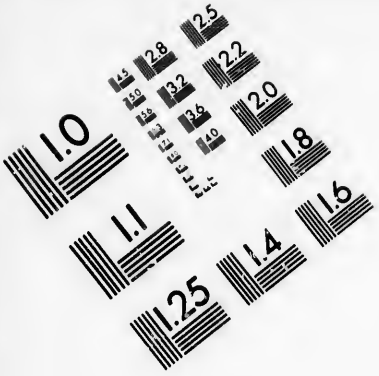
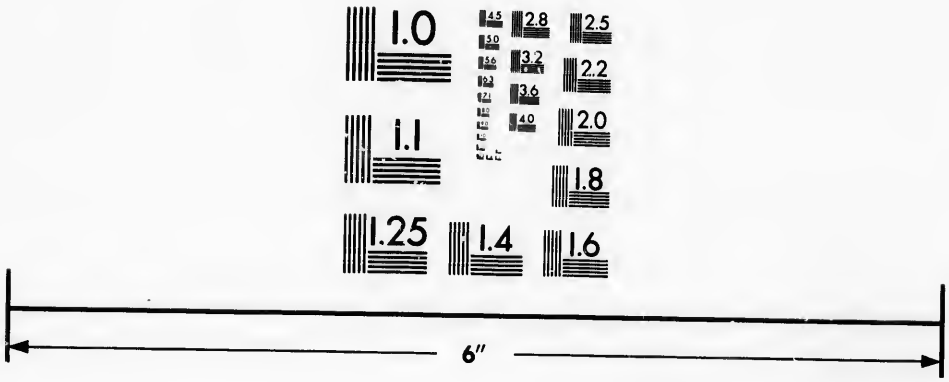
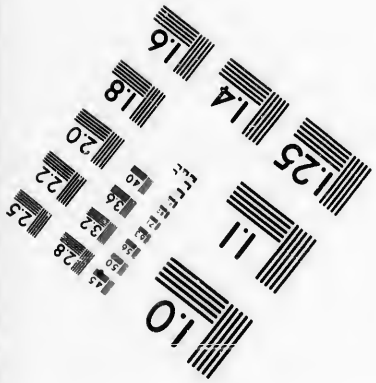
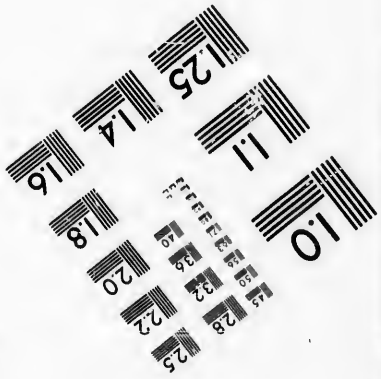


IMAGE EVALUATION TEST TARGET (MT-3)







Photographic Sciences Corporation

23 WEST MAIN STREET
WEBSTER, N.Y. 14580
(716) 872-4503

Technical and Bibliographic Notes/Notes techniques et bibliographiques

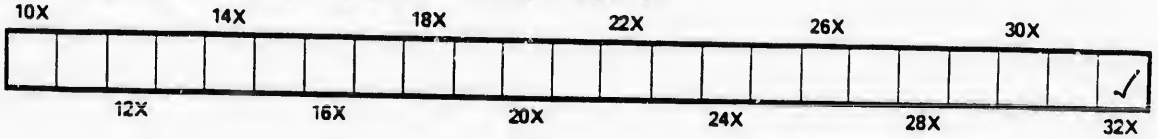
The Institute has attempted to obtain the best original copy available for filming. Features of this copy which may be bibliographically unique, which may alter any of the images in the reproduction, or which may significantly change the usual method of filming, are checked below.

