to houses and streets, very little damage was caused, and there were no serious accidents either to the general public or to the workmen employed.

Bridges.—In connection with the railway running in from Fairview to the terminals, sixteen bridges are called for. Of these, fourteen are highway bridges, arch type, constructed entirely of reinforced concrete. The one carrying the Halifax Ocean Terminals Railway over the streets at Fairview is to be built of plate girders in a single span. This bridge will have a concrete deck only.

The other, carrying the railway over Chebucto Road, is to be built of plate girders in three spans; that is, two sidewalk spans and the roadway span. This bridge will be entirely encased in concrete.

The single spans for highway bridges vary from 60 ft. to 144 ft.

At Young Avenue, the double span arch is to be approximately 225 ft. between main abutments.

All abutments and wing walls are built on solid rock and are of mass concrete.

The aggregates for the concrete were obtained from a beach at Seaforth, on the eastern shore of Nova Scotia, and shipped in flat cars over the Canadian Government Railways via Windsor Junction to the different bridge sites. There the materials were hoisted to the top of the cut by means of a clamshell bucket, operated by an ordinary stiff leg derrick.

The following mixes of concrete were used: 1 : 2½ : 5, 2-inch mesh in main abutment and wing walls; 1 : 2 : 4, 1-inch mesh in arch ribs and spandrel walls; 1 : 1½ : 3, ½-inch mesh in handrailing.

Dredging.—A very important item was the dredging and especially the rock and deep-water dredging. The more or less soft material overlying the rock in basins Nos. 1 and 2 was first removed by the dipper dredge, "King Edward," equipped with a 5-cubic-yard bucket. This dredge had a maximum dredging depth of 50 feet and a minimum of about 15 feet.

After much consideration and comparison of systems of drilling in various classes of rock and of the results obtained, drill boat No. 1 and afterwards drill boat No. 2 were constructed.

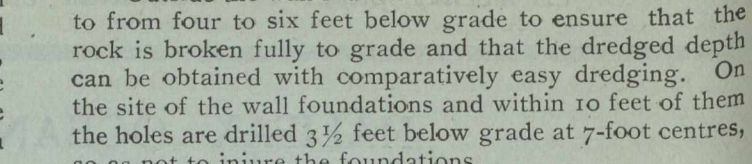
Drill boat No. 1 consists of a wooden scow 35 feet wide by 90 feet long, fitted with 7 steam drilling machines with 5⅝-in. bits and 6-in. cable, 4 spud anchors with spud engines, two winch engines, locomotive boiler and electric light generating set.

Drill boat No. 2 is similar to No. 1 only larger, consisting of a wooden scow fitted like No. 1, but containing 10 drills, 7 feet apart.

The rock encountered is similar to that found on the railway and consists for the most part of slate or shale with iron stone and an occasional trace of trap rock and quartz. It lies in very irregular inclined strata, being seamy and much broken, so much so that it is necessary to case all the holes with a 6-in. case pipe and to drive it sometimes for fully three-quarters the depth of the hole. This effectually cuts off the flow of sand, clay or mud contained in the seams of the rock, and so prevents the drills jamming. The holes are kept clean by means of a sand pump.

When the rock drilling and blasting first started the holes were drilled in rows 7 feet apart, and about 2¼ pounds 60 per cent. dynamite used to the cubic yard of material blasted. This was found to be excessive, and lated the holes where the rock was deep were spaced 10 or 11 feet apart, and about one pound of 75 per cent. dynamite used to the cubic yard of material blasted. The dynamite chart shows the amount of dynamite to be used per foot of hole and is worked out on this basis. (Fig. 2.)

Outside the wall foundations the drill holes are drilled to from four to six feet below grade to ensure that the rock is broken fully to grade and that the dredged depth can be obtained with comparatively easy dredging. On the site of the wall foundations and within 10 feet of them the holes are drilled 3½ feet below grade at 7-foot centres, so as not to injure the foundations.



This system of drilling in the rock encountered has been very successful, and as much as 6,000 cubic yards of rock have been drilled and blasted by the two drill boats in a week. Very little of the broken rock is larger than one cubic foot.

Quay Walls.—For permanent work the use of timber for the sub-structure of the quay walls in Halifax harbor was not possible, owing to the activities of both the "limnoria ligorum" and the "teredo navalis," two marine insects which are very active in attacking timber.

A careful examination of the existing timber wharves along the water front showed that the limnoria was particularly active, and that the life of timber in Halifax harbor was comparatively short. Evidence of the presence of teredo was found, but to a much less degree than the limnoria. Experience has shown that creosoted timber is able to withstand the attacks of these marine insects for a much longer period than untreated timber, but even creosoting does not render timber immune from attack.

Concrete is not subject to attacks from any marine insects and with proper precautions taken as to mixing, proportioning and placing, is in sea water practically free from disintegration. Due to climatical conditions in Nova Scotia, however, concrete between high and low water will break up through mechanical action, due to frost, when the temperature approaches zero. It was, therefore, decided to build the quay walls of concrete and face them with granite from one foot below l.w.o.s.t. to quay level. A careful comparison of designs of open work, reinforced pile and cylinder construction, mass concrete, concrete block and concrete caisson construction led to the design and adoption of a quay wall constructed of cellular reinforced concrete blocks filled with mass concrete and broken rock, whereby it was hoped to combine all the advantages derived from the use of reinforced concrete and to deposit the mass concrete under water under conditions which were as nearly as possible ideal, the blocks acting as permanent forms.

The standard blocks are 31 ft. x 4 ft. 1½ ins. x 21 ft. 10 ins. cellular with diaphragms 8 ins. thick and reinforced principally with ⅝-in. square twisted steel bars.

It will be noticed that the front and middle compartments are square and connected one with another by tri-