"BUTTERS" 100-TON ELECTRIC TRAVELLING MONOTOWER CRANE

AT MESSRS. CAMMELL LAIRD'S BIRKENHEAD YARD

In recent years the methods used in shipbuilding have undergone considerable change mainly due to the great advance in welding technique. The introduction of welded prefabricated sections, built under cover, and transferred to the building berths or slipway has improved the output in all shipbuilding yards using this method. Messrs. Cammell Laird & Co. Ltd. at their Birkenhead yards have maintained their leading position among British Shipbuilders by modernizing their yard to suit the new methods of construction. One of the problems they had to face was to find an efficient method of transferring the large prefabricated sections weighing up to 100 Tons from the welding bays to the slipway for building into the completed ship.

Finally it was decided to use "Butters" Monotower Cranes of the Travelling type with capacities of 15, 50 and 100 Tons. This type of crane having proved itself efficient and economical in many shipyards throughout the world.

Butters Bros. & Co. Limited, Glasgow, were entrusted with the job of designing, constructing and erecting suitable cranes. The following descriptive matter refers to the "Butters" 100 Ton Electric Travelling Monotower Crane now erected in the famous Birkenhead yard of Messrs. Cammell Laird & Co.Ltd. The crane lifts the maximum rated load of 100 Tons at a radius of 122 feet while standing free on a rail track set at 55 feet track centres - the largest crane of this type ever built in the world. The travelling tower is 120 feet high supported on thirty two rail wheels of the centre flanged type.

The base of the tower is constructed to give a portal opening 48 feet high and 49 feet wide thus ensuring a free passage to the building berths the level of which is 50 feet below the rail level. The ground area covered by the crane is sufficient to easily park fifteen Double Decked Transport Buses. The luffing jib is 175 feet long constructed throughout of Aluminium Alloy Rivetted Sections. The top of the revolving mast of the crane is 214 feet above rail level which is 44 feet higher than Nelsons Column in Trafalgar Square. The point of the jib when at minimum radius is 300 feet above rail level equal in height to the Central Tower of The Houses of Parliament or as high as the Dome of Saint Pauls above the base of the building berth.

The crane driver is comfortably housed in a separated cabin 126 feet above rail level glazed all round thus ensuring a clear and uninterrupted view of the loads the crane is lifting. The cabin is heated and a telephone installed to enable the operator to have easy communication with anyone at ground level.

From his elevated position the operator controls all motions of the crane which is driven by eight motors.

Behind the operator's cabin is the machinery house in which is located the main hoist, jib luffing, levelling and sluing motions of the crane. The machinery house is 55'0" long and 24'6" broad x 15 feet high of sheet steel construction.

/-

The main hoist motion is driven by a 115 B.H.P. motor which lifts the 100 Ton load on a triple pulley block at a speed of 10 feet per minute. Through a change speed clutch loads up to 40 Tons can be lifted at a speed of 25 feet per minute. The spur gearing of the hoist motion is enclosed in cast iron gear boxes and runs in an oil bath, with the exception of the barrel spur wheel and its engaging pinion. The gear cases are fitted with ball and roller bearings to carry the shafts.

An electro-mechanical brake is fitted to the motor extension shaft capable of controlling the loaded motion. An additional spring loaded, air released disc brake is included in the motion on the barrel pinion shaft. It will be noted that this brake is spring loaded to be continually in the "Holding" position and is released by air through an airflow regulator valve in the operator's cabin. Electrical counter current lowering is also included.

The main hoist rope barrel is 10'0" diameter by 11'8" long machine grooved to suit the 1.7/8" diameter rope of 6/37 construction.

The main hook of the crane is of the "Flemish Eye" type mounted on a taper roller bearing and suspended from a triple pulley block thereby lifting the loads on six falls of rope.

The auxiliary hoist motion located within the mast frame is driven by a separate 95 B.H.P. motor and capable of lifting loads up to 10 Tons at a speed of 90 feet per minute. The spur gearing of this motion is also totally enclosed in a cast iron gear case and runs in an oil bath. All shafting is mounted on anti-friction bearings. The auxiliary hoist barrel is 3'9" diameter by 5'6" long, machine grooved to suit the 1.3/8" diameter rope of 6/37 construction.

An electro-mechanical brake is fitted to the motor extension shaft capable of controlling the loaded motion. Counter current lowering is also incorporated.

The auxiliary hook lifts loads up to 10 Tons in weight and is also of the "Flemish Eye" type suspended from a ball bearing swivel housing.

The jib luffing motion consists of worm and spur gearing, totally enclosed and running in oil. The motion is driven by a 95 B.H.P. motor. The braking on this motion consists of a spring loaded, air released disc brake and an electro-mechanical brake.

The barrel is 4'9" diameter by 12'0" long, machine grooved to suit the 1.3/4" diameter jib rope of 6/37 construction.