- ☐ Coloured covers/ Couverture de couleur
- ☐ Covers damaged/ Couverture endommagée
- ☐ Covers restored and/or laminated/ Couverture restaurée et/ou pelliculée
- ☐ Cover title missing/ Le titre de couverture manque
- ☐ Coloured maps/ Cartes géographiques en couleur
- ☐ Coloured ink (i.e. other than blue or black)/ Encre de couleur (i.e. autre que bleue ou noire)
- ☐ Coloured plates and/or illustrations/ Planches et/ou illustrations en couleur
- ☐ Bound with other material/ Relié avec d'autres documents
- ☐ Tight binding may cause shadows or distortion along interior margin/ La reliure serrée peut causer de l'ombre ou de la distorsion le long de la marge intérieure
- ☐ Blank leaves added during restoration may appear within the text. Whenever possible, these have been omitted from filming/ Il se peut que certaines pages blanches ajoutées lors d'une restauration apparaissent dans le texte, mais, lorsque cela était possible, ces pages n'ont pas été filmées.
- ☐ Additional comments:/ Commentaires supplémentaires:

L'Institut a microfilmé le meilleur exemplaire qu'il lui a été possible de se procurer. Les détails de cet exemplaire qui sont peut-être uniques du point de vue bibliographique, qui peuvent modifier une image reproduite, ou qui peuvent exiger une modification dans la méthode normale de filmage sont indiqués ci-dessous.

- ☐ Coloured pages/ Pages de couleur
- ☐ Pages damaged/ Pages endommagées
- ☐ Pages restored and/or laminated/ Pages restaurées et/ou pelliculées
- ☑ Pages discoloured, stained or foxed/ Pages décolorées, tachetées ou piquées
- ☐ Pages detached/ Pages détachées
- ☑ Showthrough/ Transparence
- ☐ Quality of print varies/ Qualité inégale de l'impression
- ☐ Includes supplementary material/ Comprend du matériel supplémentaire
- ☐ Only edition available/ Seule édition disponible
- ☐ Pages wholly or partially obscured by errata slips, tissues, etc., have been refilmed to ensure the best possible image/ Les pages totalement ou partiellement obscurcies par un feuillet d'errata, une pelure, etc., ont été filmées à nouveau de façon à obtenir la meilleure image possible.

This item is filmed at the reduction ratio checked below/
Ce document est filmé au taux de réduction indiqué ci-dessous.



Canadian Society of Civil Engineers.

ESTABLISHED 1887.

TRANSACTIONS.

CONSTRUCTION OF THE CANADIAN PACIFIC RAILWAY GRAIN ELEVATORS.

By Stuart Howard, M.C.S., C.E.

The Grain Elevators lately constructed by the Canadian Pacific Ry. Co., in the City of Montreal, are located south of the old Quebec Gate Barracks, now the Dalhousie Square Station, and above the wharf belonging to the Montreal Harbor Commissioners, which property has been reclaimed from the river, the front being protected by cribwork, and the space filled in with stone, debris and clay.

There are two Elevators, 210 feet long and 80 feet wide, built on the old river slope over the Harbor wharf, it was, therefore, thought expedient to pile the foundations and not to trust to any unsound bottom, as the total weight of each building, including masonry, and timber, and a full elevator of 560,000 bushels of grain, amounts to a little over 10,000,000 lbs., the area being divided into 102 bin spaces, of about 12' square, each bin being supported upon a tier of masonry, with a weight on each of 197,000 lbs., equal to 70 lbs. on each sq. inch of concrete foundation.

A retaining wall, 12 feet wide at the bottom, 22 feet in height above the wharf level, and 5 feet below it, containing 7½ cub. yds. per running foot of wall has been constructed from the masonry of the Brock Street Ramp to the eastern elevator, a length of 118 feet, then the easterly elevator, a length of 208' between the 2 elevators 250' in length of this retaining wall, and from the west end of the westerly elevator the same section of wall is built to Barrack Street, and with a gap of 50 feet is clung to a double ramp, it is again continued to Frippsone Street, on a grade of 1 in 20 to the level of the Harbor revetment wall. The new level of Water Street being 10 feet above the old level this retaining wall was built to support the earth filled in at the back, to make the new street, which is carried some distance south of the old river bank.

