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(54) APPARATUS AND METHOD FOR TRANSPORTING AND POSITIONING PREFABRICATED STRUCTURAL MODULE IN A CONSTRUCTION DOCK

(71) We, THE RALPH M. PARSONS COMPANY, a corporation organised and existing under the laws of the State of Nevada, United States of America of 617 West Seventh Street, Los Angeles, California, United States of America, and MITSUI SHIPBUILDING AND ENGINEERING COMPANY LTD., a Japanese Company of 6-4 Tsukiji 5-chome, Chou-ku, Tokyo, Japan, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a method of and apparatus for transporting and positioning a prefabricated structural module in a construction dock.

With the construction of passenger ships virtually at a standstill, most shipbuilding operations today are concerned with the construction of cargo ships.

Because of the economics involved, cargo ships are ever growing in size to maximize the amount of cargo, such as fuel oil, which can be transported in a single trip. In the construction of such ships, the bow and stern sections are the most time consuming to construct. The prefabricated structural modules which connect the bow and stern, and which become progressively, the port and starboard sections of a ship hull, are fairly easy to fabricate.

Their fabrication within the dock however is always hampered by changing weather conditions often involving lost time. It has therefore been found that the most economical way rapidly to construct a tanker is to prefabricate the port and starboard modules at a work center protected from changing climatic conditions. These modules are of a size comparable to an 8 storey building and weight as much as 1,500 tons or more. This permits full time utilization of workers assigned to construct the port and starboard modules for the ship or tanker. In addition, it has been found most economical to construct the modules on their side.

The problem then arises of transporting the modules from the point of fabrication to dock-side, to position them within the dock and align them with the bow or stern of the ship, or to modules which have been already affixed to the bow or stern.

The present invention is directed to a solution to this problem.

The present invention provides, from one aspect, a method of transporting and positioning a prefabricated structural module in a construction dock, comprising:—

a) moving the module at least once transversely of the dock on at least one set of rail mounted transverse cars having at least the operational modes of forward and reverse and in respect of module-supporting portions of said transverse cars lift and descend;

b) moving the module at least once longitudinally of the dock on at least one set of rail mounted transport cars having the operational modes of forward and reverse; and

c) imparting pitch and/or roll and/or yaw to the module whilst it is upon the transport cars by moving module-supporting portions of said transport cars relative to the rail-engaging wheels thereof, whereby to position the module relative to other structure for assembly thereto.

The method may comprise transferring the module from the transverse cars to the transport cars and vice versa by utilizing the descend and lift operational mode of said cars to deposit the module on to a support at an intersection of the rails upon which the transverse and transport cars are mounted and to thereafter raise the module from said supports on to the other said car.

The module may be delivered to the dock in a first orientation and rotated within the dock to a second orientation before depositing it upon the transverse cars.

In another aspect, the invention provides

apparatus for transporting and positioning a prefabricated structural module in a construction dock, comprising:

a) at least one set of transverse cars mounted on rails extending transversely of the dock and having portions adapted to support the module the cars having at least the operational modes of forward, reverse and in respect of the module-supporting portions, lift and descend;

b) at least one set of rail-mounted transport cars mounted on rails extending longitudinally of the dock and having portions adapted to support the module the cars having the operational modes of forward and reverse and means for imparting selectively pitch, roll and yaw to the module whereby to position the module relative to other structure for assembly thereto.

There may be a preset support at an intersection of the rails upon which the transverse and transport cars are mounted, said supports being adapted to receive the module during transfer thereof between the transverse and transport cars.

There may be means for rotating the module within the dock from a first orientation to a second orientation before it is deposited on the transverse cars.

There may be two parallel sets of said transport cars mounted on rails spaced apart transversely of the dock and control means for controlling conjointly movement of the two sets of cars and the module-supporting portions thereof whereby in operation to impart pitch and/or roll and/or yaw to a module supported upon and bridging said cars.

A transverse or transport car may comprise a plurality of wheel pairs and a chassis, hydraulic drive means for driving the associated car in either direction along the rails upon which it is mounted, hydraulic lift means including first and second groups of hydraulic cylinders connecting the chassis of the car to the wheels for raising and lowering the chassis relative to the rails, the load-supporting portion being mounted on the chassis, the first group of cylinders being positioned adjacent one end of the car and the second group of cylinders being positioned adjacent the other end of the car, each group of cylinders comprising at least one pair of cylinders, all the cylinders in a group being interconnected hydraulically to each other so that hydraulic fluid pressure is equalized in all the cylinders of a group, the cylinders of each pair being positioned adjacent opposite sides of the car, means controlling the flow of hydraulic fluid under pressure separately to the two groups of cylinders, and spring means interconnecting one wheel of each pair on one side of the car with the other wheel of each pair on the other side of the car, the spring means being arranged to resist unequal vertical movement of the opposite sides of the chassis relative to the wheels.

There may be a separate hydraulic fluid source for each group of cylinders, means for limiting the output pressure of each of said sources to a level insufficient to lift the chassis when subject to the full weight of the load, and means for selectively connecting and disconnecting said pressure limiting means and said sources.

The apparatus may comprise first and second groups of lateral hydraulic cylinders interconnecting the chassis and the module supporting portion of said car to effect relative horizontal movement thereof, the said groups of cylinders being positioned at opposite ends of the chassis.

A said car may comprise:—

a) a chassis comprising said module supporting portion;

b) a multiplicity of associated pairs of rail engaging wheels, each pair of wheels respectively being mounted for rotation upon a pair of oppositely spaced frames connected by torsion means to one another, each frame being pivotally connected at one end thereof to said chassis and coupled at the opposed end thereof to said chassis by means adapted to pivot said frames about the axis of rotation of the respective pairs of wheels to enable raising and lowering of said chassis relative to the wheels in said lift and descend operational modes, at least a portion of the multiplicity of pairs of wheels being provided with means to propel said car in the forward and reverse directions.

