AN EXPERIMENT IN ELEVATING AND CONVEYING WHEAT IN SACKS.

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(A paper read before the Sydney University Engineering Society, October 12th, 1904).

In the following pages it is proposed to give some account of the Darling Island Grain Elevating and Conveying Plant, its inception and evolution to date.

In the year 1899 a shed 150 ft. x 80 ft., without sides or flooring, was erected by the Harbours and Rivers Branch of the Department of Public Works as a cargo shed for the temporary accommodation of shipment wheat. In October, 1900, as the outcome of a Farmers' Conference, a deputation waited upon the Minister for Mines and Agriculture and indicated the necessity for more accommodation at Darling Island to deal with the anticipated increase in wheat traffic during the season of 1900-1. This was brought under the notice of the Railway Commissioners. The Public Works Department was then asked (17th October, 1900), to construct additional sheds, and in February, 1901, intimated that a tender had been accepted for the erection of a new shed 300 ft. x 80 ft. By this time over 100,000 sacks of wheat were stacked in and around the existing shed, the site of the proposed new shed being covered. It was then realised that to meet the requirements of the principal firms handling wheat, the accommodation should be very largely increased so as to permit of wheat being held for market advantages, etc., and pending the full consideration of this question, also having in view the fact that to remove the stacks of wheat from the proposed site for immediate building would be most inconvenient, and that the shed could not then be erected in time to be of much service for the current season, the Department of Public Works was asked not to proceed with the erection of it.

In May, 1901, a scheme was prepared embracing grain sheds, elevators and conveyors, and estimated to cost £42,000, the capacity of the elevators being 150 tons per hour, and the buildings 250 ft. long, capable of storing 5,000 tons on each of two floors. The building could be made three times as high at an additional cost of £30,000.

During the same month, after conferring with the Harbour Trust Commissioners, the Railway Commissioners communicated with the Colonial Treasurer, indicating the great urgency of the matter and offering to undertake the execution of the work if authorised, payment for same to be forthcoming from a sum of £100,000 provided in the Estimates for 1900, of the Department of Mines and Agriculture, "for increased facilities for handling and export of agricultural and other products, erection of grain elevators and other purposes of a like nature," the proposal being for two sheds as just described. Sheds when completed to be handed over to the Harbour Trust Commissioners, who could use them for general storage purposes when not required for wheat, which would be eight months of the year, the wheat season being of about four months duration. For the use of the wheat shipping appliances no charge was to be made, and for storage room ½d per sack per week after one week, payable to the Harbour Trust.

On June 11th, 1901, the Railway Commissioners wrote to the Under-Secretary for Mines and Agriculture pointing out the urgency of at once making provision for the coming season's traffic. They indicated a change from the original proposal for two sheds each 250 feet long to one of 750 feet long, two storey high, the grain to be run into the basement in trucks and elevated to the upper storey by belt conveyors, whence it could be delivered by chutes into the holds of ships alongside the wharves, the plant being estimated as capable of loading 3,000 tons into ships in ten hours. On June 20th, the Engineer-in-Chief for Existing Lines (the late Mr. T. R. Firth, M. Inst. C.E.) reported on an amended proposal, that which was eventually practically adopted. It provided for one shed to store 300,000 bags on one floor, equipped with elevators and conveyors capable of loading 2,000 tons in ten hours, the shed to be of timber, and with plant to cost £20,000, shed being of temporary character in view of the probable early change to the handling of grain in bulk. It was assumed that the necessary power to drive the machinery might be obtained from the Ultimo Tramway Power House, provided it be not required during certain hours of the day, 5 to 7 p.m., when tram traffic was heaviest.

This scheme was approved by the Board of Exports and on June 24th, 1901, the Railway Commissioners intimated their intention of immediately commencing the erection of the buildings.