Piles were used in the entire foundations of the elevators and connecting buildings, the front wall or that nearest the river having 3 rows, and the back and end walls 2 rows of piles placed at 3' centres, each pier, of which there are 80 in each elevator, being built upon a cluster of 9 piles, the engine and boiler beds, and the chimney also resting upon a pile foundation. The piles were driven in by means of a driver worked by steam, the ram weighing 1 100 lbs. with a fall of 20 feet, they were cut off 9 inches above the bottom of the trenches, which were 2 feet deep, the whole of these excavations being filled in to the level of the natural ground surface with concrete well rammed, and composed of 2 parts of sand, 1 of White's Portland cement, and as much stone as required, in order that all the voids were filled, on this foundation which extended 12 inches beyond the walls on either side, the masonry was commenced. The front wall has a concrete width of 8 feet, the bottom footings being 7 feet and the wall 6 feet wide, the back and side walls are 4 feet in width and the concrete feet, these latter being further strengthened by buttresses 4 feet wide, placed every 25 feet, and bonded into the piers, in order to resist the thrust of the outside earth. The piers are 4 feet square with 2 6 inch footings, the concrete being 7 feet square, these are finished off at a level of 2'3⅜" and the copings of the walls 3'1' above low water, earth being filled in to a level of 9 inches below the top of the piers, the space up to the street level being utilized as a sort of cellar to contain the iron receiving tanks and the bottom of the elevating legs used for raising the grain from these tanks to the top of the building for distribution into the different bins. It will readily be seen from the foregoing description that the foundations up to the street level were necessarily very deep and expensive, the height from the wharf to this level being 22 feet; a casual observer approaching from the Station side would imagine the foundations to be only of an ordinary description, until on looking over the retaining wall described above, a solid wall of masonry 22 feet in height is seen. The total quantities of pilework, concrete and masonry

in the two elevators, revetment wall, engine, boiler, and chimney foundations being 43,389 lineal feet of piles, 1,362 cub. yds of concrete 16,187 cub. eyds of masonry, and over 40,000 cub. yds of excavation and filling, amounting to $10,847.00 for piles driven, $10,554.00 for concrete $125,450.00 for masonry, and $8,000.00 for earthwork, a grand total of $154,851.00 for work now covered up and hidden from view, presenting alone a line face of masonry wall viewed from the river.

On each pier 4-12"×14" posts 25'6" long are placed and kept one inch apart by wooden keys, the whole being thoroughly bolted together on these posts and mortised to them are 2 12"×12" caps, and above them 2 12"×14" pieces also keyed and bolted, and strengthened by 8"×8" braces set at an angle of 45°, and tenoned into the posts, these caps run from front to back, resting also upon 2-12"×14" posts on the copings of the walls. On those timbers and running longitudinally are 2-12"×16" timbers placed midway between the posts, forming at the centre the bin mouths; 12"×14" longitudinal pieces placed directly over the posts also thoroughly braced carry with the 4 cross timbers the bin walls. The posts around the building and on the copings, are immediately opposite those on the piers, and are 2-12" 14" timbers.

The railway tracks (two in each building) are carried by 12"×14" stringers, directly under each rail, resting upon 12"×12" timbers opposite each cluster of posts, and thoroughly braced with 9"×9" pieces. The flooring is supported on 3" 12" joists,-24 centres laid upon 8" 12" longitudinal pieces let into the sides of the posts and well bolted to them. The bin walls are constructed of 2"-6" planks, and the outer walls of 2"×8" planks laid one upon the other, breaking joint, and well spiked with 5 inch spike nails, every 15 inches, the bottoms are at an angle of 45°, with an opening of 12 inches square in the centre, resting on the 12"×16" longitudinal timbers, to the underside of which the castings for the revolving spouts are fixed. These bins are 50 feet in depth with a ladder in the corner of each made of ¾ round iron, flattened at the ends, and placed between the planking, the inside bottom of each bin being lined with iron to prevent the planks from wearing away by the friction of the grain, there are 102 bins in each elevator, 2 of which are lost however, one being used for the staircase, and the other for the driving belt, the remaining 100 having a total capacity of 560,000 bushels.