The levelling barrel to which the return part of the hoist rope is anchored gears with the luffing barrel through a spur drive so that when the luffing rope is paid out, the hoisting rope is coiled in at the proper speed to give the desired horizontal path of the load. This also has the effect of reducing the horse-power required to luff in the jib as the torque applied to the levelling barrel by the return part of the hoist rope tends to rotate the luffing barrel in the direction required to luff in the jib.

/-

The sluing motion for revolving the superstructure, jib and load is driven by a 55 B.H.P. motor running at 720 R.P.M. The 100 Ton load can be slued at the maximum radius of 122-feet at a speed of 180 feet per minute.

The motor drives through a flexible coupling to a single reduction spur gear box. The double output shafts of this spur box drive twin sets of worm and spur reduction gear to the final drive shafts of the motion. These shafts each carry slue race spur pinions which mesh with the main race wheel which is bolted to the top of the travelling tower structure. This racewheel which is neatly 32 feet in diameter is made in twelve segments bolted together to form a ring. The inner face of this ring forms the turned horizontal roller path on which bears the horizontal slue rollers.

An electro-hydraulic brake is fitted to the motor extension shaft of the slue motion. When the main isolating switch is moved to the "ON" position, this brake automatically comes off and leaves the sluing motion under the control of the hydraulic foot tramp in the operator's cabin. When the main power is switched "OFF" and the crane is to be left unattended the brake comes on automatically, holding the revolving portion in any required position.

A slip friction clutch drive is fitted in each of the twin worm boxes. This clutch will counteract the effect of any undue sudden stoppages of the sluing motion by preventing any shock load being transmitted back to the motor and primary reduction gear. These clutches are of the cone type on which a predetermined load is applied by means of helical compression springs. The load on these springs is adjusted by means of nuts on the top of the worm box output shafts. and are set to transmit the full torque required to slue the crane. The clutches will slip should this torque be exceeded by the momentum of the rotating parts.

The deadweight of the revolving portion - 580 Tons is carried on a spherical roller bearing at the bottom of the mast. This type of bearing is used to allow for the changes in alignment which occur due to the deflection of the structure and also to transmit the horizontal reaction at the base of the mast.

The horizontal slue rollers fitted just below the machinery frame transmit the other horizontal reaction from the mast to the roller path at the top of the tower. Eight of these rollers are fitted - four on the back and four on the front of the mast, mounted in pairs, on compensating beams to transmit the load equally through each roller. Other four rollers are fitted two on each side of the mast to give lateral stability, the whole system forming what is in effect a large radial roller bearing.

The travelling motion is driven by four synchronized motors each of 32.5 B.H.P. with one motor located on a driving bogie situated at each corner of the crane.

There are eight centre flanged rail wheels at each corner, of which four are driven by means of worm and spur gears from the motor to the spur rims bolted to the webs of the rail wheels. The worm and wormwheel are carried in an

/-

oil-tight cast iron gearbox; both the worm shaft and wormwheel shaft are mounted on roller thrust bearings and the gear is running in oil.

To obsorb any undue shock, a flexible coupling is fitted on the motor extension shafts and on two of these couplings is fitted a large diameter brake wheel on which acts an electro-magnetic brake. This brake is so arranged that there is a time lag between putting off the controller and the coming on of the brake, in order to prevent any undue shocks on the crane structure that would arise due to a sudden braking of this motion.

The bogies and sill girders are individually compensated to take up any irregularities in the track and to spread the wheel load equally between all wheels at any one corner.

The jib is supported at its outer end by means of a multiple rope reefing. The bridle rope which is reefed in four parts between the jib point and the bridle frame, passing round compensating pulleys to equalise loads on the four parts of the rope. The bridle frame also carries the reefing pulleys through which the luffing rope - in eight parts - is reefed. The main hoist rope is reefed from the barrel to the mast top and thence to the jib point. On passing over the jib point it is reefed through the three pulleys on the main hoist return block forming a six part reefing system.

The return part of the main hoist rope is reefed between the jib point and the mast top before passing over the "Wylie" Indicator and down the mast to the levelling barrel. This arrangement provides a levelling effect on the load path, which combined with the levelling gear, gives a level path during luffing. This type of reefing also reduces the load on the luffing gear and thereby reduces the H.P. of the luffing motor required and the size of bridle and luffing ropes.

The crane structure, excepting the jib, is of Rolled Steel Sections and Plates throughout. Welded construction is employed for the prefabricated sections in the work shops whereas rivetted site joints have been used throughout.

The jib of the crane is constructed throughout of aluminium alloy sections and plates. The centres are 175 feet with a cantilever extension at the point of 13 feet centres to carry the auxiliary lift. The depth of the centre is 8'6" over the main angles and the width 16 feet. It is constructed of two main four angle sections. The two main angle sections are securely braced together with a system of diaphragms and horizontal bracings. The main angles are of H15W.P. and the bracing angles are of H3OW.P.