At a meeting of representatives of the Commissioners and leading exporters of wheat, held on 3rd December, 1901, portions of the floor space of the new sheds were allotted by ballot to four leading grain handling firms, on the condition that the lessees should provide scales, weighers, and checkers, and all labour necessary for shipping or stacking purposes in the shed, and that they should be prepared to receive wheat at any time of day or night necessary; the Commissioners undertaking at the inception of the work to provide men to attend to the machinery.

Reporting on the state of the works on December 13th, 1901, the Engineer-in-Chief for Existing Lines pointed out the magnitude of the task of building so large a shed in five months, and equipping it with machinery for handling grain in bags. Drawings of the shed had to be prepared which took some weeks and reduced the period for actual work to four months. They had to design and arrange a Conveying Plant, such as did not exist in Australia, and find a contractor who would supply the plant in the time. This was accomplished, though much of the material, including electric motors, had to be imported from America. Internal and external elevators and conveyors necessitated the preparation of intricate drawings, and had to be built by contract, the contractors having worked overtime continuously.

On 16th December, 1901, the first trial run was made of No. 7 Elevator, and was deemed satisfactory.

It will be seen that, being compelled to design and erect within five months a plant of this magnitude and without the advantage of any similar experience, the work was largely of an experimental nature.

The original general arrangement of machinery in the shed is shown on the Plate. The shed is comparatively low, the height of building available for stacking being but 27 ft. The roof trusses are 15 ft. apart, and rest on 10 in. by 10 in. Oregon posts, the principal rafters being 8 in. by 5 in. and the tie 12 in. by 5 in. Oregon. The floor consists of 6 in. concrete laid on 6 in. rubble filling. The shed is 1,050 ft. long, and is subdivided into seven sections, each 150 ft. long. Each section was originally served by one elevator, two transverse and two longitudinal conveyors, and a portable elevator and travelling conveyor. The original elevators consisted essentially of two parallel endless link belts, carrying at intervals curved arms for the raising of wheat sacks from the siding platforms, being similar to barrel elevators. At the top end the elevator discharged the sack on to a conveyor, whence it fell on to a wooden chute, so pivoted and arranged that it might in turn discharge the sack either (1), on to the longitudinal conveyor underneath and toward either end of same; (2), into a fixed chute leading to a stack on the floor; or (3), on to a second transverse conveyor, which in turn would slightly elevate the sacks and deliver them on to another pivoted chute, whence they would pass (*a*), to the eastern longitudinal conveyor, or (*b*), on to the arm of a gantry conveyor, and thence to ship's hold—the machinery thus being employed for the purposes of stacking grain in the shed, or of conveying it through the shed to the ship.

The longitudinal conveyors were each about 110 ft. in length. Originally those in the western half of the shed were built in between the principal tie beams of the roof as shown, whilst those on the eastern side were suspended some three or four feet below the tie beams by hanger bolts. The conveyors consisted of one endless link belt, electrically driven from one end, every third or fourth link of the belt being an attachment link securing 5 in. by 1 in. by 2 ft. Mountain Ash battens transversely to it. The main stringers of the conveyor were 12 in. by 3 in. Oregon. The batten chain was supported at intervals by loose pulleys, whilst near their ends the battens could slide on 6 in. by 4 in. Tallowwood runners, which soon took a smooth greasy surface. These conveyors were driven from one end by $3\frac{1}{4}$ h.p. General Electric Co's. C.E. type reversible motor, running at 420 revolutions per minute, and gearing so as to impart a velocity of 75 ft. per minute to the conveyor belt.

Each section of the shed was provided with a portable elevator—a steel telescoping tower, built mainly of $2\frac{1}{2}$ in. by $2\frac{1}{2}$ in. by $\frac{3}{8}$ in. angle iron, carrying complete gearing, motor, etc., driving a double link belt with curved arms to lift sacks. At the top of the tower a chute was fixed to transfer the elevated sack on to a conveyor where required. These elevators had an under carriage with wheels 4 ft. $8\frac{1}{2}$ in. gauge, two tracks for same being laid longitudinally in floor of shed.