The cupola or central portion at the top is reduced to a width of 49 feet, and so that it may have a solid bearing and not be dependent upon the shrinkage of the bin walls (as formerly in elevators the upper stories rested immediately upon the bin walls) it is carried by 10"×10" posts set in the corners of the bins, and resting upon the posts on the piers, and held by iron straps passing round them and through the bin walls. There are 4 stories above the bins, the framework being posts 10"×10", with caps 10"-10", braced with 6"×6" pieces, and running longitudinally of the building, are 10"-10" timbers, also thoroughly braced, the floor joists are 2"-10"-18" centres running lengthwise of the building, the flooring being 1¼" thick. The rafters are 2"-8"-16" centres resting on 6"-10" plates, the roof being ¼ pitch, covered with one inch boarding and Canada plate. A staircase with 104 steps, 3"×6" wide, risers 8 inches and 9 inch treads, is placed in the S.E. corner of the building, carried by upright posts 6" square, being thereby made independent of any shrinkage of the bin walls, this leads only to the level of the top of the bins, above this are 2 other staircases from floor to floor, one at each end of the building. The timber in the elevator above the foundations amounts to about 1,250,000 ft. B. M. The elevator is supplied throughout with speaking tubes and gongs, and well protected in case of fire, by pipes connecting with the engine room, the pressure of water being supplied from the City, and in case of necessity worked by a Northey pump of 120lb pressure, connected with the engine, branches with hose and nozzles being laid on each floor. The whole exterior of the walls are covered with corrugated iron 26 gauge, the corrugations on the cupola and lower part being vertical, and on the bin walls horizontal iron fire escape ladders are also provided

The upper story of the cupola contains the machinery, the shaft carrying the pulleys, being from 6 to 5 inches in diameter, is made in sections bolted together and supported by cast iron brackets, on a strong timber frame. The driving pulleys, of which there are nine in all, 4 for the south elevating legs, and 5 for those on the north or track side, are 5 feet in diameter and 22 inches face they are fixed to moveable sleeves through which the shaft passes, and are thrown in or out of gear by strong clutches worked by levers with screw bar attached, and operated by means of wheels turned by hand. The legs on the north side are set in motion by belts running over pulleys on the main shaft, tightened by tightening wheels attached to a frame, and worked by ratchet gearing. The elevating legs are made of 2" T and G plank, screwed together, forming a box with an internal dimension of 12"-24", running from the bottom of the receiving tanks to the top of the building, the belt to which the buckets are fixed being inside, passing round a wheel 24" in diameter at the bottom and the 5' diameter pulley on the main shaft at the top of the building. The bottom wheel works in a cast iron frame, and can be lowered or raised at pleasure by a ratchet. The belts in the elevating legs are 256 feet long and 20 inches face, the buckets being 18"-7"-7", placed every 15½ inches, and bolted to the belt, each bucket holds ¾ of a bushel, so as the pulley makes 36 revolutions per minute, the belt

travels at the rate of 569 feet per minute, each leg being able to raise 8,790 bushels per hour. Before continuing to show the method of manipulating the grain, it is necessary to describe the power used for setting the machinery in motion.

The Boiler House is a substantial brick and timber structure, 40'× 47', placed midway between the elevators, with a height to the eaves of 20 feet, the roof sloping each way, and surmounted by a good ventilator, and contains at present 3 boilers 5' 6" in dia. and 15 feet long, with 56-3¼" tubes firegrate 4' 6" × 6', they were built at the Montreal shops of the Canadian Pacific Railway.

The boilers are placed upon a strong timber foundation of 2 thicknesses of 6" timber, placed on 10" × 10" caps, mortised on to piles placed at 3' centres, and driven through the 22 feet of earth filling over the wharf level, into the solid ground below, being at least 30' long.

