

MECHANICAL APPLIANCES USED IN THE
SHIPPING OF COAL AT THE BUTE DOCKS,
CARDIFF.*

BY MR. HENRY S. C. REE, CHIEF-ENGINEER, CARDIFF RAILWAY CO.

An account of the Mechanical Appliances for Shipping Coal, describing the first tips erected in connection with the Bute Docks, was read by Mr. John McConnochie, Engineer to the Cardiff Railway Co., at the Cardiff Meeting of this Institution in August 1874,† and subsequently an additional Paper was read by Mr. McConnochie at the Cardiff Meeting in August 1884.‡

The author now proposes to outline briefly the alterations, additions, and extensions that have been made since, necessitated by the accommodation required for vessels of larger size and for increased coal-shippments.

WEST DOCK.

This dock remains, as far as the equipment is concerned, practically in the same state as that already described by Mr. McConnochie, as shown on plan of Bute Docks, Fig. 1 (page 404).

* Descriptions of the Shipping of Coal at other Ports in South Wales and district will be found as follows:—Penarth (page 423); Newport, Mon. (page 435); and Barry (page 585).

† Proceedings, 1874, page 119.

‡ *Ibid.*, 1884, page 227.



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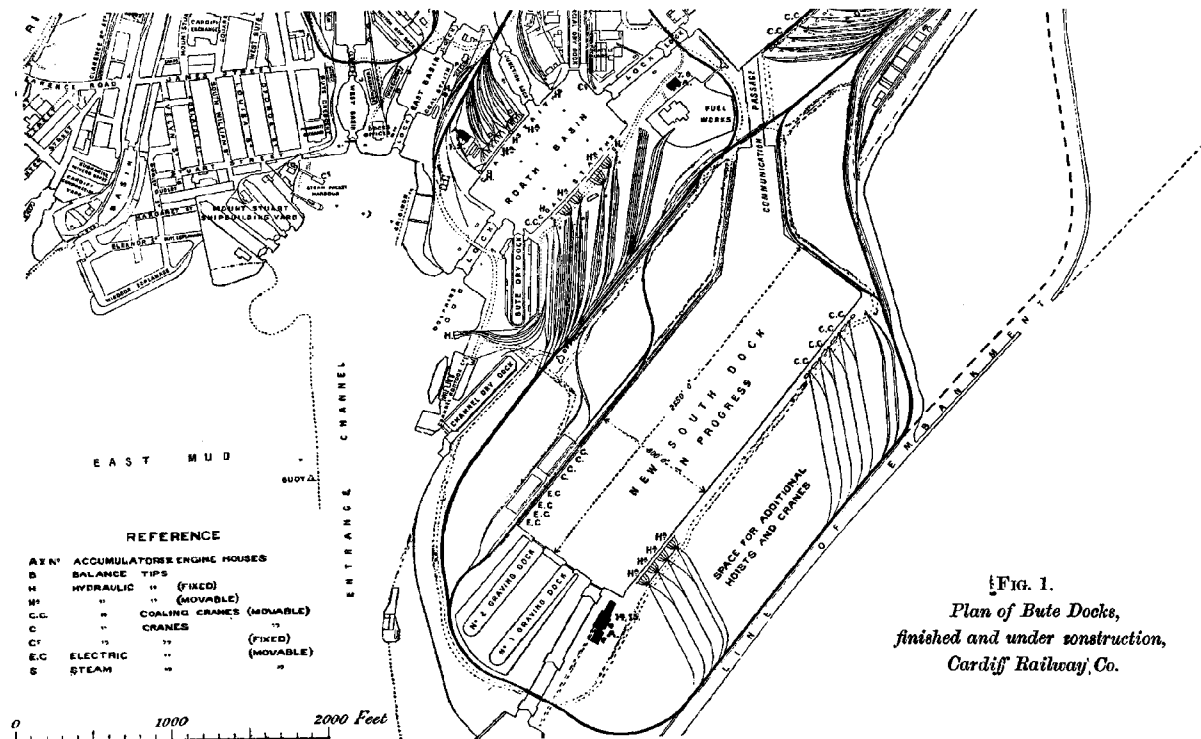


Fig. 1.
Plan of Bute Docks,
finished and under construction,
Cardiff Railway Co.

EAST DOCK.

With the exception of No. 6 Tip on the west side and No. 4 Tip on the east side, all the balance-tips have been replaced by improved hydraulic-tips, similar in construction to that shown in Mr. McConnochie's Paper of August 1874 (Plate 35), except that in order to provide for loading larger vessels it was found necessary to increase the height from the quay-level to butt of shoot from $25\frac{1}{2}$ feet to $46\frac{1}{2}$ feet, and the reach of the shoot increased proportionately, in order to cope with the increased beam of larger vessels.

ROATH BASIN.

To facilitate the most rapid shipment of coal, the west side of the Roath Basin was equipped with two movable hydraulic-tips, Fig. 1 (page 405), the invention of Mr. George Taylor, and constructed by Sir W. G. Armstrong, Mitchell and Co., to replace two of the old type (Armstrong's fixed hydraulic-tips) described by Mr. McConnochie. These were the first movable tips erected, and were the outcome of a suggestion of Sir William T. Lewis, Bart., worked out and patented by Mr. George Taylor in 1885.

On the east side of the Roath Basin two fixed and two movable hydraulic-tips, Plate 40, have lately been erected by Sir W. G. Armstrong, Whitworth and Co., having a maximum lift of 35 feet, and capable of dealing with a load of 23 tons, in lieu of fixed tips with a lift of only 20 feet, erected in 1872. Two are self-propelling and work from two turntables, each turntable having five roads, by which means the tips can adapt themselves to the holds of varying sizes and varying distances apart in the different vessels frequenting this basin.

The operation is as follows :—The full wagon after being weighed is brought on the turntable, and is then diverted on to one of the five roads leading to the cradle. These branch off from the turntable, which is connected with the full and empty roads, to main traffic lines. The cradle and wagon are then raised by the main-lift ram to a maximum height (if required) of 35 feet by chains from the main ram passing over sheaves and attached to the cradle. The

two back chains pass over sheaves on the tipping-ram, fixed on the top of the main-lift cylinder, and are controlled by a separate lever in the topman's box. By this means the topman can tilt the wagon into position for tipping by raising the back end of the cradle. The butt of the shoot can also be raised or lowered, and the height and angle altered or adjusted by very simple means. When it is required to raise or lower the shoot, two of the tippers take their place on the cradle and raise the dogs attached to the cradle for this purpose from a vertical to a horizontal position, so that the two ends extend beyond the front of the tip and catch the under sides of the pall-brackets attached to the shoot, and release the weight from the palls, which are now taken out of the rack attached to each side of the front vertical members of the tips, freeing the butt end of the shoot. These dogs are so balanced on the cradle as to hang vertically when not in use, and are thrown into action by simply pulling a small chain. The safety-chains are now taken off, and the shoot can be raised or lowered as required. The angle of the shoot can be altered, raised, or lowered, by means of a wire-rope connected to a hydraulic hauling-engine. This is done by a separate engine on the tip. The shoot has also a radial motion of $4\frac{1}{2}$ feet on each side of its centre line. Each tip is provided with an anti-breakage crane, worked by separate rams and turning cylinder fixed on the top of the tip.

