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PORT COLBORNE HARBOUR WORKS.

Description of Design, Methods and Plant.

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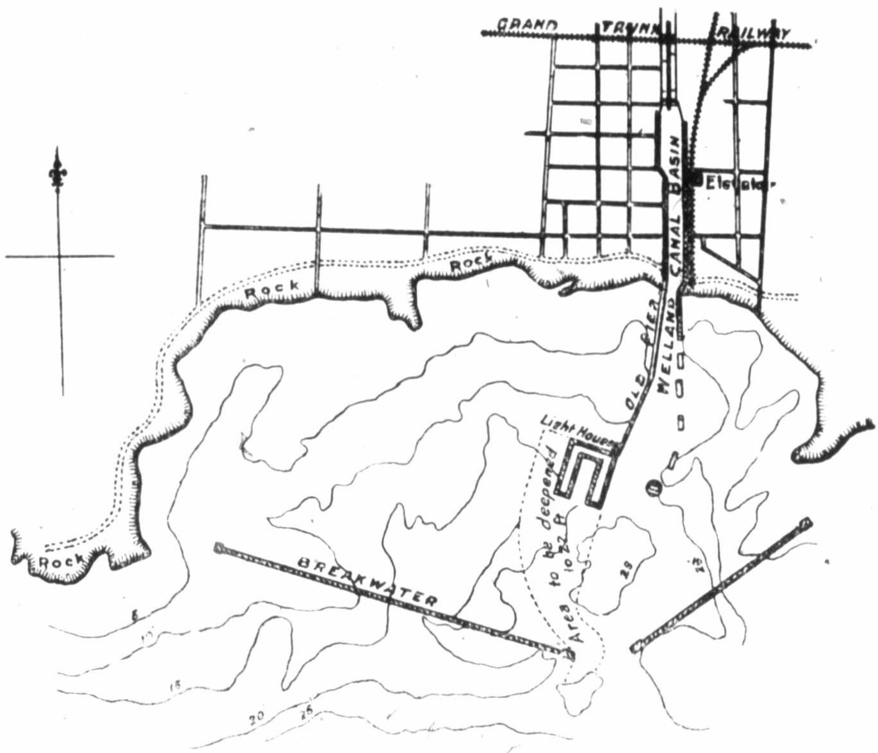
Read before the General Section, February, 1905.

Port Colborne, situated at the southern or Lake Erie end of the Welland Canal marks the limit of clear lake navigation. for from this point to Montreal the draft of vessels is controlled directly by the legal allowable draft of canals, which for the Welland Canal is 13′ 6″.

The Canadian Government has, since 1899, been engaged in extensive harbour improvements with a view to making Port Colborne a transhipping point of large dimension and a rival, if possible, to Buffalo. Should the Port Colborne scheme work out as intended, the navigation of the canal system would be largely augmented where at present, despite free tolls it is very small, especially considering the facilities offered and the excellent design of the canals.

Much of the grain which at present goes to Buffalo in the large lake carriers and thence to New York by rail or Erie Canal might be diverted to the St. Lawrence route were proper facilities provided at Port Colborne for transhipment, and it was to provide just such facilities that the works were undertaken.

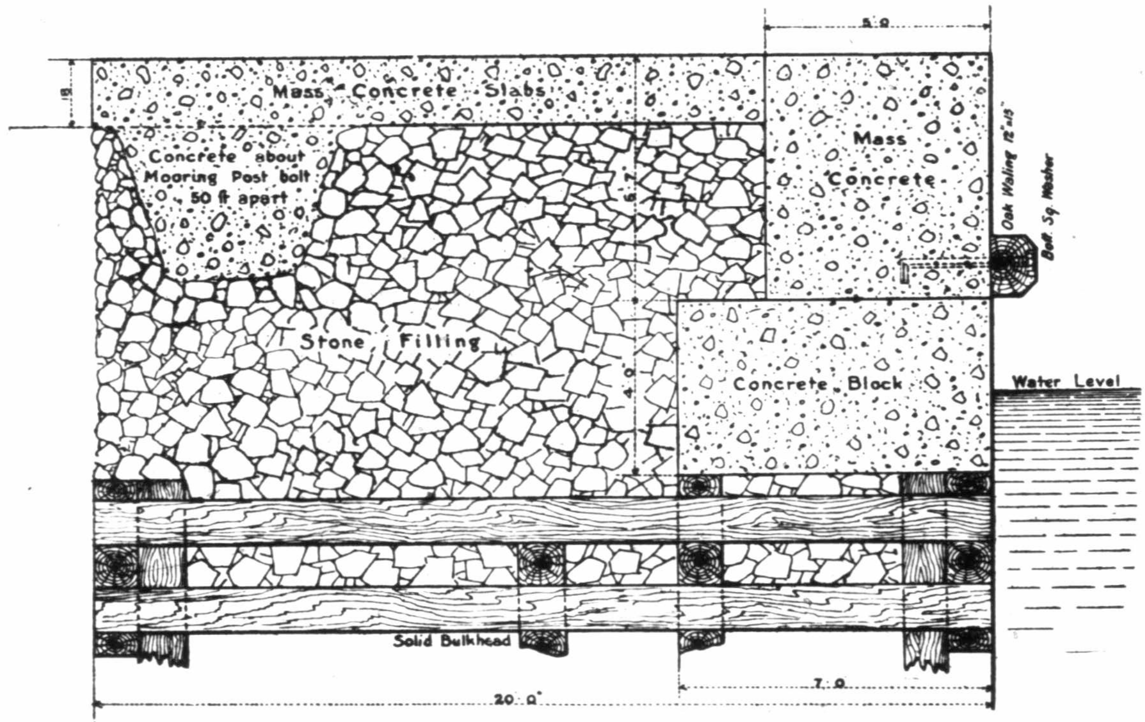
Fear of such a diversion of trade doubtless is the prime cause of the proposed large expenditure in deepening the Erie Canal; but even in its improved state the Erie Canal route will be inferior, both as regards depth (10' as compared to 14') and distance for the St. Lawrence route (Port Colborne to Montreal) is shorter by over 120 miles than the Buffalo to New York waterway.