Attention is directed to the specification of co-pending application No. 1056/75 (Serial No. 1419162) which is divided from this application and has claims directed to matter disclosed herein.

A specific embodiment of the present invention will now be described by way of example with reference to the accompanying drawings in which:—

Fig. 1 is a schematic illustration of a module transport and positioning apparatus employed in the practice of this invention.

Fig. 2 is a typical layout for a track system for the module transport system showing the inter-relationship of both the traversing and longitudinal module moving cars.

Fig. 3 is a top view of a portion of one of the longitudinal moving cars which may be used also as traversing car as such, or with minor delineations of apparatus.

Fig. 4 is a side view of the longitudinal car shown in Fig. 3.

Fig. 5 is a detail drawing of the suspension system used for all wheels for both the transverse and longitudinal cards whether powered or not.

Fig. 6 is a detail top view of the drive system for both the longitudinal transport and transverse cars.

Fig. 7 is a rear view of the drive system shown in Fig. 6.

Fig. 8 is a schematic of the drive mechanism shown in Figs. 6 and 7.

Fig. 9 is a diagrammatic plan view of the hydraulic control system of a pair of longitudinal transport cars.

Fig. 10 is a schematic diagram of the hydraulic system of any one transport car.

Fig. 11 is a schematic wiring diagram relay control system of any one transport car.

Figs. 12 and 13 combined are a schematic wiring diagram of the hydraulic valve control circuit of any one transport car.

With reference now to the accompanying drawings and first to Figures 1 and 2, there is provided as part of the general dock-side facility, a conveyor system 10 for bringing modules 12 on their side to dock-side for insertion into, and positioning them in proper alignment with ships under construction in construction dock 14. Associated with a typical ship building operation, there are provided track mounted cranes 16 which are used both in the construction of the vessel and in the assembling and disassembling of the module transport system being described. Such cranes are however, at present, incapable of handling the weight of a prefabricated module. There is also shown for reference purposes, tanker bow 18, constructed or under construction and a portion of the stern section 20, in which there is illustrated a number of modules already secured in place by a welding operation.

The transport system is particularly adapted for the movement of port and starboard modules 22 and 24 with the construction of the intermediate sections 26 being carried out in a conventional manner. The system, however, by the addition of an additional set of tracks may be used for installation of center sections 26 when they are adaptable to prefabrication outside the construction dock.

In the system illustrated, module transport is shown taking place from the starboard side of the ship. It will be appreciated, however, that the reverse of the operation is equally feasible to permit module movement from port side. However, for ease in description, the operation of the system will be described in terms of a starboard positioned operation.

The initial point of the operation is to bring a prefabricated module unit 12, shown in the drawing for ultimate positioning along the starboard side of the vessel to rotary positioning fixture 28. It will be appreciated that if the prefabricated module 12 were destined for port positioning, it would be delivered in illustrated.

There is shown on the rotary position fixture 28 a module 24 destined for alignment along the starboard side of the vessel. Rotary positioning fixture 28 consists of support structure 30 having at the upper end thereof a pair of parallel rails 32, each of which contain a plurality of teeth 34 intermeshed with the teeth of a pair of rotary quadrant gears 35 secured to block 36 which is in turn secured by arms 38 to cradle 40 having module support arms 42 at one end and counter balanced at the opposed end. Both cradle 40 and support structure 30 are readily dismantleable for removal from the dock when the last section(s) of the ship are installed in the zone initially occupied by them.

By cooperative actuation of forward and aft hydraulic cylinders 44 and 46 their mates being on the opposed parallel rail 32 of the support structure 30, quadrant gears 35 are rotated which causes cradle 40 to move forward and simultaneously rotate to position upon termination of rotation module 24 in an upright position against a stop (not shown) at a level above the tracks to permit, with reference to Fig. 2, transverse synchronized cars 48 and 50 which have at least the mode capabilities of moving forward, reverse, upwards and downwards to engage in a lowered position the underside of a cradle held module 24.

There is also provided as part of the system, cradle wells 52 to receive the cradle of rotary positioning fixture 28.

Associated with rail mounted transverse cars 48 and 50 and 49 and 51 which are respectively interconnected by umbilical cords 54 and 55 to permit synchronous operation of both cars by a control center on one (not shown), with one car of each set being connected to a dock-side source of power (not shown). Operation of a pair is generally carried out by an operator walking with the cars. The cars are moved along their respective track systems 56 and 58 between the cradle of rotary positioning fixture 28 to deposit-transfer area 60.

The transverse cars 48 and 50 (as indicated) have a lift mode of sufficient elevational capacity to lift a module 24 from the rotated cradle. The transverse cars 48 and 50 then transport the module to area 60, in which are located platforms 62 having a required number of elevated cross over plates 64, which exist at the intersections of all tracks.

The tracks are in both the transverse and longitudinal direction and are spaced from the cross over plates 64 to account for thermal expansion. The cross over plates 64 engage the flanged portions of the wheels of the transverse cars 48 and 50, and 49 and 51, and are of sufficient height to elevate the cars such that the wheels pass over the intersecting longitudinal rails. Thereafter the rail tread portions of the wheels re-engage the continuation of the transverse rails upon which they previously were disposed. The cross-over plates similarly engage the wheels of the

longitudinal cars 66, 68 to enable them to cross the intersecting transverse rails.