The steam from the boilers is conveyed to the engines which are placed in buildings 24' × 40' adjoining the elevators, by a 6 inch pipe laid in a wood n box, containing besides the feed pipes for the boilers and the exhaust pipes. The engine of No. 1 elevator is a Wheelock Horizontal Engine with condensor attached, making it equivalent to 175 horse power, the cold water for the condensor being pumped by a Northey pump, direct from the River through an eight inch iron pipe, passing under the revetment wall and into a well at the river front in the warf cribwork, the water entering by a hole cut through the front timbers, 12 inches below low water. Inside the well a foot valve is placed to equalize the pressure. The waste water is run through an ordinary 9 inch sewer pipe, laid in the same trench as the water pipe, but carried down stream on approaching the river. The dimensions of the engine are, cylinder 20" × 48" with a fly wheel of 16' diameter, making 65 revolutions per minute this is reduced to 36 by means of a 5' 4" and 9' 4" diameter cogwheels with a face of 16 inches pitch of teeth 5 inches, the larger one is on the 40' driving shaft, to which the driving pulley of a face of 18 inches and 7 feet in diameter is attached, the main belt, 46 inches wide, of 6 ply rubber, made by the Canada Rubber Co., 250 feet long, passing round it, and over a 7 foot pulley wheel on the main shaft at the top of the elevator, setting in motion the machinery for driving the elevating legs.

Between the two tracks is a platform 4 feet above the rails, and 11 feet wide, and below this are 5 receiving tanks made of 2 inch T and G planks, and lined inside with iron, set in wrought iron tanks and placed on the level of the piers, these tanks are 35 feet centre to centre, or as near as possible opposite the car doors, and at the level of the rails and extending up to those nearest the platform are iron gratings. The cars can be moved about at pleasure by means of a hawser wound round a capstair, and attached to the front of the cars. When the grain is ready to be unloaded, it is done by a wooden shovel, with 2 handles attached (in shape like a railway scraper) with a rope connected to it, and wound round a drum working automatically, on a shaft fixed to the posts over the platform, and running the whole length of the building, there are 5 of these shovels, one over each tank; the shovel is drawn into the car, and as soon as the tension is taken off the rope, a small hammer falls, and the drum is turned, winding up the rope, and scraping the grain from the car's door, down on to the grating through which it passes into the tank, the sides of which are at an angle of 45°, it pours then through a small door at the bottom immediately under the elevating leg, the buckets scooping it up, and elevating it to the top of the building, where it is discharged into a receiving hopper, from this it drops into the weighing hopper, of a capacity of 30,000 lbs, or 500 bushels of grain. The shovels have an unloading capacity of one car of 600 bushels in 15 minutes, in most cases 5 cars per hour, and as there are 5 shovel machines with 2 drums on each the total number of bushels that can be unloaded per hour, with all the machines working, amounts to 30,000 bushels. The scales used are those made by the Fairbanks Scale Co., and are nine in number, an accurate account of the grain weighed being kept, the weight being also checked by a contrivance patented by Mr. Jamieson, a pencil operating on a card around a circular roller attached to the scale, and registering the exact weight each time the hopper is filled. Under each weighing hopper is a circular table, around which are fixed a number of wooden spouts leading to the bins belonging to its particular radius, the grain is therefore discharged through a revolving spout, fixed to the bottom of the weighing hopper, and placed opposite any particular spout, leading to the bin required to be filled. There are 4 legs on the south side, similar to the 5 on the track side, so that grain can be taken from any bin, run into one of these tanks, elevated, and put into another bin, and by dropping it, and continually passing it on, it is possible to take grain from a bin at the extreme end of the building, and put into one at the other.

The grain can be thoroughly cleaned by being passed through a separating machine, the smut and dust dropping into a receptacle for that purpose, the air is conducted from the cellar through a tight wooden box, the draught being caused by 2 fans, 4' in diameter each, revolving 625 to the minute. There are 2 separators one at each end of the building, and on the same floor as the scales and weighing hoppers.

