners of the bucket to pull it. The third passes over a pulley wheel in the bridle and then divides, going to the two upper front corners of the bucket. The center of gravity of the bucket, either loaded or empty, is in front of the carrying bridle, so the dumping is accomplished by smartly slacking off the lead line. From 300 to 400 cu. yd. per day were taken out by this little dredge, which was handled on a boom derrick having a 32 ft. mast and a 52 ft. boom, both of 12x12-in. pine. A scow 42x28x2½ ft. carries the dredge, together with a boiler and two Lidgerwood engines, one used for hoisting while the other swings the dredge. The total amount of excavating done is estimated at 20,000 yd. About 2,500 cu. yd. of wall were built.

Lone Tree Point is the summer home of Mr. Victor F. Lawson, of Chicago, for whom the work was done by J. J. O'Heron & Co., of Chicago. Mr. Robert Isham Randolph was the engineer in charge of the work.

may not lead to binding power, as they are capable of existing in allotrophic modifications which differ in this respect. Alumina and many other substances can be easily prepared by wet reactions in the laboratory, either as gummy colloids or as finely crystalline precipitates, by slightly varying the conditions. In nature the conditions are of every possible variety, and thus we find a physical property like cementing power varying through wide limits in those rock species which exhibit it. In a word, those rock dusts which contain a certain proportion of particles which on soaking with water soften to the extent that they become, to ever so slight a degree, glue-like (colloid), and thus adhere, are those which are useful to the road builder. Many of the traps, limestones and sandstones, fall under this head. Those rocks, on the other hand, which are of an entirely unaltered crystalline structure, or those which, through metamorphic changes—heat and pressure—have had the active hydrated particles destroyed—such as slates and quartzites—should be avoided on the surface portion of the road.

These conclusions are borne out in service where the problem has to be solved of building roads of material which, while hard enough to bear traffic, is without binding power. A good example is furnished by the excellent sand-clay roads in the Southern States, described in The Engineering Record of July 16, 1904. A somewhat similar case is that of burnt-clay roads, which have been advocated by the Division for several years and on which experiments are now being made.

It may be objected that at least one exception to the general rule is furnished by certain furnace slags which certainly have not undergone secondary changes, and yet have been successfully used on roads in some localities. This subject has been specially investigated by the Division, and it has been found that siliceous slags are in no case suitable for a binder surface. Certain basic slags, which have an excess of lime in their composition and have been quickly cooled at the furnace, make an excellent material for light-traffic roads, as the slag dust takes on an actual mild set similar to that of Portland cement. Doughs made of such slag dust set hard before they can be aged 24 hr. preparatory to molding the test pieces. It is apparent that this special case of slags has no general bearing upon the conclusions reached.