As shown in Fig. 2, there is provided a set of three longitudinal rail systems 70a, 72a and 74a and 70b, 72b and 74b. This, as illustrated in Fig. 2 allows the longitudinal cars to be spaced depending on the width of the module to be transported for interconnection with the ship. As illustrated in Fig. 2, port side longitudinal cars 66 and 68 are on outer tracks 70a and 74a for transport of a large module whereas companion starboard side longitudinal cars 66 and 68 are on tracks 72b and 74b for transport of a more narrow module so that the center of gravity of a module shall be between the longitudinal cars.

Returning now to the operation, transverse cars 48 and 50 enter under the module deposited in an upright position by the rotary positioning fixture 28 and raise the module by hydraulic action from the cradle. It is then transported across tracks 56 and 58 to zone 60 and lowered by transverse cars 48 and 50 in a synchronous manner into pre-set blocks (not shown). The platens of the traversing cars are then lowered and the cars removed to a neutral zone as shown in Fig. 2 or returned to pick up another module.

Longitudinal cars 66 and 68 with their attending power car 76 with their platens lowered below the level of the deposited module pass under the module and lift it from its blocks.

With reference to Fig. 1 where the module is to be transported to the port side of the ship, it is lifted from the blocks, carried by a set of longitudinal transport cars 66 and 68 along any preselected pair of tracks.

Where instead, the module is destined for positioning along the starboard side of the ship under construction, transport cars 66 and 68 only transport the module to the opposed end of zone 60 where it is again deposited on prepositioned blocks. The platens of cars 66 and 68 then being lowered from the deposited module and the cars moved out of place. Transverse cars 49 and 51 generally operated in the same manner as cars 48 and 50 interconnected by umbilical cord 55 then come into play and are driven along tracks 57 and 59, with their platens in a down mode position, and pass under the deposited modu'e, lift the module from its blocks and transport the module along tracks 57 and 59 to area 78 where it is again deposited on a pair of predeposited blocks (not shown) the cars 49 and 51 moved out of place.

Starboard side longitudinal cars 66 and 68 as powered by control and power car 76 then move under the module, lift it and transport it along the starboard side of the dock as shown in Fig. 2 to the stern section of the ship.

It will be appreciated that a companion transfer system may be positioned on the bow side of tracks 56 and 58 for carrying out the same operation with respect to the starboard bow section of the ship.

When the cradle is positioned in the starboard side of the dock a companion set of longitudinal cars may be employed on the starboard bow directed tracks corresponding to tracks 70b, 72b and 74b for operations connected with the starboard construction of the ship.

To that extent, once the utility of the longitudinal cars associated with the construction of the starboard side of the stern portion of the tanker has ended, they may be moved by cranes 16 to the bow side of the rotary positioning fixture to position modules against the starboard side of the bow portion of the ship.

Before attending to the flexible utility of transport cars 66 and 68 whose operation is modulated by attending power and control car 76, some detail of their construction and sub-construction be dealt with.

With reference now to Figs. 3 and 4, there will be described general elements of the transverse and longitudinal transport cars with particular emphasis being directed to the elements of a longitudinal transport car as it includes all the modes of operation but is more complex than a transverse car.

Referencing it to transport car 68 or its companion 66 of Fig. 2, it consists in general of a rigid chassis 80 consisting of longitudinal structural beams 82 and a plurality of transverse support beams 84. These support a platen 86 consisting of frame 87 carrying a plurality of spaced module support units 88. Platen 86 is supported on and spaced from chassis 80 by slide bearing spacers 90 between beams 82 and frame 87.

A plurality of port and starboard oriented hydraulic cylinders 92 are positioned at the forward and aft ends of each longitudinal transport car and connect to beams 84 and frame 87 of platen 86.

When hydraulic cylinders 92 are actuated, the platen 86 is moved laterally on the slide bearing surfaces 90. If the forward cylinder 92a is actuated in one direction and the aft cylinder 92b (not shown in Fig. 2, but indicated in Figs. 9 and 10) is actuated in the opposite direction, the platen is rotated.

There is also contained on chassis 80 hydraulic power system 98, the energy to which is supplied from attending control car 76 (not shown) and the necessary hydraulic control valves (not shown) and hydraulic piping (not shown). The hydraulic valves are electrically controlled from the control car 76.

The attending control car 76 consists primarily of a rail mounted diesel generator and a control unit for a set of longitudinal cars. In operation, the attending car 76 provides power to a set of longitudinal cars but is not

self driven, rather it is carried along by the longitudinal transport car to which it is connected.

The cars, whether transverse or longitudinal transport in nature, generally have 12 sets of axle connected wheels adapted to engage a track in the tread sections thereof and roll over a rail crossover plate on machined flanges. For the operation approximately normally 1/3 of the total wheel units are powered by hydraulic motors 100 secured to beams 84. As illustrated in Fig. 3, three such motors are shown, a fourth being hidden by the platen 86.

Although the driven wheels may be positioned at any point along the length of the car, they are preferably positioned at the central portion of the car with two motors, where 12 wheel units are employed, being positioned on each side of the center line (C_L) of the car. The suspension system for each set of wheels whether driven or not is indicated by 102 in Fig. 4.

In considering a transverse car, since only upward and downward movements are required, in addition to forward and reverse, and lateral movement unnecessary, hydraulic cylinders 92a and 92b, as well as slide bearings 90, may be eliminated and platen 86 secured directly to chassis 80 of the car. In the alternative, the frame 87 of platen 86 may be eliminated and support members 88 connected directly to chassis 88 of the transverse cars.