Between the shed and Darling Harbour run two lines of rail, so, to convey wheat from the floor of shed to a ship at any point along the shed a gantry was built, one rail for same being carried by the posts of the shed, and the other by the coping of the wharf. This gantry carried two arms pivoted on a horizontal shaft, on a framework supported on a turntable, so that it was possible within limits to move the arms to any position. These arms formed a continuous conveyor, worked by an electric motor attached to the framework. Each arm consisted of two lattice girders 1 ft. 6 in. deep, built of $2\frac{1}{2}$ in. by $2\frac{1}{2}$ in. by $\frac{3}{8}$ in. angle iron, and 2 in. by $\frac{3}{8}$ in. bars, the conveyor belting being two endless link belts 2 ft. 3 in. apart, supported at intervals by 4 in. diameter iron rollers attached to the crossbracing of arms and carrying Mountain Ash battens 5 in. by 1 in. by 3 ft. The arms were each raised and supported by two $3\frac{1}{2}$ in. circumference flexible steel wire ropes, worked off a 1 ft. 3 in. diameter barrel driven by hand power through bevel and worm gearing. By hand power also, through worm gearing, the turntable was operated, the conveyor frame traversed on the gantry transversely to wharf, and the whole gantry traversed longitudinally to wharf. Four of these gantries or travelling conveyors were built.

The chutes used for stacking in the shed or into a ship were built of hardwood planking, and trussed to afford necessary strength and rigidity.

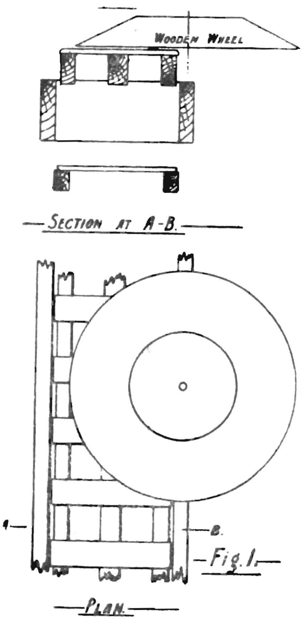
Having dealt thus very briefly with the original equipment it remains to indicate the results achieved and the alterations made.

One of the most difficult problems to be dealt with lay at the first link of the chain, so to speak, viz., in the fixed elevators. The curved arms so successfully employed in elevating barrels were found to give results far from satisfactory in dealing with sacks of all degrees of satiety. With a tight sack the elevating was generally fairly successful, but with anything short thereof the sack had an unfortunate way of becoming involved in the elevating belt, or of falling headlong, which was of course dangerous, considering that the slope of the elevator was about 75 deg. with the horizontal. This type of elevator has accordingly been superseded, and in its place there has been erected what may be called an elevator-conveyor, similar in structure to the conveyors now installed, viz., two parallel link belts, about 1 ft. apart, carrying 5 in. by 1 in. by 2 ft. battens, spaced from 11 in. to 13 in. centre to centre. The belts are driven from the top end by a motor supported on a platform erected on the principal tie beams. The main frame of this elevator consists of two 12 in. by 3 in. Oregon beams 2 ft. 1 in. apart, and carrying two pairs of 6 in. by 3 in. Tallowwood runners, to carry up and down-going belt and battens. The battens are bevelled, as shown, on the upper or front edge, and armoured with a strip of $\frac{1}{16}$ in. by 1 in. W.I. to increase their hold upon the sacks. Generally speaking, the tendency of a sack of grain is to hold more tightly on the batten belt as its elevation proceeds. Experience has shown that the greatest useful inclination of this arrangement of elevator is 45 deg.

It was found necessary to build the elevators as steep as indicated in order to provide headway for the roads passing between the foot of the elevator and the shed; but when sufficient elevation is obtained the slope is much reduced, consequently there may be two or even three different inclinations in the one elevator. For convenience of handling, the platforms have been widened by 1 ft. 6 in., allowing the foot of an elevator to be set thereunder and of a 40 ton weighbridge being erected at each platform. In order to prevent accident through the back-running of an elevator when loaded, being stopped through any cause, an automatic mechanical brake has been fitted to the driving end of the elevator, coming into action as soon as the load begins to descend.