ROATH DOCK.

The Roath Dock, designed by Sir William T. Lewis, was commenced in 1883, and was completed in 1887. The following are the dimensions:—Inner lock, 600 feet between outer and inner gates, and 80 feet wide; dock (area 33 acres), 2,400 feet long, 600 feet wide; quayage, 7,520 feet in length; depth from coping to dock bottom, 46 feet; depth of water in dock, 32 feet to 37 feet.

The north side and east end of this dock are laid out for the accommodation of the import trade, and are equipped with twenty-eight movable hydraulic wharf-cranes, Fig. 1 (page 404). Most of them are constructed to lift 35 cwt. to 2 tons, and were supplied by Sir W. G. Armstrong, Whitworth and Co., Messrs.

Tannett Walker and Co., and the East Ferry Road Engineering Co., London. There are also two 6-ton cranes made by Messrs. Tannett Walker and Co. The jetty is provided with seven 35-cwt. hydraulic cranes, one 70-ton hydraulic crane with a lift of $61\frac{1}{2}$ feet, and a radius of 50 feet, constructed and erected by Messrs. Tannett Walker and Co., and one 7-ton steam-crane. At the east end of the Roath Dock a masonry jetty, supported on stone arches, extends for a length of 800 feet into the dock, and is 60 feet in width. At the water end a double-floor warehouse has been constructed, 400 feet long by 48 feet wide. Part of this, 120 feet in length, has been set aside exclusively for perishable cargoes requiring cold-storage accommodation. The refrigerating plant was supplied by the Haslam Foundry and Engineering Co., Derby. The stores are fitted throughout with a complete installation of electric light and hydraulic lifts on the top floor.

The equipment of the Roath Dock Lock and the construction of the gates has been fully described by Mr. McConnochie. The author does not propose to describe them further, but merely to add that in 1881 an extensive cattle lairage was constructed on the north side of the lock, affording accommodation for 450 cattle (tied up) and for 600 sheep. Three chill-rooms attached to these buildings have a total capacity for 300 sides of beef. The area covered by these buildings is about one acre.

The south side of the Roath Dock is reserved for coal export, and is equipped with coaling-cranes and appliances patented by Sir William T. Lewis, and Mr. Charles L. Hunter, late engineer to this Company, in 1887, Figs. 3 and 4, Plate 41.

After much consideration the Cardiff Railway Co. decided to adopt the Lewis-Hunter system of improved appliances for loading coal and other material, as this system possesses many advantages over other methods hitherto adopted, not only with regard to despatch, but also in reducing to a minimum the breakage of the coal in loading and trimming. Two of these cranes were constructed and erected by Messrs. Tannett Walker and Co., and as these, after exhaustive trials, fully satisfied the expectations of the

inventors, nine more were constructed and erected by the same firm, making a total at the present time of eleven coaling-cranes, on the south side of the dock; see C.C. on Fig. 1 (page 404). The coal is brought over the Company's main lines to the shipping berths in the usual way, and placed on the full roads, which have a gradient sufficient to allow the wagons to gravitate towards the weighbridge. The empty roads have a fall so as to allow the wagons to retire from the quay and re-taring weighbridge.

The operation of shipping coal is as follows:—After a wagon is weighed, it is run on a turntable and transferred to a tip-up cradle, when it is tilted, and the coal discharged into one of the Lewis-Hunter coaling-boxes, which are capable of taking 10 to 12 tons of coal, Fig. 5, Plate 41. During the process of tipping, the coal is screened, the screenings falling into a similar box, placed underneath the shoot in the coaling-pit. The large box is then lifted and swung into position over the hatchway of the vessel, when it is lowered to within a few feet of the bottom of the hold, and the conical bottom of the box is allowed to drop, discharging the coal by sliding in four directions. If it is desired to place coal to one or the other side of the hold, it is only necessary to secure one side of the conical bottom of the box with chains attached for that purpose.

The cranes travel on lines running parallel with the dock coping, having a gauge of 21 feet 6 inches. This arrangement provides sufficient space and height for two lines of railways to pass underneath, and thus the quay can be utilized for imports as well as exports simultaneously. The cranes are of the ordinary turret-top type, and are self-propelling, this movement being effected by separate hydraulic engines, suitably geared. They also lift, slue, and derrick, the whole of the three motions being performed at the same time if necessary, and controlled by one man. The hoisting cylinder and ram are placed in the tower, as well as the ram for lifting and closing the cone of the coal-box. The latter is secured by three chains, the centre one being fastened to the centre of the cone of the box-bottom. When the box has been lifted and swung into position, and lowered into the hold of the vessel, the cone is released by exhausting the pressure in the cone cylinder, and the

conical bottom is then dropped 2 feet 6 inches, the box itself being held by the two side chains.

Turning is effected by four cylinders and rams, two being placed outside and two inside the turning table on top of the crane pedestal. The crane-tower revolves on a fixed steel roller-path secured on top of the pedestal. The derricking motion is performed by a cylinder and ram fixed in an inclined position at the back of the tower. Provision for lifting light loads, not exceeding 2 tons, is made by placing a small cylinder and ram outside the centre tower, the chain passing through a special sheave on the jib-head.

This dock is also equipped with three coal-hoists (two movable and one fixed) on the south side. The two movable hoists were constructed and erected by Sir W. G. Armstrong, Whitworth and Co. These tips were erected to meet the demand of certain shippers who required additional screening in certain cargoes of coal, but the Lewis-Hunter cranes have proved so satisfactory, both as regards despatch and saving in breakage of coal, that they are principally in request for all large vessels.

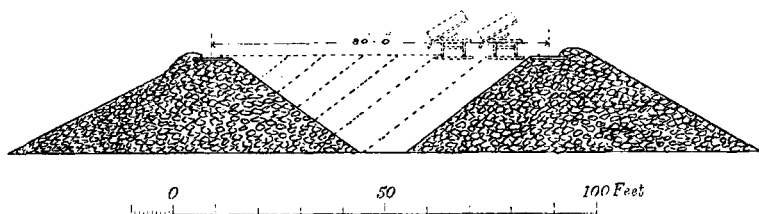
SOUTH DOCK.