PORT COLBORNE HARBOUR IMPROVEMENTS

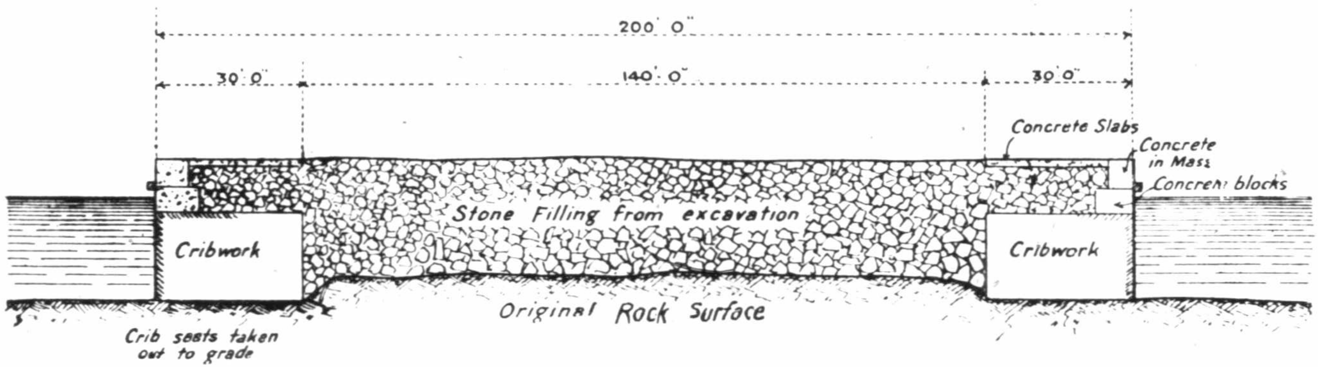
Fig. 1.

The works comprise new docks, excavation of channels, and two large breakwaters to east and west of the port. These breakwaters, of which one, 5,000' long, is totally finished, while the other, 2,400 long, is half completed, are under the supervision of Department of Public Works. The rest of the works are in the



SECTION INSIDE HARBOUR WALLS.

Fig. 2.



SECTION THROUGH PIER"

Fig. 3.

Department of Railways and Canals. This paper will discuss only the latter.

The hatched portions of map shew plainly the scope of work which may be divided into outer harbour and inner or canal basin.

The former calls for the construction of two docks, 200′ x 700′, and the deepening of an area to 22 ft. to allow approach by largest lake carriers. The excavation shown is entirely of solid rock, over 300,000 cu. yds. in all, averaging a cut of 3 to 4 feet from lighthouse to canal basin entrance a depth of 18 feet is required, principally sand and soft material. The canal basin itself is dredged to afford 16′ of water. This plan, however, will no doubt be changed to afford a depth of 22′ over entire area of both inside and outside harbour. In addition the sides of the canal basin have been dug out and concrete docks built as shewn

Dock Design.

Design of inside and outside harbour docks is similar save for width of crib. Figures 2 and 3 show the design which is essentially submerged crib work filled with stone, and surmounted by concrete blocks carrying a mass concrete wall, the whole covered for width of crib by an 18″ slab of concrete.