The working of the longitudinal conveyors with single link belt carrying the battens left much to be desired.

The conveyors throughout have now two belts of a lighter build, and the idler wheels supporting the belt have been dispensed with, the result being smooth running, absence of noise, and immunity from broken battens. On the other hand there is considerable wear between the battens and supporting runners, and it will probably soon be found necessary to protect the latter by a strip of metal. It was found unnecessary to have two longitudinal conveyors, consequently but one, that on the Darling Harbour side of the shed, is now in use. It has been framed up between the principal tie beams, extended in length to 140 ft. approximately, and divided opposite the cross conveyor into two equal lengths, a motor and driving gear being placed at each outer end. It can thus now work as two independent conveyors, or as one by driving each half in the same direction, thus enabling sacks to pass from one end of the section to the other. An idle hexagonal roller 6 in. diameter, of hardwood, supports the sack in its passage across the gap between the half conveyors, which, of course, are only sufficiently far apart to afford clearance for the travelling battens.



Various attempts have been made to solve the problem of how to switch sacks from the conveyors at any point during their progress. One scheme may be mentioned as affording illustration of the difficulty of elevating and conveying grain in sacks. This device was a wooden wheel about 4 ft. diameter, of a truncated cone shape, the face being 6in. wide, and sloping at an angle of 30 deg. This was arranged to revolve just above and over the battens as indicated in figure. It was found to answer fairly well with sacks well filled, but a partially filled sack was nearly always drawn in between this wheel and the battens and torn.

To provide for as well as to predict the vagaries of a partially filled sack of wheat has been a perplexing problem for those engaged in the design and operation of the plant.

The transverse conveyors were originally built as shewn on the Plate. The elevated sack was delivered on to these by fixed and pivoted chutes, as indicated on the drawing. This necessitated a drop of some feet in height, requiring re-elevation of the sacks, a loss of energy. The transverse conveyor has been remodelled, by the substitution of a small conveyor for the fixed chute, this latter conveyor being driven from the original one, a hexagonal wooden roller, between the ends carrying the sacks over the interval. The sacks first descend slightly, sufficient to obtain clearance under the middle roof guttering of the sheds, but the surplus energy after overcoming friction is utilized, while the passage of the sacks is more nearly absolutely mechanical. The transverse conveyor is also driven by an electric motor from its higher end. A more recent arrangement has made the transverse and intermediate conveyors one and the same. Under the higher end of this conveyor, and fixed over the longitudinal conveyor is a wooden chute pivoted so that it may be turned in azimuth through an angle of 180 deg. It can be trained to discharge on to either half of the longitudinal conveyor or over it on to a chute leading to a ship's hold. The pivoted chute (see plate) is carved out of 12 in. x 3 in. tallow-wood and so shaped that it can automatically turn the sacks through any angle up to a right angle, the sacks always travelling end foremost.

For the purpose of stacking wheat in the shed from the railway trucks, it is elevated and discharged through chutes from the ends of the elevators or conveyors. Formerly these chutes were built of wood about 2 in. thick by 3 ft. 6 in. wide, in several lengths up to 28 ft., some fixed to the roof timbers and others detachable. The labour and time expended in the erection or removal of these as required, were considerable, and this led to the design and adoption of the present type. This consists essentially of two parallel weldless steel tubes, 2½ in. to 3 in. dia., braced together at long intervals by light channel iron yokes; they are made telescopic to allow for variation in length necessary as stacking progresses. They are very light and strong and may rapidly be placed in or out of position and not only so, they command a larger area of floor than wooden chutes, because of the smaller co-efficient of friction. With well worn tallow wood chutes the sacks would just slide down a slope of 4⅜ in. in 1 ft. or about 20 deg.; whereas on the steel chutes they will just slide down a slope of 3¾ in. in 1 ft. or about 17 deg.