2 spouts on the lower floor are used for loading cars, and the discharge

is so great that a car of 600 bushels can be filled in three minutes. On the lower floor is a 4 inch shaft, connected to the main driving shaft, and running longitudinally, supported on iron standards, the centre being 18 inches above the flooring, this is utilized for driving the conveyor belts. The conveyors are carried across the wharf on trestles, formed of 5" × 8" timbers, resting on sills bolted to posts, the bents being well braced and bolted, and placed at 12' centres. The chords are of 2-3" × 8" pieces strengthened by braces and straining beams, keyed and bolted to the chords on these rest the floor joists 2" × 8"–11'0" long and at 3' centres, the flooring being 2" thick and 11 feet wide. The upper portion is made as light as possible, being a simple framework supporting convex rollers 38" long, placed at 6' centres, there being two rows, 14 inches centre to centre. The grain in transit is protected by a tarred canvas covering, fastened to circular iron bands 3 inches wide and half an inch thick, placed 18 feet apart and supported also between these at every 3 feet by ¾ inch bars bent to the same radius, namely 36 inches, openings with flaps are opposite every roller, so that the journals can be oiled from the outside, space being left between the covering and the outside of the floor to admit of decent footwalks protected by hand railings, and leading across the entire structure from the elevator to the tower.

On a small shaft in the elevator is a 18" diameter pulley face 38", on a loose sleeve, worked with a clutch, and set in motion by a reversible bevel gearing, so that the conveyor belt can be run either in or out of the building for loading or unloading vessels. The conveyor belt is 36" wide, 5456" long of 4 ply rubber, and is carried on a level over the convex rollers, the grain being dropped on to it from the bins above through a small hopper, the belt being bagged at this particular point to run the grain on to the centre. The conveyor belt travels at the rate of 455' per minute, and its capacity is about 9,000 bushels per hour. The transit of grain should be seen in operation to be realized, as the idea that wheat and other grain, and especially peas, can be carried along on a flat and level belt without running over the sides is a wonderful fact. The grain after passing into the tower, which is at the river end of the structure, is discharged into a small hopper, to the bottom of which is fixed a rotating iron spout, capable of being raised or lowered to suit the height and position of the vessel's hatches, and dropping it into the ship's hold. There are 2 conveyors to each elevator placed at 146' centres, and are made as light as possible, the whole structure being put together with bolts, as they must be removed from the wharf as soon as navigation closes, and before the river rises. In the towers are horizontal tighteners, around which the belt passes fixed to a moveable iron frame, and worked by hand.

The Halifax elevator, as also the million bushel one in Boston, have conveyors on this principle. On my visit to the latter place I had the pleasure of seeing peas carried by a conveying belt out to the ocean steamers. Here the conveyor was over a quarter of a mile in length, and built not in one straight line but round corners, the grain being thrown from one belt on to another the belt itself being the driving power, bevel gear being keyed on to the shaft of the pulley wheel at the extreme end, and set into another on the adjoining belt at right angles to the centre, and at the angle of the turn the power being conveyed thereby. The last portion of the conveyor is built down the centre of a wharf with vessels on each side, and at certain distances on each side of the structure are receiving hoppers with spouts attached under which the vessels are placed.

Moveable trippers are then placed under the belt, lifting it up some little height above its level, the grain ascending the incline, and being shot forward by its velocity over the summit falls into any particular hopper, opposite which the tripper is placed, and is conveyed into the vessel's hold.

The chimney rests upon a pile and concrete foundation with 49 piles at 3' centre, the concrete being 24' square on the up to the level of the street is a solid mass of masonry 20' square at the bottom 22'6" high, and at the ground or street level 15' square. The ashlar work is carried up to a height above the street of 19'; with a heavy chamfered coping, from this the brickwork starts with a square base of 12', measuring in height 132 feet with a batter on each face of 1 in 47½. The walls are 18" in thickness at bottom with an air space of 12 inches, this space is carried up to a height of 100 feet the wall being reduced alternately 4 inches on either side of this space at every 25' of height, until at the point where it is vertical the walls are 16" and 20 inches, the top is surmounted with an iron cap, weighing over a ton, and is thoroughly bolted down to the brickwork, and was made in eight sections and bolted together in place. The shaft is 4' square inside measurement, and up to a height of 40' above the stonework is lined with 8 inches of firebrick. The walls are banded together with iron bands, and built into the brickwork in one corner the whole height of the chimney are iron steps.