While this will minimize construction costs for the transverse cars, it is possible, however, that all cars have identity of construction in so far as the car elements are concerned in order that they may be utilized as both transverse and longitudinal cars.

With reference now to Figs. 4 and 5 and particularly Fig. 5 there is shown the detail of the suspension system provided for each wheel of a transverse or longitudinal car whether driven or merely a rolling support wheel.

Suspension system 102 is connected to longitudinal beam 82 of chassis structure 80 by support structure 104, shown in Fig. 7 and secured to it by torsion bar 106 which is keyed to member 108 secured to suspension frame 110. There is also secured to frame 110 parallel to torsion bar 106 the axle of wheel 112 which engages track 114.

The opposed end of suspension frame 110 is connected to hydraulic cylinder 116 which is in turn pivotally connected to frame 110 and transverse beam 84.

A companion structure appears on the reverse side of the car with its track supported wheel interconnected to wheel 112 by a common axle.

In this suspension system, torsion bar 106 tend to hold chassis 80 level while at the same time permitting, by torsional deflection, one wheel 112 to be higher or lower than its companion axle coupled wheel by an amount of elevation difference to be expected in the setting of rails 114. While the resulting wheel loads will be slightly different due to the resulting torque in torsion bar 106, the loads on the hydraulic cylinders 116 will remain constant since they are hydraulically interconnected. The suspension system employed for each pair of axle wheels 112 plays an important part in the various mode functions for both the transverse and longitudinal cars.

As a minimum, all hydraulic cylinders 116 may be employed in conjunction to raise or lower the platform 80, and other members on it, of each car to receive or deposit a module at a desired position along the module transport system.

This is accomplished, where a raised function is, for instance, required by forcing fluid into hydraulic cylinders 116 associated with each pair of rail engaged wheels 112. Since the tracks 114 are firmly affixed to the floor of the dock, the only member which may move is frame 80 of the car causing rising of the car relative to the wheel by pivoting of suspension frames 110. In a reverse function, lowering of the car relative to the wheels is achieved by uniformly exhausting hydraulic cylinders 116. The position of the wheels which engage the rails, however, remains unchanged. Therefore pivot occurs about the axle of the wheels. Any tendency for frame 80 to rise at one side more than the other is opposed by torsion bar 106.

With reference now to Figs. 6, 7 and 8 there is described the drive mechanism employed for any one of the driven rail engaging pairs of wheels on either the longitudinal or transverse cars.

With reference first to Fig. 6, there is shown the top view of the mechanism involved in the raising and lowering functions as well as the forward and reverse mode of operation of one of the driven rail engaging wheel pairs which differs from a traveling axle connected wheel pair only by the drive mechanism employed.

There is provided as part of chassis 80, longitudinal structural members 82 and transverse beams 84, a companion pair of hydraulic cylinders 116 attached in pivotal relation to longitudinal structural members 82 and suspension frames 110.

As indicated, the principal mode of function to be described is that associated with driving a car in either a forward or reverse direction employing driven wheels.

As part of the system, there is secured to beam 84 a reversible hydraulically driven motor 100. Through a reduction gear box 101, it supplies by a chain drive, power from sprocket 120 to sprocket 122 secured to annu-

lar drive shaft 124 which surrounds the torsion bar 106. The power is in turn transmitted to sprocket 126 also secured to annular drive shaft 124 and transmitted in turn by a chain drive to sprocket 128 on axle 130 connecting a pair of wheels 112.

With reference now to Fig. 7, which is the rear view of Fig. 6 and with additional reference to Figs. 3, 4 and 5, there is shown all the common members. Here again, hydraulically driven motor 100 through gear box 101 drives sprocket 120 connected by chain drive to sprocket 122 which through annular drive shaft 124 transmits power to sprockets 126 which, with reference to Fig. 6, transmits by a chain drive, power to sprocket 128 attached to axle 130 to propel axle coupled wheels 112 in either a forward or reverse direction. By means of support structure 104, the entire system is pivoted about torsion bar 106 to maintain the point of pivot during lift, and descend modes about the axle 130 connecting wheel pairs 112 in order that axle connected wheels 112 may be maintained in a stationary position while chassis 80 may be raised and lowered relative to axle connected wheels 112 by coaction of hydraulic cylinders 116 in cooperation with torsion bar 106.

With reference now to Fig. 8, there is provided a schematic representation of the drive mechanism employed. To rigid chassis 80 consisting of longitudinal beams 82 and transverse beams 84, there is secured thereto hydraulically driven motor 100 connected to a reduction gear box 101. Power is transmitted to sprocket 120 connected by a chain drive to sprocket 122 secured to a annular drive shaft 124 which rotates about torsion bar 106. This power is then transmitted through annular drive shaft 124 to the companion sprocket 126 (not shown) and by a chain drive to sprocket 128 attached to axle 130 interconnecting wheels 112 maintained in contact with rails 114.

This drive mechanism permits the use of the hydraulic system to raise and lower the chassis 80 relative to wheels 112 without changing the contact force between wheels 112 and track 114.

As to the multiplicity of paired-wheels 112, the only difference between the driven wheels and rolling wheels is that the motor drive mechanisms are eliminated. Apart from them, every element shown in Figs. 5 to 7 is present with the wheels coupled to torsion bar 106 by frame members 110 which are rotatably connected to axle 130 of wheels 112 and which are in turn pivotably connected to hydraulic cylinders 116 attached to transverse beam 84 of chassis 80 which again permits raising and lowering of chassis 80 relative to wheels 112 supported on rails 114.

Considering now Figs. 2 through 8, there will be described the several functional modes available to each of the rail engaged longitudinal cars 66 and 68 as controlled by attending cars 76.