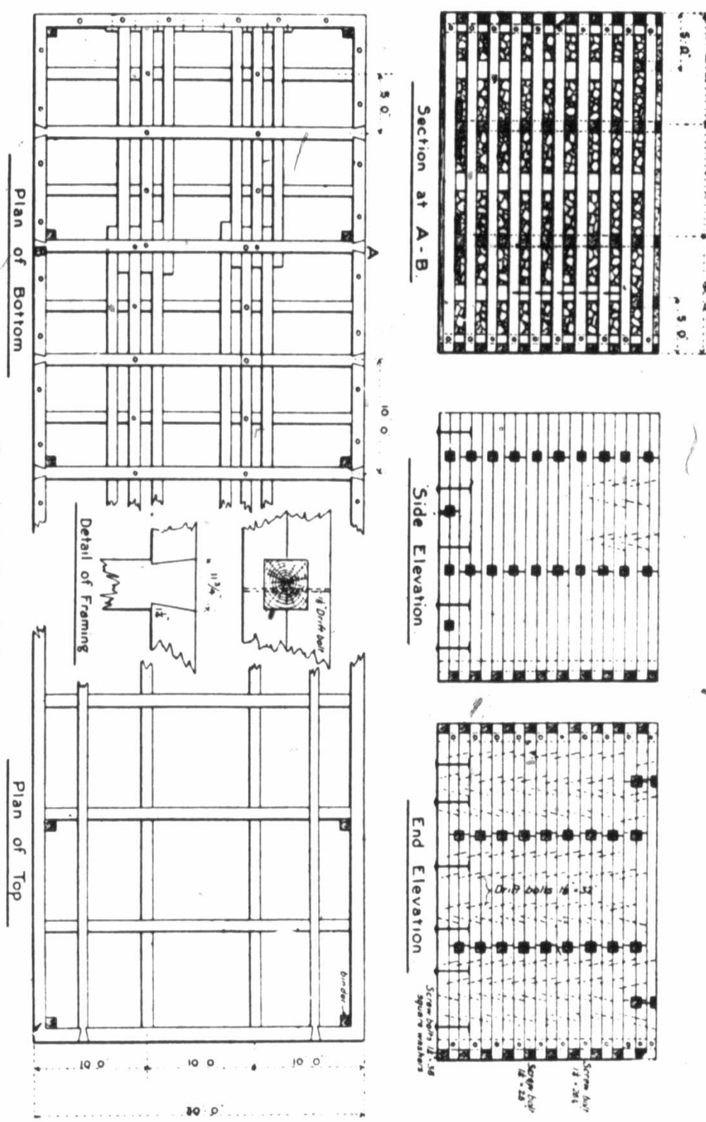
These cribs are built to within 2′ of an assumed water surface (14′ above mitre sill of lock) so that no timber is exposed to rot. The use of concrete blocks does away with the difficult operation of placing green concrete under water, and ensures a lasting job in a position where permanency is required. Crib seats were in all cases dug out to grade with dredges, but the interiors of outer docks were left as found.

Cribwork.

Plan "C" shews details of cribs. The outer harbour cribs were 30′ wide as against 20′ for inner harbour, the extra width being called for the exposed position. The construction points do not vary beyond the extra solid bulkhead in the 30′ crib.

The timber used, about 35,000,000 ft. B.M. in all, was all 12″ x 12″ square hemlock, proud edged with small quantity of wane allowed in ties or longitudinals. A small quantity of 6″ x 12″ is used for bottom grillage and block seat.

Ties and longitudinals are dovetailed, as per sketch, preventing the possible pulling apart or crushing in of cribs. They are placed at intervals of 10′, except in lower course, where an extra tie is put in every 5′. Side joints are simply butted, ends being

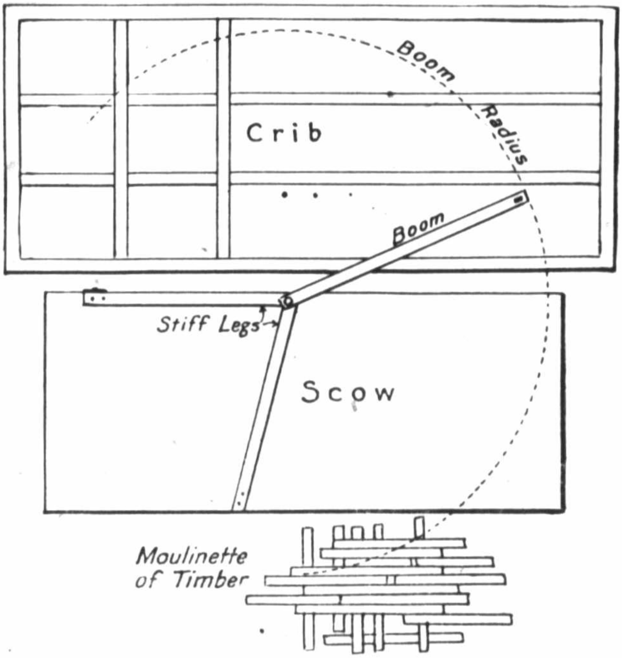


DETAILS - 30 x 100 CRIB

Fig. 4.

cut exactly square with ¼″ allowable opening. End joints lap alternately. The longitudinals form two solid bulkheads for full length of the crib, which is a feature of great strength. This calls for short 10′ fillers between ties on every second course.