These chutes are now used for delivering sacks directly into the holds of vessels lying at the wharves, when the vessels are not too high out of the water; on the decks the chutes are supported on telescoping trestles made of the same material, and to lessen the speed of sacks are generally curved before being brought into the hatchway; down the hatchway the sacks travel on tubular chutes from one side to the other, turning one or more somersaults in their descent, and thence after traversing another length of straight tubular chute, are stacked by a few hands in the hold. Thus from the foot of the elevator, across the shed and to the bottom of a vessels hold, the travel of the sacks is continuous and mechanical.

Formerly, when it was desired to load vessels which stood high out of the water (*e.g.*, the deck rail of the "*Medic*" when light stands about 27 ft. or 28 ft. above the wharf at Darling Island), the sacks were discharged in the shed on to one arm of the travelling conveyor hereinbefore described, and by it elevated to to the deck. On these travelling conveyors the sacks were formerly carried broadside on, and on account of the arms being supported by wire ropes, their operation gave them a swinging motion vertically, which caused some amount of slip, to the sacks, which consequently mounted together and overloaded the arms. To remedy this the gearing has been altered to run at higher speed, and the arms narrowed to take the sacks end on, as in the remainder of the system. These conveyors are now also used to load ships from the shed in a simpler and more direct method than hitherto. Formerly a portable telescopic steel tower elevator was used to hoist sacks on to the arm of the travelling conveyor, either directly or by way of the transverse or longitudinal conveyors. This was partly necessary because the arm of the travelling conveyor could not be lowered to within less than about 12 ft. of the ground. Now a light steel movable conveyor has been built, which can be rapidly attached at its top end to the end of the travelling conveyor arm, the bottom end resting on the floor of the shed. It is inclined at 45 deg. and is worked continuously with the travelling conveyor as an elevator-conveyor combined. This detachable conveyor is built of $1\frac{1}{2}$ in. x $1\frac{1}{2}$ in. x $\frac{1}{4}$ in. angle iron and $1\frac{1}{2}$ in. x $\frac{1}{4}$ in. W.I. bars in two lattice girders, 18 in. deep, which can readily be taken apart if necessary. It is about 16 ft. long and weighs about $3\frac{1}{2}$ cwt. in all. These travelling conveyors in combination with the elevator attachment just described, and the tubular chutes have worked so satisfactorily during the wheat season now ended (1903-4), that the Railway Commissioners contemplate building four additional ones, the arms to be mainly 2 in. x 2 in. x $\frac{1}{4}$ in. angle iron and 2 in. x $\frac{1}{4}$ in. W.I. bars.

In all the elevators and conveyors the link belt is capable of adjustment as to length; at the driven end it passes over idler wheels, the shaft of which passes through 'take-ups' each of which consists essentially of a handwheel and square threaded screw spindle, the end of which is socketed in a bearing through which the idler shaft of the conveyor passes. The conveyor shaft may thereby be traversed back or forward.

To overcome a serious difficulty in the traffic arrangements at the sheds, an electrically operated capstan has been erected between each elevator house. The trucks after being placed in the siding have to be moved forward as they are emptied, one at a time. This necessitated the employment of men and horses, until the capstans were built during the last wheat season. They have long since paid for themselves, their cost working out now at about threepence per diem each for power.

The following is a bill of cost of working the plant for a period of six months (the last wheat season) from December 1st, 1903, to May 26th, 1904.

	£	s.	d.
Fixing chutes on ships	312	2	4
General Maintenance	979	5	9
Supply of current for working elevators, etc. ...	73	12	3
Supply of current for lighting shed	138	5	5
Renewals, repairs, alterations to elevators ...	443	0	4
Total ...	£1,946	6	1

Amount of wheat handled 1,278,695 sacks = 142,077 tons.

Cost of handling = $3\frac{9}{32}$ pence per ton.