Traverse movement of a contained module on a set of cars has already been described with reference to, in particular, Figs. 3 and 4.

Forward and reverse operation of any car alone or in conjunction with another is simply accomplished by employing the drive mechanism of the driven wheels of any one of or set of the longitudinal transport or transversing cars.

With respect to longitudinal transport cars 66 and 68, control is by attending control and power car 76 which is connected directly to one of the longitudinal cars which is connected to the other by a for or aft umbilical cord 132. This permits entry under and removal from underneath modules until all patterns of blocking.

As indicated with respect to transversing cars, operated as a pair, the minimum mode functions are forward and reverse operations as well as raising and lowering of chassis 80 of the cars through action of hydraulic cylinders 116 associated with the suspension mechanism illustrated in Fig. 5. A set of transverse cars normally operate in unison to maintain chassis 80 level with respect to their longitudinal and transverse axis.

Longitudinal transport cars operating as a pair are adapted to more complex modes of operation.

There is, of course, forward and reverse, as well as raising and lowering of chassis 80 of each car alone or in conjunction with the other by means of hydraulic cylinders 116 and drive mechanism has has been described above and the sideward motion of the platen by hydraulic cylinders 92a and 92b.

For proper alignment of a transported module with a companion module already attached to either the bow or stern of a ship under construction, there are incorporated additional functions.

One involves roll. This involves rotation of the module supported by a pair of companion cars 66 and 68 about the longitudinal axis. This is achieved by raising or lowering the chassis 80 of one of the cars relative to the other. The slight angular rotation of the platen 86 and chassis 80 of each car relative to the longitudinal axes of the cars that occurs during this motion while the axles 130 remain parallel to the dock floor, causes a small relative extension of the hydraulic cylinders 116 on the rising side and a retraction of those on the lowering side of each car and there is a slight twist of the torsion bars 106. The differential motion of the opposed hydraulic cylinders of a pair is accommodated by exchange of hydraulic fluid through their common manifold. The torsion bar accepts the twist elastically and returns

to its original shape after the load is removed.

The next function available is pitch. This involves pivoting of rigid chassis 80 about a transverse axis relative to tracks by hydraulic forces introduced through hydraulic cylinders 116. The cylinders 116 are interconnected in two groups, the groups, with reference to Fig. 3, being all hydraulic cylinders 116 associated with all wheels forward of centre line (C) and all hydraulic cylinders of all wheels aft of the centre line (C).

If an upward pitch is desired, hydraulic fluid is jumped into all of the hydraulic cylinders 116 connected to the suspension systems of all wheels forward of the center line (C) of the transport cars 66 and 68. Each suspension system associated with each pair of wheels will raise in the amount required to maintain the platen in intimate contact with the module.

In the aft portion of the cars, there is an interchange of hydraulic fluid from the forward half of the aft group of cylinders 116 to the rear half of the group 112. Again, in proportion to the degree of angular rotation imposed, there will be extension or retraction of all transverse pairs of cylinders 116 as required to maintain the platen in intimate contact with the module. In this mode of operation pivot will be, in general, about the center of the rear group of cylinders.

It will be appreciated that the reverse will occur if pitch in the opposed direction is desired and that similar results could be achieved by raising or lowering the rear group of cylinders 116 or by actuating the forward and rear groups oppositely and simultaneously.

The next function is yaw which produces a rotation of the module about a vertical axis. With particular reference to Figs. 2, 3 and 4, for clockwise yaw employing port side longitudinal cars 66 and 68, this is induced in part, by activation of hydraulic cylinders 92a and 92b. Cylinders 92b in the aft portion of both cars can be activated to move the platen toward the port side and activation of the hydraulic cylinders 92a in the forward portion of each car can be activated to move the platen toward the starboard side. Simultaneously, longitudinal car 66 is driven aft while longitudinal car 68 is driven forward. The clockwise rotation of the platens produces the clockwise rotation of the module while the aft motion of car 66 and the forward motion of car 68 produce the forward and aft motions of the port and starboard sides of the module which occur as a natural result of the clockwise rotation.

It will be appreciated that if the actuation of hydraulic cylinders 92a and 92b and the longitudinal drives of cars 66 and 68 are all reversed from the directions indicated above that a counter clockwise motion of the module will result.

It will further be appreciated, however, that the degree of yaw will normally be minimal as the major alignment of the module on the set of longitudinal cars is established and maintained throughout the assembly, rotation and transport of the module.

By imparting the several degrees of motion, each in the proper amount, a module to be connected to a vessel may be accurately aligned with a previously positioned module within the degree of precision required by the industry and that is can then be blocked in that position preparatory to welding to its neighbours.

The longitudinal cars may then be relaxed to their normal position, frame 80 and platen 86 thereby lowered, and the companion pair of cars removed out of position for reception of another module.

Although the operation of the entire system has been described as being hydraulically powered, there are provided electrical control systems for the various hydraulic power systems. It will be appreciated that pneumatic or hydraulic control systems could be employed in lieu of the electrical. The electrical control system facilitates engagement and disengagement of the sets of cars and facilitates the control of sets of cars by one operator from one control console. It will be further appreciated that both types of cars can be operated either singly or in sets.

In addition, while the system has been described as operated hydraulically, there may be employed any other operative means such as DC driven motors with screw drive to supplant hydraulic cylinders as well as induction AC motors again associated with screw drives to achieve the various functions accomplished hydraulically. Some provision would have to be made to achieve the synchronization and load equalization that is essentially automatic in the hydraulic systems. Electrical motor drives may also be used to propel the cars.