Binders are placed every 20′ with the object of tying the face courses together vertically so they might not have to depend upon bolts alone to prevent them being forced apart.



METHOD OF BUILDING CRIBS BY SCOW.

Fig. 5.

BOLTING, &c.

Binders are fastened to face timbers and ties by 1¼″ x 26″ screw bolts with square plate washers.

The three lower courses of crib are made specially strong to withstand stresses caused by filling, weight of wall, contact with uneven bottom, and rough usage in handling &c. They are fastened with 1¼″ x 36″ screw bolts and washers passing through whole three courses and spaced 5′ apart. The other courses are bolted as shewn with 1⅛″ x 32″ drift bolts having sheared points. These bolts pass through two entire courses and partly into a third. The short blocks shown in section, coming almost under the rear of concrete block, aid in preventing any deformation of tie and consequent settling of wall.

These cribs are built on ways up to 7 or 8 courses, and then launched and finished in the water. Owing to depth of water in basin being insufficient to float a finished 20 course crib, it was necessary to tow cribs into the open lake, and finished them near their sites.

Cribs were built by derricks afloat on scows. A feature was the placing of the derrick at the edge of the scow, and so arranging the stiff legs that derrick boom could have greatest possible radius of action. Only one move was required by scow to lay a whole course of timber. Hoisting engines having boom fall and swinging drums were used, so that the engineman controlled the whole movement of a stick of timber. The timber was unloaded from vessels directly into the water in piles or moulinettes; this being the only and most convenient method of storing the enormous quantities of timber used. As required, the moulinettes were towed alongside the crib scows and built directly into the cribs. The timber was thus placed in the crib with only one handling, as the ship was bound by contract to unload its own cargo.

Crib scow also had an air compressor plant to supply pneumatic augers used for boring, as all drift bolts were driven into holes bored ¼″ to ⅛″ too small.

A gang of 20 men in all launched two crib bottoms of 7 courses and binders regularly each week, while a completed crib represented about 8 days' work.

Cribs were sunk by placing on them several concrete blocks on temporary platforms at ends and middle. When properly aligned and level the filling was dumped in as rapidly as possible, and blocks later placed in their proper position. Owing to weather conditions the filling of each crib had to be completed at once, or about 2,000 cubic yards of stone filling provided. All this filling was dredged up from the "yellow" area already referred to.

Concrete Blocks.

These blocks, 4′ x 4½′ x 7′, were moulded in timber forms made of 2″ dressed pine, tongue and grooved. A piece nailed to side of mould gave required joggle to block. The moulds were tied across by two ½″ round iron rods with nuts, threaded both ends. The lower rod passed through the partition forming end mould of block.

Sides were held in position by shoulder formed by lapping on 3" x 4" upright. To remove moulds, nuts are slacked and uprights taken down, when the sides will remove in one piece and are utilized again. These moulds were filled with concrete in layers and allowed to set for 48 hours before removal of moulds.

In top of the block is seen a basin-like depression, while in the side a slot or joggle is moulded. When blocks are placed side by side, the mass concrete of wall filling up joggles, etc., forms a

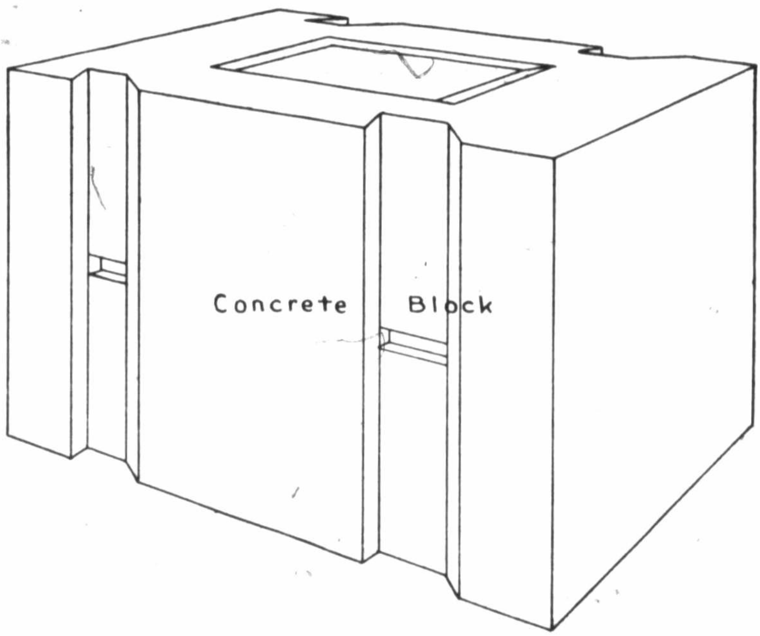


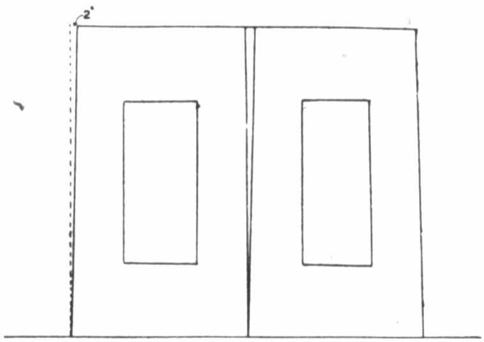
Fig. 6.

strong joint between each block and between top of block and wall above, and prevents any lateral displacement of blocks relative to the wall which might be caused by impact of the heavy seas or vessels.