When the author took up the duties of resident engineer at the South Dock, Cardiff, in April 1898, the site for the South Dock and Lock had already been reclaimed from the sea by the construction of an embankment some 7,700 feet in length, Fig. 1 (page 405). The construction of this embankment was a matter of considerable difficulty and anxiety owing to its exposed site, the great rise and fall of the tide (40 feet) and the thickness and soft nature of the mud on which it had been formed, especially near the entrance to the South Dock. At this point the site was intersected with a number of ancient water-courses or reens which had silted up, and it was not an uncommon occurrence for the bank which had been brought up, say 8 or 10 feet above the level of the mud, to have disappeared when the men resumed duty next morning.

The method of procedure was as follows, Fig. 6:—Two banks were formed of slag and scoræ obtained from the old Pentyrrh Ironworks, 6 miles distant. These banks were parallel to one

another, the centres being 80 feet apart, and extended from a point to the south of the low-water pier in the entrance channel to the Roath Dock to a point on the foreshore near the southern end of the Roath Dock. The seaward or outer bank was first pushed ahead with greater rapidity than the inner one, in order to allow locomotives and trucks to pass over the entire length of the embankment. The inner bank was then formed, working from each end of the bank, and as this work progressed the space between the two banks was filled in with earth, clay, and lighter material, etc., brought in as ballast by the ships. On one occasion, after the two banks had been closed, the tide came over, and the water thus impounded burst the bank, and the outrush of escaping water made quite a deep channel.

FIG. 6.—No. 1 Embankment.
Mode of Filling between Banks.
Cross-Section.



Sluices were placed here, and the bank was again burst in 1897, wagons and rails being carried away with the inrush of water into the enclosed space.

When the author took charge of the work, this bank was finished, and the enclosed area (some 140 acres) ready for dock and lock works to proceed. The construction of this embankment and the enclosure of the mud, Fig. 7 (page 412), were carried out under the direction and personal supervision of Sir William Thomas Lewis. On the contract for the South Dock Works being let to Messrs. Topham, Jones and Railton, in June 1898, the outer face of the above embankment was protected from the heavy seas experienced in rough weather with large blocks of stone from the Castletcoch and Pwll-y-pant Quarries.

Simultaneously, another embankment, some 600 feet to the seaward of the embankment just described, was made by Messrs. Topham, Jones and Railton, encircling the inner embankment and

FIG. 7.—No. 1 Embankment.

Plan.

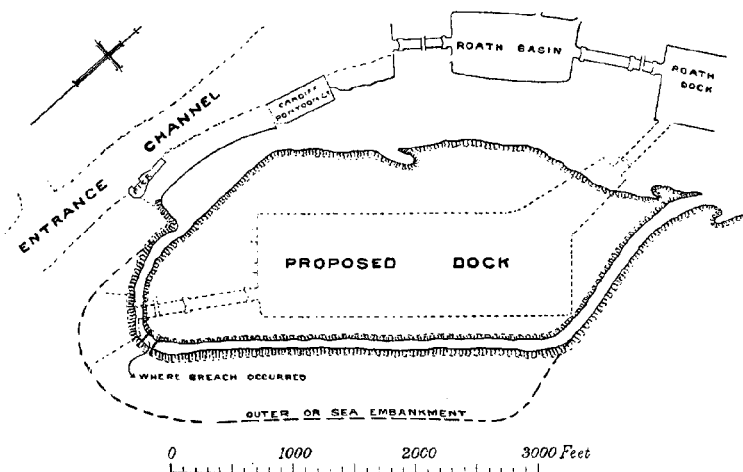
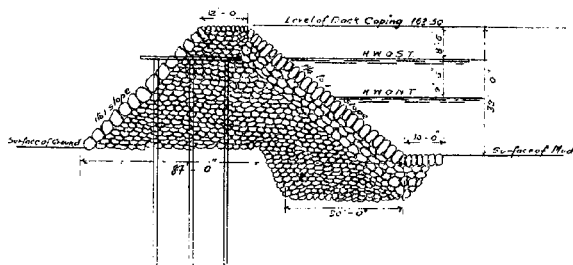


FIG. 8.—Outer or Sea Embankment.

Cross-Section.



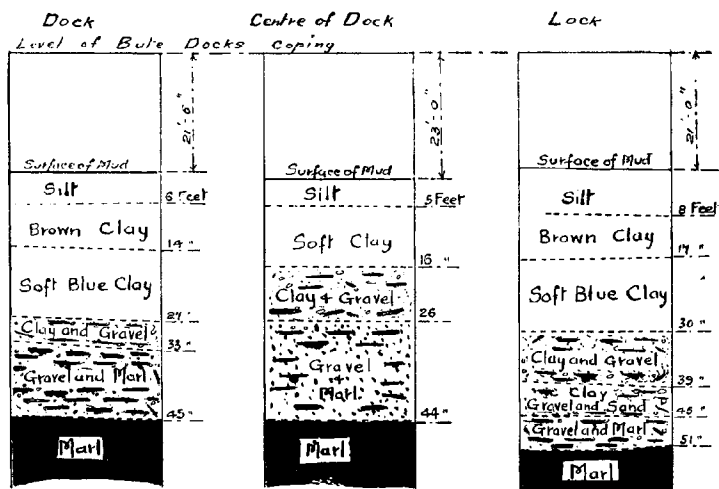
the site for the new dock, and was constructed in the following manner. A timber gantry, of sufficient height to allow engines and wagons to pass over it at high water, was built. On the seaward

side of this a channel was excavated by a dredger some 12 feet deep and 80 feet in width at bottom. This channel was then filled with heavy stones side-tipped from the gantry, and upon this the stone embankment was formed to the following dimensions: 12 feet wide on top, and 84 feet at the bottom, with slopes 1 in $1\frac{1}{4}$ in the sea side, and 1 to 1 on the inner. The height of bank above mud-level is 32 feet. The space between these two banks was then filled in with excavation from the dock and the wall trenches, that is, the outer bank constructed by Messrs. Topham, Jones and Railton, and the inner bank built by the Cardiff Railway Co., and the land thus formed was used for railway sidings, the inner bank serving to prevent the mud from the dock excavation rolling back into the dock trenches, and the outer or sea embankment keeping it from spreading seawards, Figs. 7 and 8. Before the mud was tipped from the inner embankment, the heavy pitching which had been placed there as a protection was removed, and the slope of the outer or permanent embankment pitched with it. Fig:9 (page 414) is a diagram showing the nature of the strata found in the dock and lock, giving the depth to which it was necessary to go before a firm foundation could be obtained. The gravel, though it had the appearance of affording a good foundation, was considered, on further examination, to be unreliable, as it was intersected and laminated with a number of thin layers and pockets of clay of a soft nature, from 1 foot to 2 feet 6 inches in depth, which would be liable to compression under the heavy weight of the walls and the machinery in the various coal-tipping appliances the foundation would have to carry. This opinion has been fully borne out in the only instance where masonry was founded on gravel, a decided settlement taking place, fracturing the crown of an arch, which had to be pulled down and rebuilt. This may be of interest to those who contemplate building structures similar to those at the South Dock, on ground of this nature.