While it is preferred that the driven wheels occupy the central portion of each car, it will also be appreciated that each wheel may be equipped with a drive mechanism or that drive mechanisms may be associated with wheels other than those centralized with respect to the center line of each car.

Further, more than one-third of the available wheel pairs may be driven or less than one-third of the available wheel pairs of each car may be driven depending upon the traction and power requirements for each car employed.

While it is preferred, in the system described, that a set of cars consist of two cars, it will be appreciated that any number of cars can be included in a set, according to the load and space requirements.

The transport system being described is capable of accurately positioning modules dur-

ing the construction of ships having a dead weight tonnage ranging from 200,000 tons to 580,000 tons or more. The modules employed in their construction will generally range in weight from 675 tons to 1,500 tons.

To accomplish this task, both the transverse and transport cars may have an overall average length of 70 feet and an average width of 6.5 feet.

Car dimensions, however, are subjected to change depending upon the size and weight of a module to be transported within a dock during a shipbuilding operation.

Referring to Fig. 9, there is shown the basic power control system of the longitudinal cars 66 and 68. Each car includes a pair of hydraulic pumps 140a and 140b, each driven by an electric motor 142. Electric power and control lines extend from the tender car 76, which has a diesel-powered generator 143 and a central control panel 145. The plan view of the car 66 in Figs. 9 shows diagrammatically twenty-four hydraulic lifting cylinders 116 arranged with twelve lifting cylinders 116a forward of the centerline of the car and twelve lifting cylinders 116b aft of the centerline. Also for control purposes, the lateral cylinders 92 are arranged in two groups, a forward group 92a of four and an aft group 92b of four. The position of the four drive motors 100 is also shown. While the lift cylinders 116 have been indicated in relation to the inboard car 66 and the lateral control cylinders and the drive motors have been shown in the outboard car 68 in Fig. 9, it will be understood that both cars include all of the lift cylinders, lateral control cylinders and drive motors arranged as shown for each car.

Referring to Fig. 10, the hydraulic control system for one longitundinal car is shown diagrammatically. The two pumps, designated at 140a and 140b, pump hydraulic fluid from a common reservoir 146. Bypass valves 148a and 148b return fluid from the outlet side of the pumps directly to the reservoir until the control system requires hydraulic power to be delivered to any of the motors and/or control cylinders, at which time the valves 148 are closed. The fluid from the pump 140a is supplied by a high pressure hydraulic line to each of the three control valves 150, 152, and 154. The output of the pump 140b is similarly supplied by a high-pressure hydraulic line to two other control valves 156 and 158, and also to the control valve 154. Each of the control valves 150, 152, 154, 156 158 has a low-pressure return line going back to the reservoir 146.

Each of the control valves 150, 152, 154, 156, 158 has three control positions. The intermediate or neutral position, shown in Fig. 10, is an OFF position in which fluid does not flow through the control valve. The control valves, which are each solenoid-actuated by a pair of solenoids, such as indicated at 150a and 150b, 152a and 152b, 154a and 154b, 156a and 156b, and 158a and 158b, can be moved in either direction from the intermediate position, so as to direct fluid through the valve to one outlet port or the other outlet port of the control valve, as shown by the arrows in Fig. 10.

The control valve 150 is used to control the flow of fluid to the twelve forward lift cylinders 116a. The twelve cylinders are connected in parallel across a pair of hydraulic lines extending back to the two outlet ports of the control valve 150. Thus when the control valve 150 is actuated to move it to a "RAISE" position by solenoid 150a, fluid pressure is applied to one side of all of the twelve cylinders to cause movement of the forward end of the car frame in a lifting direction. When the control valve 150 is moved to the "LOWER" position by solenoid 150b, the hydraulic pressure is applied to the other side of all twelve cylinders 116a, causing a net movement of the forward end of the car frame in the lowering direction. By connecting the cylinders 116a in parallel, the fluid pressure equalizes among the cylinders so that if a greater external force is applied to some of the cylinders provided a net increase in fluid pressure, fluid will be forced into the remaining cylinders until the load is equalized. This permits the unequal movement of the lift cylinders when a pitch movement is applied to the car frame by actuating the forward lift cylinders 116a but not the aft cylinders 116b or to permit adjustment of the wheels in passing over high points on the rails.

Similarly the control valve 156 controls the twelve aft lift cylinders 116b, the twelve cylinders being connected in parallel across the alternate outlet ports of the control valve 156, permitting the control valve 156 to provide fluid under pressure selectively to either side of all of the aft lift cylinders to produce a net lowering or raising movement of the aft portion of the longitudinal car.

The control valve 152 similarly provides fluid under pressure to either side of the four forward lateral cylinders 92a connected in parallel. By moving the control valve either to a "starboard" or "port" position by means of solenoids 152a or 152b, the fluid under pressure is applied to the lateral cylinders to produce a net movement either in the starboard direction or the port direction. Again, by connecting the cylinders in parallel, the pressure is equalized and the cylinders adjust automatically to equalize the load on each cylinder.

The control valve 158 by means of solenoids 158a and 158b similarly controls the four aft lateral cylinders 92b.

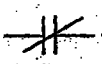
The control valve 154 by means of solenoids 154a and 154b controls the direction

of flow of hydraulic fluid through the drive motors 100, which are also connected in parallel, the control valve 154 having a "forward" position and an "aft" position in which the drive motors operate respectively to drive the car in a forward direction or in an aft direction.