The joggle also allows of the simple method of handling the blocks shewn in Figure 4.

Much difficulty was experienced in setting these blocks level and close jointed, especially the latter. This was due to the uneven character of the bed left by the dumping in of stone filling and the difficulty of levelling same in 2' and 3' of water. As an aid to obtaining close joints the blocks are now made with a batte 2" from face to rear of block which allows of the front face being brought closer to the neighbouring block.

Moulds for concrete wall are of similar material to block moulds and similarly fastened, except the lower rod, which rests on the block and supports outside upright which overhangs the face of wall. This rod remains in the wall. The rear upright is wedged into the joggle. Moulds were erected in sections of 60 to 75 feet, a day's work. The next day's work began at finishing point of previous day, which allowed sufficient expansion. Canvas nailed to inside face of mould and allowed to drape over the block, was extensively used to prevent washing out of concrete by seas before thoroughly set at the level of block.



SHOWING BATTER OF BLOCKS.

Fig. 7.

CONCRETE.

Concrete was 1. 2. 4. mixture. Owing to the large area covered by the works it was impossible to set up a permanent plant anywhere, as the slow transportation of concrete by scow, and the extra handling thus entailed would result in poor work and much expense. The convenient approaches to most of the work being by water, the plan of utilizing a floating plant was adopted with good results.

A large deck scow was equipped with a derrick, mixer, and crusher, and storage provided for cement and sand. The lay-out was so arranged that the derrick, having a 88' boom, controlled all the operations. Materials for the day's work were loaded each morning, and the scow towed to the site. The stone for crushing was obtained directly from the back filling of the cribs and hoisted to the crusher platform in tubs, where two men fed it continually to the crusher. This stone, being dredged from the bottom of the lake, was clean and excellent for concrete. The stone thus crushed runs out below into another skip or tub. When 3" or 4" have accumulated the spout door is closed and a wheelbarrow of sand from the pile close at hand is dumped in and spread, followed by two or

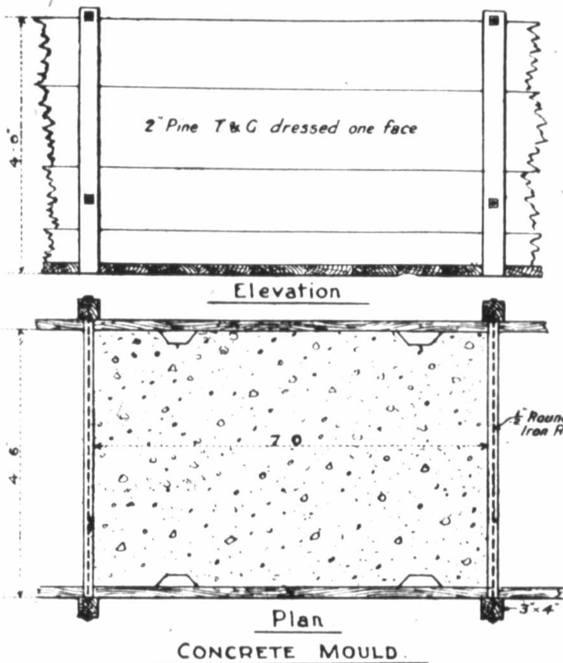
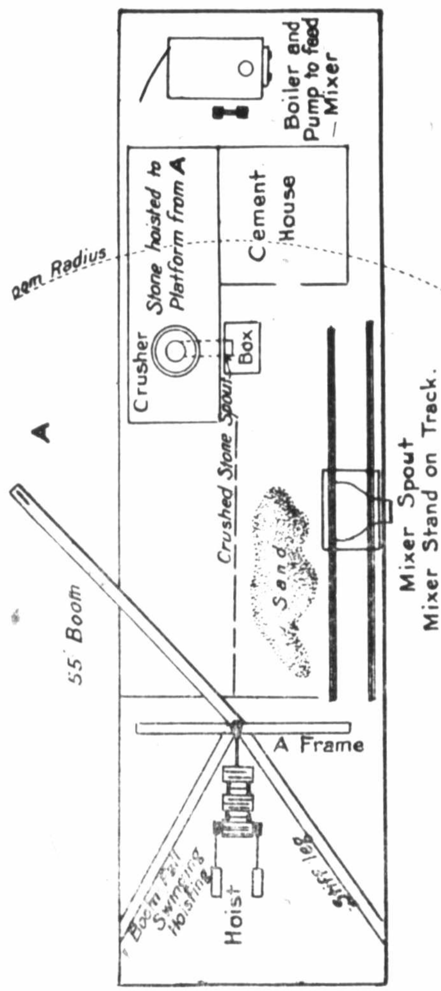


Fig. 8.

three bags of cement. This alternate process is continued until the box is filled, when it is hoisted up and dumped into the incline bin of the mixer, and thus runs in a continuous stream through the mixer itself and into moulds below. Besides being continuous, this system is compact and has great range. Where stone was not available from filling it was brought alongside in scows and used as wanted.