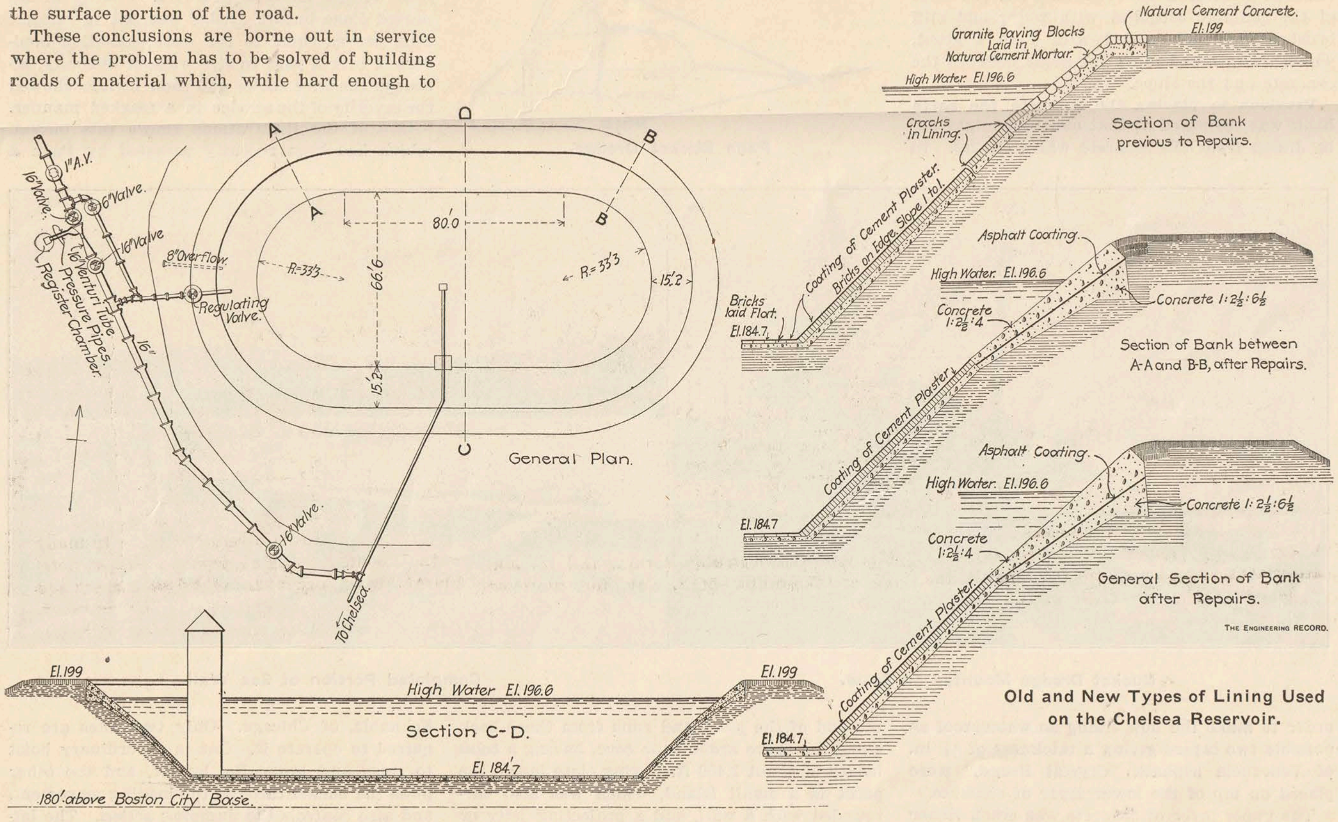
It happens that certain ferruginous limestones and gravels bind exceedingly well, and this has led to an erroneous impression that iron is the cause of the bond of cementation. Broadly speaking this is not true, for many of the highly ferruginous red sandstones do not bind. A series of experiments was made in the laboratory to determine whether iron ores, such as hematite and limonite, possessed cementing power, and it was found that exceedingly pure limonite had a low value and hematite none at all. If, however, there were siliceous or clayey impurities present, the values would be much higher.

Those who are interested in a scientific study of road materials will undoubtedly acknowledge the importance of understanding the fundamental causes of all the useful qualities these materials possess. It is natural, however, that the average man should desire more particularly such information as will enable him to select the best material for his purpose. If the actual results of service have not already been determined there is no alternative but an appeal to the testing laboratory. The studies of the Division show that cementing value is not confined to any particular species of rock. The highest trap tested among a large number of samples had a cementing value of 500, the lowest a value of 1. In the same way the limestones were found to vary from 231 to 4.

The Water Power Plant at Gersthofen, some 5 miles from Augsburg, Germany, contains five 1,500-h.p. double Francis turbines working under a head of [illegible].5 to 34.5 ft., receiving water from the river [illegible]ch. Two of the turbine units are coupled to two 1,000 kw. direct-current generators, two are coupled to two 1,000 k.w., three-phase alternators, and the fifth is coupled to a direct-current generator on one side and to a three-phase alternator on the other.

Repairing the Lining of a Small Reservoir at Chelsea, Mass.

In connection with the high-service water supply of Chelsea, Mass., there is a small reservoir on Powder Horn Hill, with a capacity of about 1,000,000 gal., which is supplied by the high-service system of the Metropolitan waterworks. This basin is semi-oval in plan, the top being 178 ft. long by 98 ft. wide, and the bottom 148 ft. long by 68 ft. wide. The depth is 15 ft. and the slope of the sides about 1:1. The reservoir was built in 1887, and had a double lining. The lower layer was natural cement concrete. From the water line to the top of the slope, the upper layer was granite block paving laid in natural cement mortar; the remainder of the slopes and the floor had an upper layer of brick covered with cement plaster. The experience with this lining was the subject of an interesting paper read before the New England Water-Works Association on Nov. 9 by Mr. C. M. Saville, of which an abstract follows; the paper and discussion in full will be published by the Association in its "Journal."



Old and New Types of Lining Used on the Chelsea Reservoir.

On first filling the reservoir the leakage was considerable, especially at the juncture of the stone and brick paving. A coating of cement mortar was applied to the whole inside slopes and bottom, and no further serious trouble developed until 1899. At this time and again in 1901, horizontal cracks appeared in the lining, when they were filled with cement mortar. Cracks appeared for a third time in 1903 and 1904, when it was decided something radical should be done to prevent them. Attention may be called to the fact that the greatest damage has always appeared on the south bank, leaving the lining on the north bank intact. When the reservoir was relined the section of the north bank was made thinner than that of the other banks.

The work of repairing was done by the maintenance force of the Metropolitan Water-Works, under the general supervision of the engineer-