A lift leveler control is provided by a solenoid-operated valve 155 which bypasses the output of the pumps 140a and 140b through check valves 157 and 159 and through a pressure-relief valve 159 back to the reservoir 146. The valve 159 is set to open when the pressure reaches a predetermined level, for example 500 psi, so as to limit the pressure of the fluid in the system whenever the valve 155 is open. This arrangement is used when initially raising the platens of the two cars against the module. The platens, under limited pressure, are pressed against the module so as to take up any lost motion without applying sufficient force to actually lift the module off its supports. The leveler control is then turned off and full pressure applied to all the lift cylinders to raise the module. The initial leveling action ensures that the load is equally distributed to all four groups of lifting cylinders 116.

Operation of the control valves 150, 152, 154, 156, 158 to properly position a module is shown by the schematic wiring diagrams of Figs. 11 and 12. The control circuit controls and coordinates the operation of both the inboard car and the outboard car which together support and position a single ship module 24. Figs. 11 and 12 show two electrical circuits one for operating a series of relays in response to manually controlled switches, and the second circuit for controlling the hydraulic control valves 150—158 in both the inboard and outboard longitudinal cars in response to the relays in the first circuit.

Considering first the relay control circuit, the relays are driven from a relatively low voltage, for example 50 volts, derived from the secondary of a transformer 160, the primary of which is connected to the electrical power source provided by the generator 143. All operations can be controlled from either a remote control panel or a local control panel which provide duplicate control push buttons for controlling the various positioning movements which can be imparted to the module by the inboard and outboard longitudinal cars. In the drawing, all relay contacts operated by the same relay bear the same reference number followed by a letter. Normally closed relay contacts are represented by a pair of parallel lines with a slant line through them, thus



Normally open relay contacts are represented by a pair of parallel lines without the slant line, thus



Forward and aft movement of the module is controlled by a group of push-button switches, including local and remote STOP switches, local and remote FWD switches, local and remote AFT switches, local and remote JOG FWD switches and local and remote JOG AFT switches. The STOP switches have normally closed contacts connected in series circuit with normally closed contacts of the JOG FWD switches, the normally open relay contacts 162a, normally closed relay contacts 164b, and the coil of relay 162 across the 50-volt voltage source. Normally open contacts operated by FWD push-button switches are connected in parallel across the contacts 162a so that pushing either of the FWD switches completes a circuit energizing the relay 162 to close the contacts 162a. The relay 162 then remains energized until one of the STOP switches is actuated, breaking the circuit through the relay 162. The relay 162 is also energized by depressing either of the JOG FWD switches to close normally open contacts to complete a circuit through the relay coil 162 that bypasses the contacts 162a. Thus when a JOG FWD switch is released, the relay 162 is immediately de-energized without operating the STOP switches.

The two STOP switches are also series connected through normally closed contacts operated by the JOB AFT switches, the normally open contacts 164a, normally closed contacts 162b, and the coil of a relay 164. The AFT switches have normally open contacts connected in parallel across the contacts 164a so that depressing either AFT switch energizes the relay coil 164. The JOG AFT switches also include normally open contacts which, when closed, complete a circuit through the relay coil 164, but bypass the contacts 164a so that the relay is de-energized when the JOG AFT switches are released.

It should be noted that the normally closed contacts 164b and 162b provide an interlock arrangement so that both the forward and aft drives cannot be operated at the same time by someone attempting to close both the FWD switch and the AFT switch at the same time.

The relays 162 and 164, when activated, operate the hydraulic control valve 154 to operate the hydraulic drive motors 100 in direction to move the longitudinal cars in a forward or in an aft direction. To this end, solenoids of the control valves are connected by particular relay-operated contacts in a

second circuit shown in Fig. 12. All relay contacts have the same reference numberal as the associated relay in the relay circuit of Fig. 11 with an added letter for identification. The relay 162 has normally open contacts 162c which connect the solenoid 154a associated with the control valve 154 of the outboard car across the voltage source. Thus when the relay 162 is energized, closing the contacts 162c, the solenoid 154a moves the control valve 154 to a position to pass hydraulic fluid to the drive motors in a direction to move the outboard car 68 in a forward direction. Similarly normally open contacts 162d connect the solenoid 154a of the control valve 154 in the inboard longitudinal car 66 to the forward position when the relay coil 162 is energized.

To drive the two cars in the aft direction, normally open contacts 164c and 164d energize the reverse solenoids 154b of the control valves 154 in both the outboard and inboard longitudinal cars.

To raise and lower the module, the control circuit of Fig. 11 includes a pair of relays 166 and 168. The relay 166 is activated by either a local or remote UP push-button switch, the normally open contacts of the UP switches being connected in parallel across the normally open contacts 166c operated by the relay 166. Similarly the relay 168 is energized by operating either one of a pair of DOWN push-button switches having normally open contacts connected in parallel across the normally open contacts 168c operated by the relay 168.

The relay 16 when energized closes normally open contacts 166c to lock the relay 166 while relay 168 when energized closes normally open contacts 168c to lock the relay 168. Either relay is released by either one of two STOP switches having normally closed contacts connected in series with both relays.

Referring to Fig. 12, the relay 166 operates normally open contacts 166d to complete a circuit through the solenoid 156a operating the control valve 156 to raise the aft section of the outboard car. A pair of normally open contacts 166e operated by the relay 166 at the same time complete a circuit through the solenoid 156a of the control valve 156 in the inboard car for raising the aft section on the inboard car. The outboard car forward section is raised by closing normally open contacts 166f, operating energizing solenoid 150a to operate valve 150. The inboard car forward section is also raised by closing contacts 166g.

Similarly, the relay 168 closes normally open contacts 168d and 168e to operate the solenoids 156b associated with the valves 156 for lowering the aft section of the outboard and inboard cars. Closing of normally open contacts 168f and 168g operates solenoids 150b for lowering the forward sections of the outboard and inboard cars.