The mixer used consists essentially of a sheet iron spout having small iron rods placed to line of flow to give a tumbling or turning over motion to the concrete. A perforated pipe, controlled



PLAN OF CONCRETE SCOW
110' x 30' x 12'.

Fig. 9.

by a valve sprays water over the dry mixture as it passes. A door at the bottom of spout is operated by a man, who also controls the water. The door is kept closed till the lower chamber of the spout is filled when concrete is released and door closed for another batch, about two shovelfulls.

A larger boiler on the scow provided steam for hoist, crusher and engine, and small pump, which fed mixer.

An average day's work consisted of 65 to 75 yards for a gang of 18 Italians, forman and hoistman, or about 50 cents per yard for labour. Cement used (at least 40,000 barrels to date) was Rathbun "Star," made in Deseronto, Ontario, and the results obtained have been excellent.

The mixer moved on tracks, and both could be lifted off and set up on a wall within radius of boom, and the concrete process go on as before. Such a method was used in laying slab covering of docks.

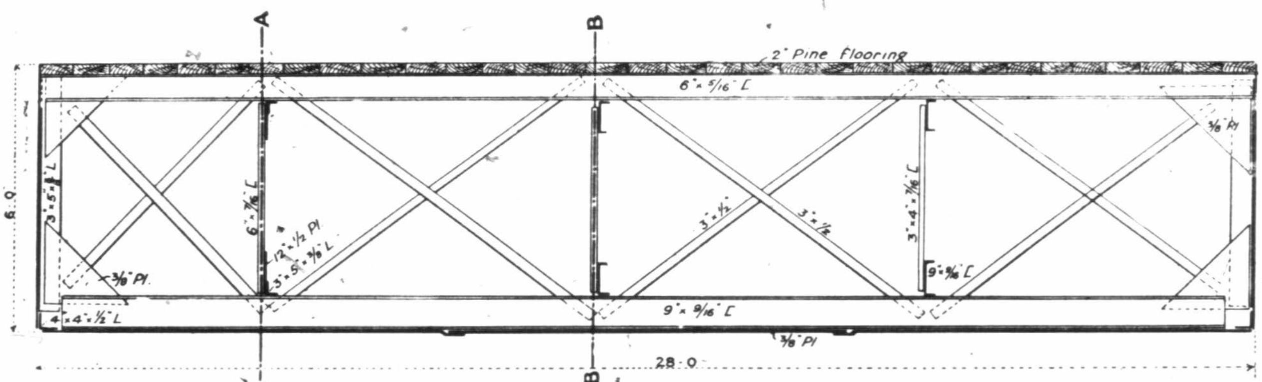
Excavation.

The principal item of this part of the work consisted of the drilling, blasting and dredging of 300,000 cubic yards of very hard flinty limestone over a great area. The above quantity is in place, not scow measurement. The cut varied from 6" to 6' but to get down to grade it was necessary to drill and blast at 2' to 3' below the grade to avoid pinnacles and ledges being left. No payment is allowed however, for this extra depth, except as filling. Owing to constant interruptions by storms this has been the most troublesome part of the work.

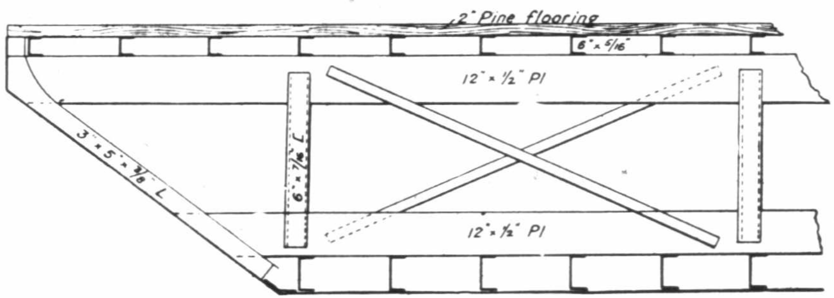
Drilling and Blasting.

To drill and blast this a submarine drill boat is used, consisting of a specially strong hull, steel preferably, housed over and carrying the boiler, large steam pump drill frames, drills and hydraulic feed for same.