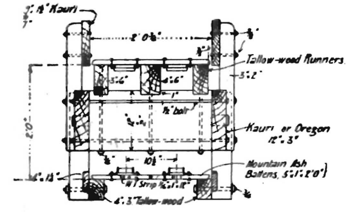
This cost is sufficiently low in itself, but the utility of the plant is scarcely expressible in figures. Its working has enabled a record harvest to be dealt with expeditiously while ordinary traffic was carried on without obstruction in place of the hopeless congestion of traffic that formerly followed on even moderate harvests. In one day 245 trucks containing 17,653 sacks, have been unloaded at the sidings.

The record performance of any elevator was reached with the travelling or gantry conveyor when 94 tons per hour was loaded throughout a three hours run. In loading the "*Indralema*," on August 18th to 20th last, 12,700 sacks, equal to 1,400 tons, were stored in eight hours, a record day's performance. Another good performance was in loading the "*General Roberts*," on May 19th last, with 2,440 sacks = 270 tons, in three hours. This is particularly good, seeing that the original designs provided for a discharge of 60 tons or less per hour per conveyor. The "*General Roberts*" was loaded with 3,000 ton in 42½ conveyor hours, an average rate of 70 tons per hour per conveyor.

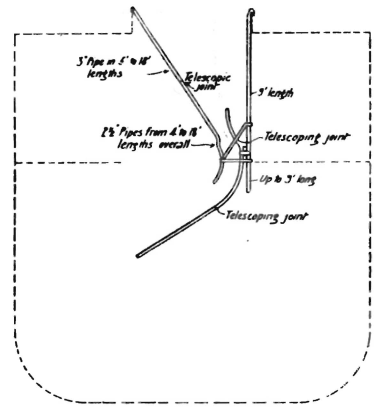
In conclusion the author desires to acknowledge the facilities kindly afforded him by Mr. J. Fraser, M. Inst. C.E., Engineer-in-Chief, and Mr. R. Kendall, Assoc. M. Inst. C.E., Supervising Engineer, Existing Lines Branch, for obtaining the *data* and plans used in compiling this article.

An Experiment in Grain Elevating and Conveying.

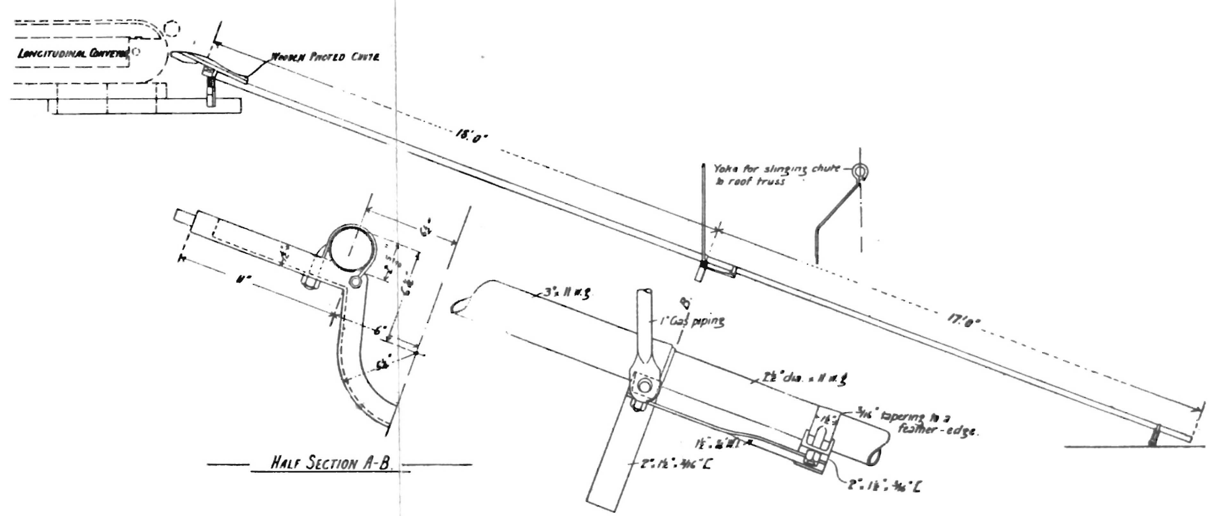
Darling Island.