Alluminium alloy N6 rivets are used throughout the jib. Rivets up to 3/4" diameter have pan-heads. The larger diameter rivets have recessed ends producing dimple heads. All rivets are pneumatically driven.

BUTTERS BROS. & CO. LIMITED
GLASGOW AND LONDON.

ELECTRICAL EQUIPMENT

The electric supply for the crane is 400/440 volts, 3 phase, 50 cycles. The main hoist motion is operated by a 115 B.H.P. motor; the auxiliary hoist and luffing motions, each operated by a 95 B.H.P. motor; the sluing motion operated by a 55 B.H.P. motor and the travelling motion operated by four motors of 32.5 B.H.P. each (synchronized). These motors are all totally enclosed, slip ring, reversing type, fitted with heavy duty ball and roller bearings, half hour rated, except the main hoist which is one hour rated. Each motor is capable of exerting a starting torque of twice full load torque with a starting current of 2.5 times full load current and has an overload capacity of not less than 100 per cent for fifteen seconds in accordance with B.S.S. 2613 for short time rated motors.

In the operator's cabin is fitted a main supply circuit breaker, it is fitted with a hand lever for manual operation, 3 - overloads with inverse time lags, no-volt relay and complete with a separately mounted "STOP" push button.

Each motion is controlled by a separate contactor panel. Control for the main hoist motion consists of the necessary contactors to give plain rotor controlled hoisting with counter current lowering under supervisory control of relays connected across the slip rings of the motor. The panel has relays which work in conuunction with the "Wylie" safe load equipment and is suitable for use with a 24" diameter, direct current, shunt wound brake.

Control for the auxiliary hoist motion consists of a panel and brake similar to the main hoist motion.

The luffing motion control consists of a negative phase sequence panel, comprising the necessary contactors to give plain rotor controlled "Luffing-in" and "Luffing-out" by the unbalancing of the stator voltages of the motor through an inbuilt transformer. The panel is suitable for use with a 24" diameter, direct current, shunt wound brake.

The sluing motion comprises the necessary contactors to give plain rotor control and plugging in both directions. Plugging ensures a quick accurate stop or reversal under the control of the master controller without having to use the brake. The panel is suitable for use with an 18" diameter, direct current, shunt wound, electro-hydraulic brake.

The travelling motion control consists of the necessary contactors arranged to give plain rotor control and plugging in both directions to operate all motors simultaneously. The panel is fitted with a timing relay to ensure a time delay so that the brakes do not set immediately the controller is brought to the "Off" position, thus ensuring smooth braking. The panel is suitable for use with two - 18" diameter, direct current, shunt wound brakes.

The contactors fitted in the above panels are heavy duty D.C. steel mill type, mounted on vertical insulated steel bars. The direct current supply is obtained from an inbuilt rectifier and transformer unit. Each of the panels are fitted with triple pole main and double pole control isolating switches. This enables the panels to be serviced in the contactor house with safety as the isolation is at hand. Also with the use

/-

of the control circuit switch the sequence operation of the contactors can be checked without running the motors. Three single pole adjustable magnetic overloads with inverse time lags and no-volt relay are fitted to each panel. For each brake a metal rectifier is fitted so that the brakes can be fed with direct current.

Each motion has a suitably rated starting resistance, for the travel motion, one resistance is connected in the stator circuit of the motors and four resistances are mounted adjacent to the motors and connected permanently across the rotors of the motors. These four resistances can be adjusted to ensure equal loading on all motors.

The contactor panels and resistances are fitted in a contactor house within the structure of the crane mast.

Each motion is controlled by a cam operated master drum controller, mounted on a horse-shoe shaped frame at the front of the operator's cabin.

A self-contained fully automatic compressor unit complete with a 4 H.P. squirrel cage motor is fitted in the machinery house for the air supply to the main hoist and luff air brakes. These brakes are designed to "Stop" and "Hold" the motion if and when the air supply fails.

COLLECTOR COLUMN

A totally enclosed, slip ring collector column is fitted above the bottom gudgeon pin at the mast bottom. It has the necessary number of rings for the main supply, travel motors, etc. Each ring is fitted with two-controller type fingers with renewable carbon tips.

CABLE DRUM

A totally enclosed, counterweight operated, cable reeling drum of the radial design and construction, incorporating 4 - phosphor bronze slip rings which in turn are fitted with two carbon brushes, 3 - insulated for power and the fourth uninsulated for Earthing purposes. The drum is complete with a "Fuzee" type counterweight barrel extension, together with wire rope, pulleys and C.I. balance weights. The drum is capable of carrying 540 feet of 4 - core round, flexible trailing cable, of 2.67" overall diameter. With the length of cable carried and the crane fed from a centre point on the track, the crane can travel a total length by 1,080 feet. A 600 feet length of 4 core 392/.029 vulcanized rubber insulated and polychroroprene sheathed trailing cable 660 volt grade and 0.25 square inch cross sectional area is fitted on the cable drum.