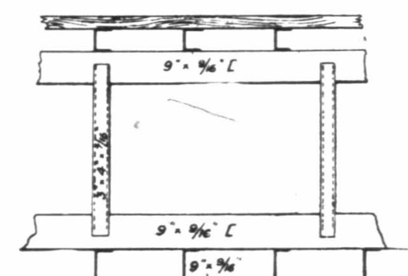
The latest type used at Port Colborne, and built 1903, consists of steel hull 100' x 27' x 6' of ⅜" plate (see Figure 10) having cross and longitudinal trusses composed of channels and bracing. It will be noticed that the drill frame side is specially strengthened by shortening the panel length in cross section so that panel post comes under drill frame, and also by the use of ½" x 12" plate and bracing longitudinally. The stresses are here a maximum, owing to constant pounding of drills and the impact of the blast underneath. Another feature is that scow ends, in place of the ordinary square form of design, the corners of which were soon opened by the blasting, and it was impossible to keep the boat tight. The boat



Cross Section
DRILL BOAT "VOLCANIC"



Section A-A.



Section B-B

Fig. 10.

is also easier to tow. The boat is pinned up, i.e., part of her weight, possibly 60 tons, taken on oak spuds 14" x 16" at each corner. She is thus held in place. These spuds run in guides and have cast iron rocking sunk even with their face on inner side. A gear wheel attached to slides works in this rocking and lowers or hoists spuds. A single upright engine operates a series of shafting under deck which connects wit hthis spud gear wheel. This is an imprcvement on the old method of an engine attached directly to each spud, as owing to these engines freezing up, no winter work could be done.

The drill proper is attached to a carriage composed of two angles latticed, and having a saddle at top. This carriage moves on two uprights, i.e., the drill frame. An hydraulic ram, working between these uprights and attached to saddle drill carriage takes the place of the hand feed on land drills. This ran is controlled by a three-way valve, by which the drill carriage is lowered or raised, and, of course, the drill with it. A large steam pump, to which is attached a governor to control the speed of pumping to requirements, supplies hydraulic power for ram. The drill bore is of 1¾" round machinery steel to which is welded a piece of 2" octagon steel to form drill shank. The drill having 8½" stroke is run by steam similar to land drill.

Three drill frames are mounted on the boat on rails and moveable by ratchet and level attached to the axle of the drill truck wheel.

To load holes a cylinder is used having a smaller diameter than the hole and of sufficient length to admit the whole cartridge. This cylinder is slotted on one side to insert cartridge and connecting wire. To cylinder is attached a long piece of 1" gas pipe coming well above the water. The drill bar being withdrawn, this apparatus is put down into the hole and a long pole, run down through the pipe, forces the cartridge from the cylinder into the hole. The loading apparatus is then withdrawn and charge exploded by battery.

Dynamite of 75% strength (as against 40% ordinarily used) is required for this work. Holes placed 6' apart and loaded 7½ lbs. to an 8' hole gives best results. The dynamite is made in sticks 1¾" diameter and 3' long, a stick weighing 5 lbs. The shock from a blast in 16' of water is quite perceptible.

The following data compiled by the writer from foreman's reports, etc., show the results accomplished by one drill boat for the five months from April to August, 1904. Owing to the constant storms, which drive the boats from their ranges and the loss of time in getting back on said ranges, the records are not a measure of the actual capacity of the boat.

	Days of 12 hrs. worked	Holes.	Feet drilled	Lbs. powder	Ft. per hs. per 3 drillr
April...	49	2282	10170	8527	18
May..	43	1348	6280	5624	12.2
June..	50	1453	8133	6947	13.5
July..	43	1512	6950	6104	13.4
August	43	1348	6478	5511	12.5

Days worked included the time to set up on ranges and the time the drill was on the range, but could not drill owing to weather. Night and day crews were worked. The time the drill lay idle in basin weather-bound is not included in days worked. The month of April shows larger results because the drill worked in a sheltered position in the canal. The depth of drilling seems to make little difference to average result as seen from June and July records, the depth of drilling in the former month being in excess of the latter. A deep hole requires an extra drill bar which takes time to insert, and deep drilling is also troublesome on account of binding, etc., but this is off-set by the extra blasting in shallower drilling, and loss of time in starting holes.

The best performance, as indicated by the record, was the drilling of 323 holes, or 1,615 feet, in 72 hours, day work, from April 4th to 9th, or an average of 22.4 feet per hour, per three drills. Best day's work was 315, or an average of 27′ per hour.

Dredging.

The dredges used to dig this rock are of recent construction, i.e., 1902 and 1904, and possess great power. The hulls are of steel ½″ plate at sides and 1″ at bow. The dredge is pinned up on two forward spuds (see photo) 36″ x 36″ oak running in slides. These spuds form the front corners of the hull, which gives a clear side with no projections to be knocked off at the stern (scow type). A single spud 20″ square placed in centre of boat and at an angle to the vertical holds boat up against the bank, and prevents swinging. This spud is geared simflar to drill spuds, and has a separate engine, while forward spuds are operated by cables from main engine. The feature of the hull is the extra strength of machinery Kelsons, which instead of being small I beam box girders, consists of stiff truss the depth of hull and fastened to deck channels above, as well as to floor or bottom of boat. This greatly stiffens the vulnerable part of the boat, the bow, and prevents working of Kelsons under the pull of the engines and consequent opening of bottom and bow plates. Another feature is the carrying of the overhead truss the full length of the boat, thus aflording a sucure fastening of the stern anchors and a better distribution of the stress it exerts, besides adding to the general stiffness.