The work of constructing the above dock was commenced by Messrs. Topham, Jones and Railton in June 1898. The principal dimensions are as follows:—The dock is 2,550 feet in length and 800 feet in width, and 50 feet from coping to level of dock bottom. The concrete foundations for the walls are founded on marl some

Cardiff Railway Company.

FIG. 9.—Sections showing Strata in Dock and Lock.



An average of the three sections shows:—

	Feet.
Brown clay and silt	12
Blue clay	12
Clay and sand	
Clay and gravel with bands of blue clay	22
Gravel and sand	
Gravel and marl	
Keuper marl	—

In this bed, at a point where it rested upon Keuper marl, there occurred several upright trunks of trees, about 2 feet high, rooted in a black clay with stones, the roots extending down into the red marl. The trunks were found in the communication-passage with the Roath Dock at a level of 17 feet below Ordnance datum. The surface of the marl in this dock varied from $9\frac{1}{2}$ to $47\frac{1}{2}$ feet below that datum.

20 feet below the bottom of the dock. At the north-east end the dock has been widened to 1,000 feet, so as to afford greater facility in turning vessels of excessive length. The dock walls enclose an area of $50\frac{1}{2}$ acres of water, and provide about 6,700 lineal feet of additional quay space. A communication passage into the Roath Dock, 600 feet in length and 90 feet in width between two masonry walls similar to the dock, is provided.

The entrances for two dry docks have already been constructed, one 85 feet in width and the other 75 feet, and 33 feet in depth below coping. The sea-lock has a length of 850 feet between the outer and inner gates, and is 90 feet wide. The cills of the outer and middle gates are 50 feet below the dock coping, and the inner cill 47 feet. This will allow of a depth of about $41\frac{1}{2}$ feet of water at the outer and middle cills, and $38\frac{1}{2}$ feet on the inner at ordinary spring tides. At neaps there will be about 10 feet less. The sea-gates at the entrance to the lock are protected by two concrete piers extending into the channel. The dock has a separate entrance from the entrance channel, which channel has been widened and deepened by dredging through Cefn-y-Wrach and the Cardiff Flats.

The lock-gates, Plate 42, were built and erected by Sir W. G. Armstrong, Whitworth and Co., and are very similar in design and construction to those erected at the Roath Dock, except that they are of steel, and the heel-post is formed in a novel manner by stiffening and returning the steel sheeting and forming the heel-post in this manner. The gates travel on a cast-steel roller-path—a most necessary provision in gates of this size, and with the great rise and fall of tide in the Bristol Channel. The gates are opened and shut by direct-acting hydraulic rams, fixed in masonry chambers built in the lock. The rams are designed to work the gates at a minimum pressure of 600 lbs. per square inch.

The principal dimensions for the outer and middle gates are as follows:—Length from centre of heel-post to mitre-post, measured along the cill, 50 feet $6\frac{1}{2}$ inches; height from top of cill to gangway, $50\frac{1}{2}$ feet; radius of heel-post, 2 feet; radius of roller path, $43\frac{1}{2}$ feet. The foregoing dimensions also apply to the inner gates,

with the exception that the height from top of the cill to the gangway is $47\frac{1}{2}$ feet. A gangway, or footbridge, of ample width is provided over each pair of gates.

Caisson.—A caisson has been constructed of steel and built by the Mountstuart Dry Docks and Engineering Co., Cardiff, to fit both the caisson cills of the communication passage and the two caisson cills of the new entrance lock, so as to be used in either position as necessity requires. It is now placed in the communication passage for the purpose of preventing the water in the Roath Dock from flowing into the South Dock. The principal dimensions are as follows:—Length, keel, 92 feet 8 inches at bottom; extreme beam, 25 feet; breadth of roadway deck, 13 feet; depth from top of roadway deck to bottom of keel, $48\frac{1}{2}$ feet.

Bridges.—A double-track swing-bridge has been built over the communication passage between the Roath and South Docks by Messrs. Handyside and Co., Derby. The main girders are of the "N" truss type, with suspended cross-girders attached to the vertical members of same. The width of the bridge between the girders is 27 feet, and provides for two lines of railways and cartways and also two foot-paths 4 feet wide. The hydraulic machinery for opening the bridge was made by Sir W. G. Armstrong, Whitworth and Co. When it is necessary to swing this bridge, it is first lifted by a hydraulic press beneath the centre pivot and turned by a pair of hydraulic cylinders and chains acting on a steel drum attached to the girders of the bridge.

Another swing-bridge has also been placed over the entrance lock. It is of the "N" truss type similar to the above, but has accommodation for only one line of railway. It is worked in the same manner to that at the communication passage. This bridge was also constructed by the same firms. The north side and east end of the South Dock has been reserved for import trade, and the quay-space thus provided will nearly double the existing import capacity of the docks.

On the north-west side of the dock, near the entrance to No. 2 Graving Dock, two corrugated iron import warehouses have been erected by Messrs. A. and J. Main, London, one being 300 feet in length by 80 feet wide, and the other 300 feet long by 80 feet wide, with a cellar underneath and two storeys, making three floors in all, Fig. 1 (page 405). For the service of these warehouses four electrical cranes have been ordered from Messrs. Stothert and Pitt, of Bath, all to lift a working load of 2 tons. Two with a radius of 45 feet have been erected, and two, with a radius of 55 feet with the centre of the jib head pulley 60 feet above the rail level at the maximum radius, are now in course of construction, Fig. 11, Plate 43. These cranes are to have lifting, derricking, and slueing motions, operated by separate motors. The cranes are mounted on pedestals running on four wheels at a 13½-foot gauge, centre of rail to centre of rail. The cranes have the following speeds:—Lifting, maximum load, 200 feet per minute; slueing, maximum load, 400 feet per minute measured at crane hook; derricking, maximum load, 15 feet in twenty-five seconds.