CRANE LIGHTING, ETC.

The following lighting is provided on the crane, two - 100 Watt lamps in the operator's cabin, six - 100 Watt lamps in the machinery house, one - 100 Watt lamp in the auxiliary hoist compartment and the contactor house. Two - 1,500 Watt lamps are fitted two-thirds up and in line across the jib. One - 1,000 Watt heater is fitted in the operator's cabin. The above circuits are fed from a 5 kVA. output single phase transformer with an output voltage of 110. In the machinery house and the contactor house a low-voltage transformer is fitted for use with a portable hand inspection lamp.

/-

PROTECTIVE DEVICES

A double pole shunt type limit switch is fitted on the main hoist motion, so that in the event of the hook overhoisting, the circuit is broken and the current cut off. The electro-mechanical brake automatically comes into action and takes control. Two single pole shunt type limit switches are fitted on the luffing motion to prevent overluffing of the jib in both directions. The switches are operated by differential gearing running in an oil bath and driven by chain drive from the main hoisting and luffing barrels. The arrangement ensures that the main hoist switch cuts out when the hook reaches a pre-determined distance from the jib point no matter at what radius the crane is operating. Also on the luffing motion double pole series type limit switches are fitted in both directions to cut "Off" the power supply to the motor if and when the shunt limits fail to operate. A single pole shunt type limit switch is fitted on the auxiliary hoist motion to prevent the overhoisting of the auxiliary hoist hook.

A "Wylie" type automatic safe load indicator is fitted on the main hoist and auxiliary hoist motion to give visual and audible warning. The equipment for each indicator comprises-
1 - Transformer, 440 volt primary, 12 volt secondary.
1 - Light signal unit. 1 - 12 volt A.C. Bell. 1 - Indicator Switch.

Also on the main and auxiliary hoist panels relays are fitted which trip the "Main" and "Hoist" contactors thereby ensuring that a load beyond the capacity of the motion cannot be lifted.

Because of the silent running of the travelling gear of the crane, an alarm bell is fitted on two of the driving bogies, to indicate that the crane is in motion along the track.

WIRING

All wiring for the electrical gear of the crane is carried out in 660 volt grade single core vulcanized rubber insulated cable, except lighting, etc., which is 250 volt grade single core. The cables are laid in mild steel troughing in the machinery house and operator's cabin with conduit to motors, etc., where necessary. The cables running down the mast to the auxiliary hoist compartment, contactor house and collector column are laid in troughing and located therein by means of cable clamps. Flexible tubing is used where there is relative movement between two connections.

TECHNICAL DATA FOR

"BUTTERS" 100-TON ELECTRIC TRAVELLING MONOTOWER CRANE.

175'0" JIB: 120'0" TOWER: 55'0" RAIL CENTRES:

10-TON AUXILIARY HOIST

LOADS & RADII:

100-tons at 122-feet Radius with Return Block (6 falls)
75-tons " 132-feet " " " " "
60-tons " 145-feet " " " " "
40-tons " 160-feet " " " " "

Auxiliary Hoist:

10-tons at 170-feet Radius

Minimum Radius:

100-tons at 52-feet Radius

with a jib 175-feet long, centre to centre, fitted with an extension piece at the point and standing free on rail track 55-feet rail centres.

SPEEDS:

Hoisting	100-tons at	10-ft./min.	(Slow Gear)
"	40-tons "	25- "	(Fast Gear)
Aux. Hoisting .	10-tons "	90- "	
Luffing	100-tons "	28/30- "	
Sluing	100-tons "	180- "	
Travelling	100-tons "	40- "	

CURRENT SUPPLY:

400/440 volts, 3 phase, 50 cycles alternating current.

B.H.P. OF MOTORS:

Main Hoisting motor	115	B.H.P.
Aux. " "	95	"
Luffing motor	95	"
Sluing motor	55	"
Travelling motors	4 at 32.5	" (synchronized)

WHEEL LOADS

Maximum Wheel Load under Working Conditions:-

100-tons at 122-feet Radius and 5/7½-lbs. per sq.ft. wind pressure ..... 45.5 tons

Or maximum load at one corner i.e. the load on eight wheels ..... 364 tons

Maximum Wheel Load under Gale Conditions:-

No load 30-lbs. per sq. ft. wind pressure .... 45.625 tons

Or maximum load at one corner i.e. the load on eight wheels ..... 365 tons

/-

The total weight of the crane in complete working order including all ballast is approximately ..... 890 tons

BUTTERS BROS. & CO. LIMITED.
GLASGOW AND LONDON