The power is got from two 18 x 20 horizontal engines fed by Scotch Marine Boiler 11′ x 13′, furnishing 140 lb pressure. A small

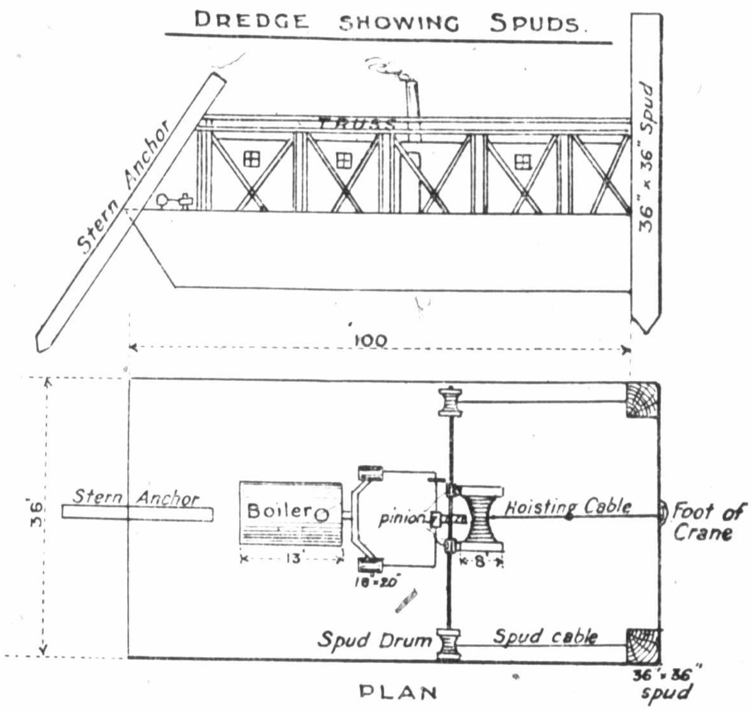


Fig. 11.

ends of which are attached two more small pinions operating the main hoisting drum, which is 8′ in diameter. The first series of shafting is extended in bearings to the sides of the boat, and has pinion on engine shaft operates a larger pinion on a shaft, to the attached to it the drums for lifting spuds. When boat is pinned up these drums are thrown out of gear and spuds held up by friction brake, operated on deck by the crew. To lower away the dredge it is only necessary to slack the friction brake.

The hoisting cable is of 2¼" wire rope, and when in digging anything specially hard is encountered care has to be taken or the dredge will snap this cable-like rope. The average life of a cable in digging rock is not over a month. The dredges are of the single whip variety, no system of pulleys or blocks being used on crane to obtain power, but a single line of cable from drum to bucket. Anchor cables are of 1¾" wire rope, while a special engine and 1¼ test chain is used for swinging.

These dredges operate a four yard bucket. Their performances vary greatly, for the frequent hauling of drills from ranges for safety causes many undrilled areas of small extent, which make difficult and almost solid rock dredging. As little as 250 yards a day is sometimes got. Tests taken of the new 1904 dredge in well drilled material loaded in skips of five yards capacity shewed an output of 4,385 cubic yards in six days of twelve hours. Deducting five hours delay for repairs, this gives an actual average of 65.5 cubic yards an hour. No effort was made for a record. Her best performance was 1,000 yards (in tubs) in 12 hours. These are rock figures, the dredges never having been tried in soft material.

The excavation is loaded in dump scows or tubs, according to the purpose for which it is required. No filling can be done by dump scows in less than 7′ of water. To handle skips, a large A frame steel derrick with 65′ boom, capable of lifting 20 tons, was built. To carry this a special scow 120′ x 36′ x 11′ was built, having steel trusses, etc.. Owing to its breadth and stiffness it was possible to lift to the capacity of the derrick without any pinning-up apparatus.

While this derrick was an experiment it proved most succesful, being easier to handle and tow than regular speed derrick, and besides requiring no time to pin up, it provided a large space for carrying materials.

These works are now almost completed. The tenders for putting in foundations for a 2,000,000 bushel elevator are under consideration, and with the erection of this elevator Port Colborne will possess a harbour equal to the best.

The work has been done by contract under enormous difficulties. Many of the features were new, and of the experimental character, which required new devices and new methods. The weather proved a constant menace, summer and winter, time and again storms having wrecked cribs, sunk scows and drill boats, and driven the fleet into the harbour and twice below the canal locks for shelter. With the system of breakwater erected such a state of things can no longer prevail.