Four 2-ton derricking wharf hydraulic-cranes are being constructed by the East Ferry Road Engineering Co., Fig. 12, Plate 43. These are to be of the centre-pillar type, and are to run on the same gauge as the electrical cranes, and both the hydraulic and the electrical cranes will span a line of railway 4 feet 8½ inches gauge, the spans being 15 feet high. Each crane is to be capable of lifting, slueing, and derricking at the following speeds:—Lifting the full load at the maximum radius, 200 feet per minute; slueing, or turning, with the full load at the maximum radius 400 feet per minute (measured at the load); derricking, with the full load, 15 feet in ten seconds.

Two hydraulic coaling-cranes somewhat similar to those already described and at work on the Roath Dock Coaling Wharf have been constructed and erected by Messrs. Tannett Walker and Co., at the south-east corner of the dock, and two similar, but of increased power, are being constructed by the same firm, Fig. 13, Plate 44. The first two cranes are intended to work with a special pit which is so arranged that a 20-ton wagon of coal can be tipped at one operation. The coal is delivered through a double shoot into two boxes, each

capable of taking 10 to 12 tons, which are then dealt with in the usual way.

At the south west corner of the dock, near the inner gates of the entrance, two coal-hoists have been built, and two more are now being erected by Sir W. G. Armstrong, Whitworth and Co. They are all capable of dealing with a load of 23 tons, two with a lift of 55 feet above dock coping, and two with a lift of 60 feet to the butt of the shoot, Plate 40. Each hoist will have a turntable with five roads converging, and the coal will be dealt with in a similar manner to that at the Roath Dock and the east side of the Roath Basin already described. Additional movable coaling-cranes and tips will be erected as found most suitable for the requirements of the coal trade.

On the south side of the entrance lock, near the inner gates, a large centrifugal pumping-house and hydraulic engine-house and boiler-house have been erected, the former in order to maintain the water at a convenient level in times of drought. The contract was entrusted to Messrs. W. H. Allen and Co., Bedford, for three of their "Conqueror" centrifugal pumps, having a disc $7\frac{1}{2}$ feet in diameter. Each pump is designed to deliver 100,000 gallons of water per minute, and to have a discharge branch 60 inches in diameter, and two suction branches 42 inches in diameter. These pumps derive their supply from the sea, through a culvert about 1,000 feet in length, almost semi-circular in form, having a height of $16\frac{1}{2}$ feet and a minimum width of $13\frac{1}{2}$ feet. The foundations for the hydraulic engine-house and boiler-house are all built on newly-made ground. After much consideration, it was decided to adopt ferro-concrete (Hennebique's system). It was found necessary to drive a large number of piles ranging from 55 to 60 feet in length before a firm foundation was reached. The floor is of ferro-concrete, is self-supporting, and designed to carry the load independently of any support from the ground.

The hydraulic engines (constructed by the East Ferry Road Engineering Co.) consist of two horizontal compound tandem hydraulic-pressure accumulating engines, each capable of giving off 350 H.P. at the pumps, at 50 revolutions per minute, with 120 lbs.

per square inch steam-pressure working against a hydraulic-pressure of 850 lbs. to the square inch in the accumulators, and are very similar to those at Nos. 12 and 13 pumping station on the west side of the East Dock, Fig. 14, Plate 44. Five boilers, each having 4,780 square feet of heating surface, arranged to be set in $2\frac{1}{2}$ batteries, together with superheaters and piping, have been constructed and erected by Messrs. Babcock and Wilcox, of London. Each of the boilers is provided with a Babcock and Wilcox superheater, capable of imparting from 100° to 120° F. of superheat to the steam produced by the boiler. The working pressure is 180 lbs. per square inch.

Motive Power.—The motive power for working the whole of the hydraulic coal-hoists, cranes, capstans, gates, sluices, etc., is supplied by thirteen hydraulic pumping-engines. The sites are shown on Fig. 1 (pages 404 and 405) and numbered 1 to 13. With the exception of Nos. 1, 2, 3 and 4 hydraulic engines, all the rest have been erected since the date of Mr. McConnochie's last Paper, and they are all, except No. 4 engine, of the horizontal type, the pumps ranging from 4 inches diameter to 7 inches diameter. The indicated horse-power is as follows :—

No. 1	Engine	.	.	.	.	.	80 I.H.P.
" 2	"	.	.	.	.	.	80 "
" 3	"	.	.	.	.	.	80 "
" 5	"	.	.	.	.	.	125 "
" 6	"	.	.	.	.	.	125 "
" 7	"	.	.	.	.	.	150 "
" 8	"	.	.	.	.	.	150 "
" 9	"	.	.	.	.	.	80 "
" 10	"	.	.	.	.	.	150 "
" 11	"	.	.	.	.	.	225 "
" 12	"	.	.	.	.	.	225 "
" 13	"	.	.	.	.	.	225 "

Nos. 4, 11, 12 and 13, are compound surface-condensing engines.

The time occupied in weighing, tipping, lowering, and re-taring one wagon of coal, containing from 10 to 12 tons of coal, by the different systems at the various docks is as follows :—

Balance-tips, West Dock (high level)	.	.	.	4 minutes.
Hydraulic-tips, East Dock (high level)	.	.	.	1 minute 45 seconds.
Hydraulic-tips, Roath Basin (low level)	.	.	.	2 „ 30 „
Coaling-cranes, Roath Dock	.	.	.	2 „ 30 „

As an illustration, the following shows the time within which certain vessels were loaded :—

The s.s. “Armando R.” shipped 5,279 tons of coal in 12½ working hours, being at the rate of 422 tons per hour.

The s.s. “Lady Lewis” shipped 4,773 tons of coal in 10 working hours, being at the rate of 477 tons per hour.

The s.s. “Askehall” shipped 6,715 tons of coal in 11 working hours, being at the rate of 610 tons per hour.

Recently 995 tons of coal were shipped in one hour by four Lewis-Hunter cranes working into one large steamer.