GENERAL CROSS SECTION OF ELEVATORS, ETC.

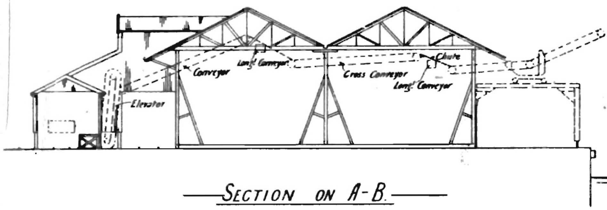


TELESCOPIC CHUTE IN SHIP'S HOLD.



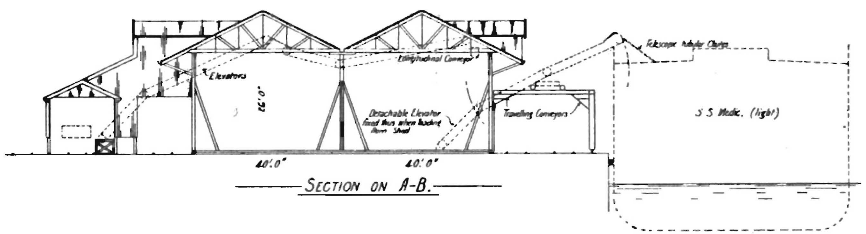
HALF SECTION A-B.

TELESCOPIC TUBULAR STEEL CHUTE AT END OF LONGITUDINAL CONVEYORS.

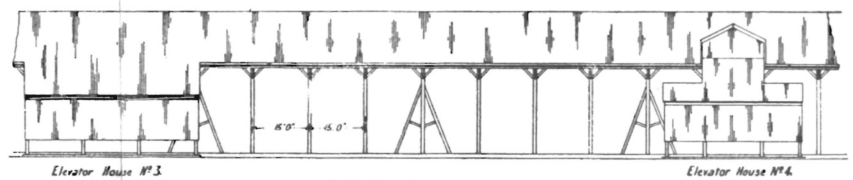


SECTION ON A-B.

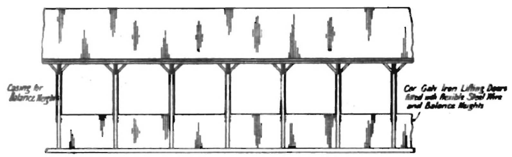
THE ORIGINAL ARRANGEMENT.



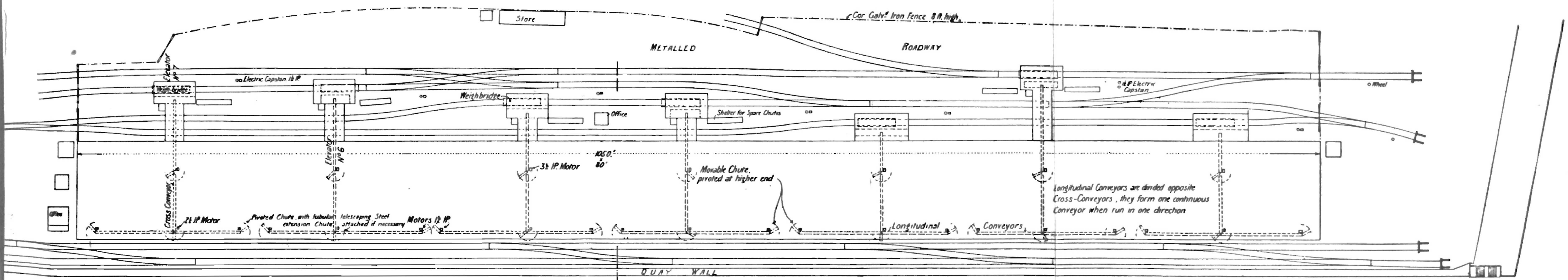
SECTION ON A-B.



PART ELEVATION.



PART ELEVATION TO WHARF.



GENERAL PLAN.