In the Table below the author has endeavoured to show, as far as he has been able to ascertain, the size of the largest steam-vessels

*Examples of the Dimensions of the Largest Typical Steamers
Trading to the Bute Docks in the Undermentioned Years.*

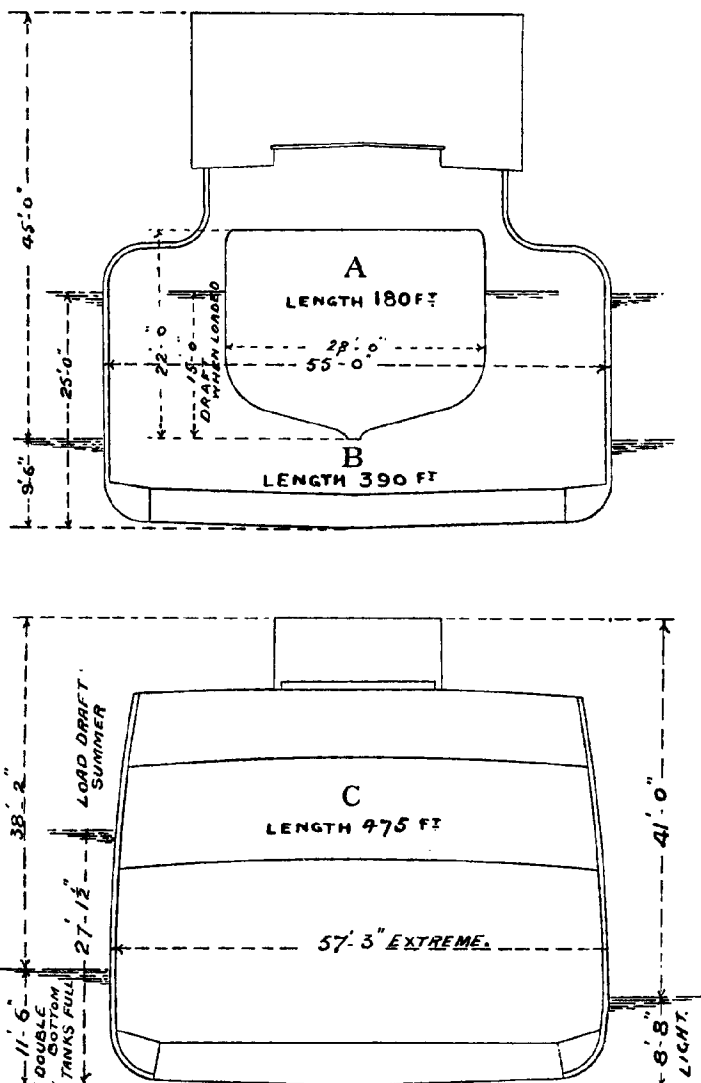
Year.	Quantity shipped.	Length.	Breadth.	Draught of Water.	Remarks.
	Tons.	Feet.	Feet.	Feet.	
1850	700	180	28	15	{ West Dock opened in 1839.
1860	2,000	250	33	22	{ East Dock opened 1855 and 1859.
1870	3,000	300	42	24	East Dock.
1880	4,500	360	43	25	{ Roath Basin opened 1874.
1890	5,500	375	45	26	{ Roath Dock opened 1887.
1900	9,000	470	56	27	Roath Dock.
1905	12,000	475	58	27½	Roath Dock.

NOTE.—Steamers of upwards of 500 feet in length have frequented this port to bunker. The greatest draught of water of any steamer trading to the Bute Docks is 28½ feet.

FIG. 15.—Cross-Sections of Vessels entering Cardiff.

A. Typical Sailing Ship in 1850.

B and C. Modern Typical Steamers Trading to the Bute Docks in 1900 and 1905.



frequenting the Bute Docks at different periods between 1850 and 1905. It has been necessary from time to time to increase the height of the various coal-shipping appliances at a great expense, in order to accommodate the growing size of vessels. It should be noted that the vessels are now built almost flat-bottomed, with vertical sides, and the tonnage has been enormously increased, in some cases with very little alteration in the draught. A, Fig. 15 (page 421), represents the midship cross-section of a type of sailing vessel frequenting the West Dock in 1850. Steamers of similar cross-section but varying in length also coal in this dock. The two ships shown, B and C, Fig. 15, represent cross-sections of actual modern vessels frequenting the Roath Dock for coaling purposes at the present time, and will show the immense change that has taken place in the height of these ships above the water-line when light, independently of tonnage, from those first frequenting these docks.

The Engineers from whose plans the South Dock has been constructed are Mr. G. N. Abernethy, of Westminster, who was joint consulting engineer with the late Mr. Charles L. Hunter, for many years Engineer to the Cardiff Railway Co. The author, formerly Resident Engineer, succeeded Mr. Hunter as Engineer-in-chief to the Cardiff Railway Co. and Joint Engineer with Mr. Abernethy in March 1902. The South Dock is constructed to the order of the Cardiff Railway Co., and under the general direction of Sir William Thomas Lewis, Bart., the Managing Director.

The Paper is illustrated by Plates 40 to 44 and 6 Figs. in the letterpress.

[NOTE.—*The discussion on this Paper was combined with that on Messrs. Riches and Heywood's and Mr. Macaulay's Papers, and commences on page 466.*]

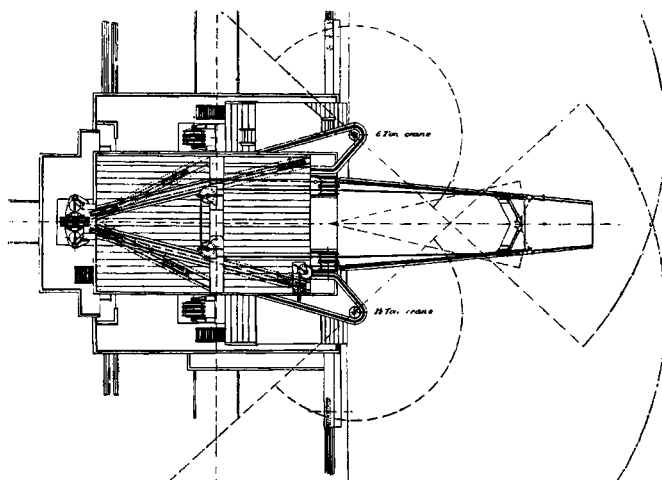
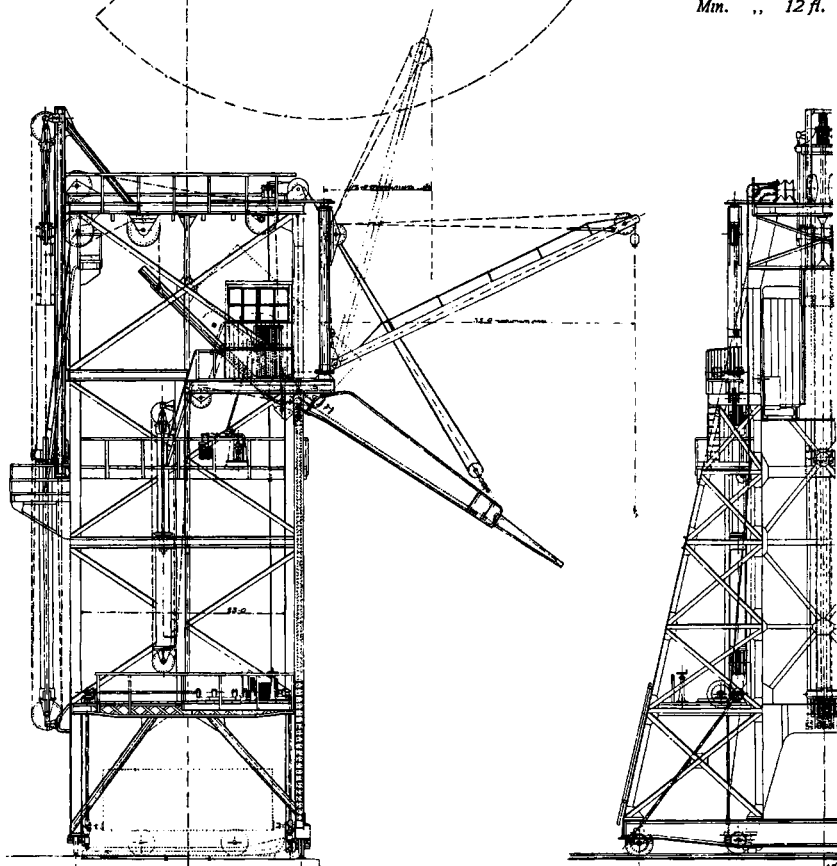


Fig. 2.
*Hydraulic
 Coal-Hoist
 (Armstrong,
 Whitworth and Co.)
 Roath Basin
 and
 South Dock.
 To lift 23 tons
 through 60 feet.*

*Max. Rake 35 ft.
 Min. „ 12 ft.*



18-ton Hydraulic Coaling-Crane, Roath Dock.

Fig. 3.

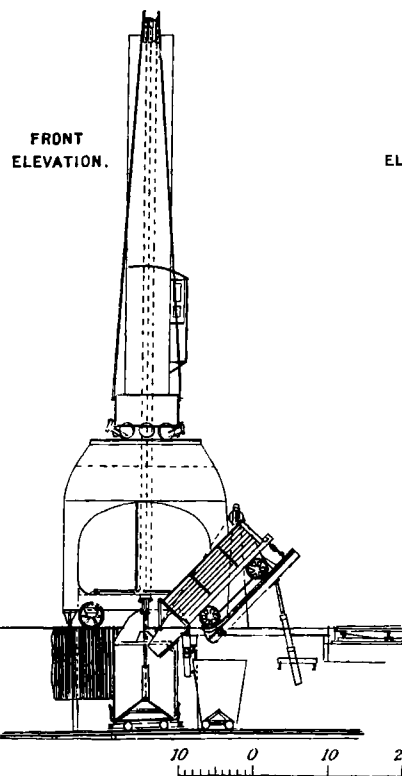


Fig. 4.

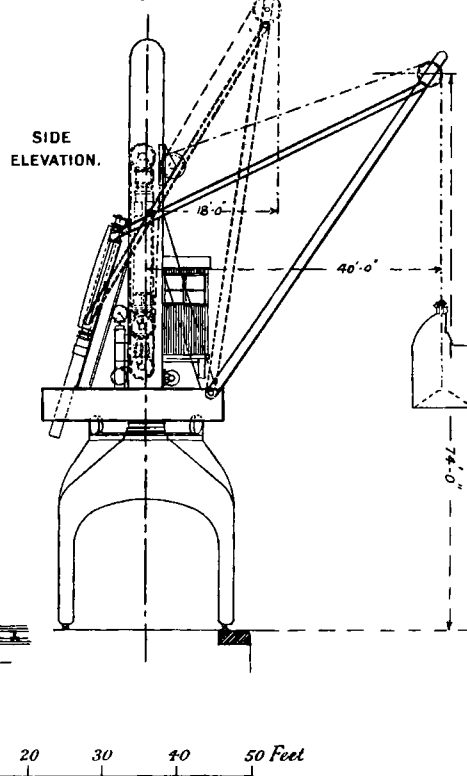
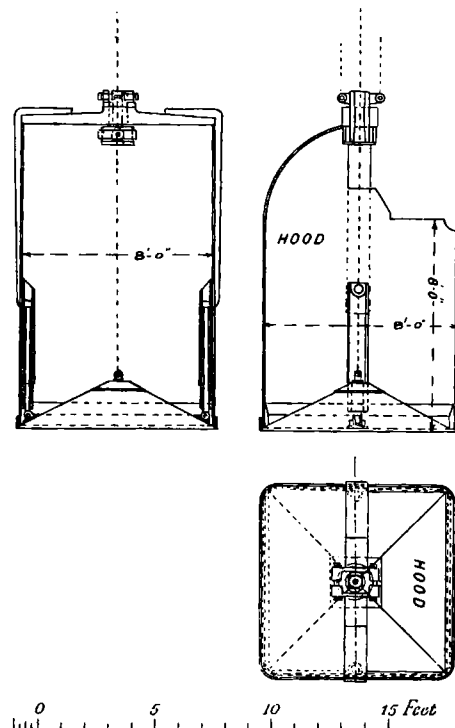


Fig. 5. 10 to 12-ton Coaling-Box.
(Lewis-Hunter.)

Pl. 41.



COAL-SHIPPING APPLIANCES AT CARDIFF. Pl. 41.

COAL-SHIPPING APPLIANCES AT CARDIFF. Pl. 42.

Fig. 10. General Arrangement of 90ft. Gates and Machinery,
New South Dock. (Armstrong, Whitworth and Co.)

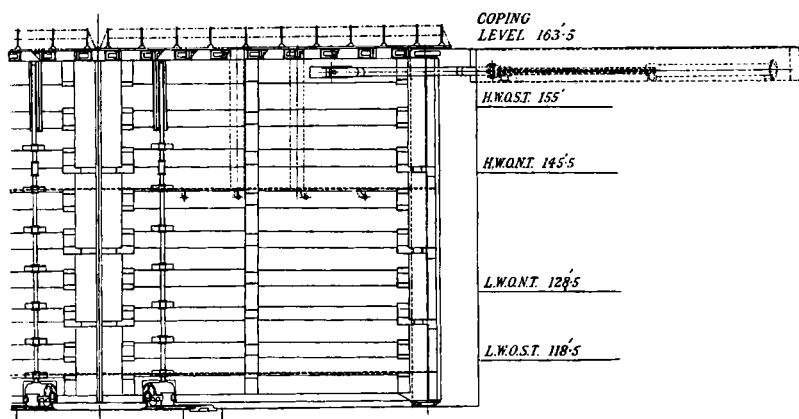
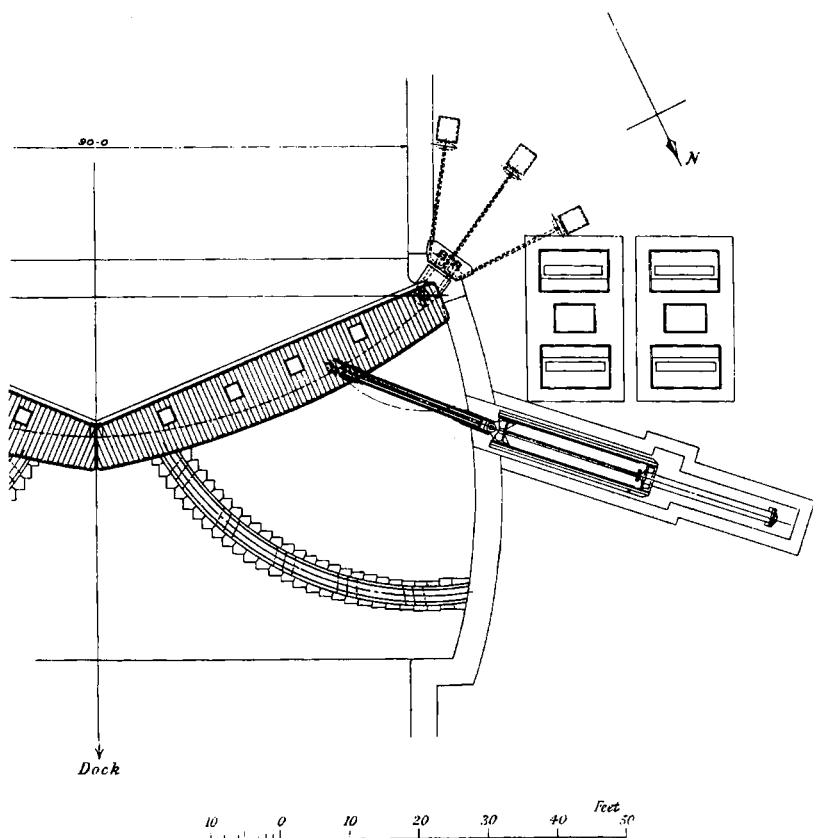


Fig. 11. 2-ton Electrical Crane.

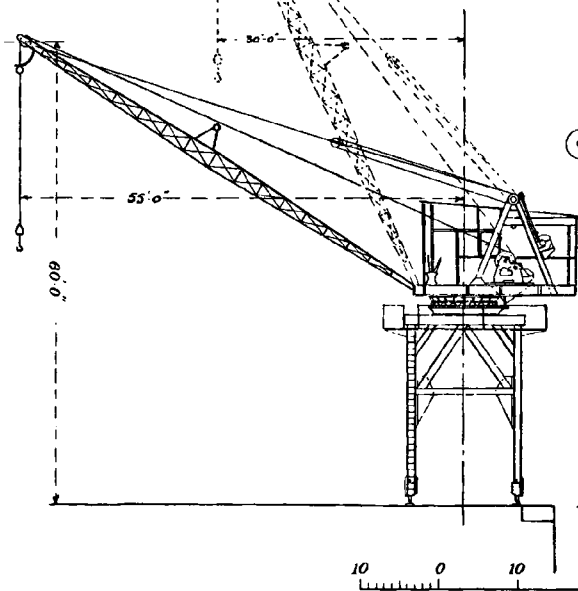
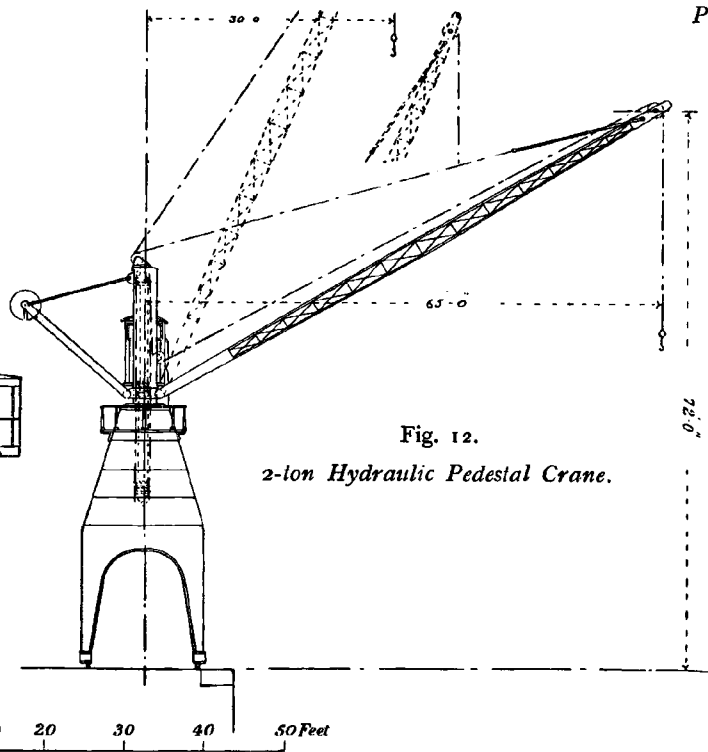
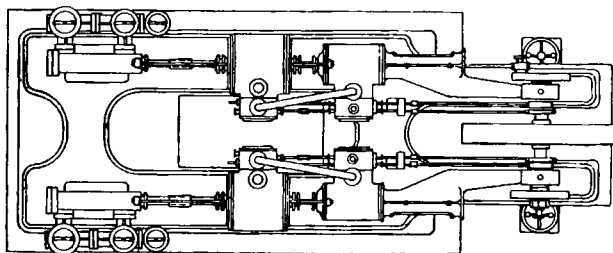
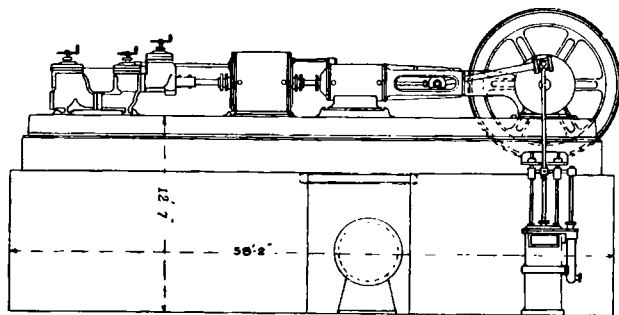
Fig. 12.
2-ton Hydraulic Pedestal Crane.

Fig. 14.
Hydraulic Pumping-Engine.



0 5 10 15 20 25 Feet

Fig. 13. 18 and 20-ton Hydraulic Coaling-Cranes,
South Dock.