The roll control includes a pair of relays 170 and 172. The relay 170 is energized by pushing either one of a pair of ROLL STBD switches to close normally open contacts. Normally closed contacts 172a are connected in a series with the relay 170, while normally closed contacts 170a are connected in series with the relay 172 to provide an interlock to prevent both the starboard and port roll to be initiated at the same time. The relay 172 is energized by closing one of two ROLL PORT push button switches to actuate a pair of normally open contacts.

As shown in Fig. 12, relays 170 and 172 cause the outboard car aft section to be raised or lowered by operating respectively normally open contacts 170b connected in parallel with the normally open 166d contacts and by the normally open contacts 172b connected in parallel with the normally open contacts 168d. Also the outboard car forward section is raised and lowered at the same time by control valve 150 by normally open contacts 170c and 172c respectively. Thus it will be seen that a roll starboard is accomplished by raising the aft and forward sections of the outboard longitudinal car together while the aft and forward sections of the inboard car remain at the same level.

Pitch is controlled by a pair of relays 174 and 176 (see Fig. 11). Closing the normally open contacts of either one of the PITCH AFT switches completes a circuit through the relay 174 and the normally closed contacts 176a. Closing either one of the PITCH FWD switches similarly energizes the relay 176 through the normally closed contacts 174a. The contacts 174a and 176a provide an interlock between the two relays to prevent both relays from being energized at the same time.

To effect a pitch aft, as shown in Fig. 12, the relay 174 closes normally open contacts 174b and 174c. These contacts, when closed, complete a circuit through the solenoids 150a associated with the control valves 150 to raise the forward section of both the outboard longitudinal car and the inboard longitudinal car at the same time. To achieve a pitch forward, the relay 176 closes a pair of normally open contacts 176b and 176c for energizing the solenoids 150b associated with the control valves 150, which causes the forward sections to be lowered on both the outboard car and the inboard car at the same time.

To achieve lateral positioning of the vessel module either to the starboard side or to the port side, two relays 178 and 180 are respectively energized by closing one of the LAT STBD push-button switches or one of the LAT PORT switches. The normally closed contacts 180a in series with the relay

178, and the normally closed contacts 178a in series with the relay 180 provide an interlock to prevent both relays from being energized at the same time.

To achieve lateral movement to starboard, the relay 178 closes normally open contacts 178b, 178c, 178d and 178e. Closing of the contacts 178b completes the circuit through the solenoid 152a associated with the control valve 152, to operate the forward lateral hydraulic cylinders 92a on the outboard car in the starboard direction. Similarly closing of the contacts 178c operates the corresponding valve 152 in the inboard car. Closing the contacts 178d and 178e closes the control valves 158 in the outboard car and the inboard car to effect the starboard movement of the aft lateral hydraulic cylinders 92b on both cars simultaneously.

Similarly the normally open contacts 180b, 180c, 180d, and 180e are closed by the relay 180 to operate the control valves 152 and 158 in both the inboard and outboard cars simultaneously, providing lateral movement to the port side by the platens of both cars.

Finally the yaw control of the module in either the clockwise (CW) or counter-clockwise (CCW) direction is controlled respectively by a relay 182 and a relay 184 (see Fig. 11). The relay 182 is energized by actuating either the remote or local CW push-button switch, energizing the relay 182 through a pair of normally closed contacts 184a. Similarly the relay 184 is energized by operating either one of the CCW push-button switches through the normally closed contacts 182a. Again the contacts 182a and 184a provide an interlock preventing both relays from being energized at the same time.

Referring to Fig. 13, with the relay 182 closed to provide a clockwise yaw, normally open contacts 182b are closed, energizing the solenoid 154a and operating the control valve 154 to provide a forward car drive of the outboard longitudinal car. At the same time normally open contacts 182c are closed completing a circuit energizing the solenoid 154b associated with the control valve 154 on the inboard car so as to cause the inboard car to drive in an aft direction. Also the relay 182 closes normally open contacts 182d, energizing the solenoid 152a associated with the control valve 152 and causing the outboard car forward lateral control to move the forward end of the platen in a starboard direction. Normally open contacts 182f at the same time energize the solenoid 158b of the control valve 158 on the outboard car to cause the aft lateral control to move in the port direction. Thus the platen on the outboard car is caused to pivot in a clockwise direction. At the same time normally open contacts 182e and 182g operate the control valves 152 and 158 on the inboard car to move the forward end of the platen in a lateral direction to the starboard side and the aft end to the port side, thereby rotating the platen on the inboard car also in a clockwise direction.

The relay 184, when energized, produces at counterclockwise yaw of the module by means of normally open contacts 184b and 184c which cause solenoids 154b in the outboard car and 154a in the inboard car to be energized. This causes the outboard car to move aft and the inboard car to move forward. At the same time contacts 184d and 184f operate solenoids 152b and 158a on the outboard car to produce counterclockwise rotation of the outboard car platen. The contacts 184e and 184g at the same time complete a circuit to solenoids 152b and 158a of the inboard car to produce counterclockwise rotation of the inboard car platen.

The lift leveler control portion of the circuit of Fig. 11 includes a relay 186 operated by a pair of STOP switches having normally closed contacts in series with normally open contacts 186a operated by the relay 186. A pair of LEVEL switches have normally open contacts connected in parallel with the contacts 186a so that operation of either LEVEL switch activates relay 186, closing contacts 186a. Operating either STOP switch breaks the circuit, releasing relay 186. The relay 186 operates normally open contacts 186b to complete a circuit through solenoid 155b to operate valve 155 in both the inboard and outboard cars 66 and 68.

Each of the relays 162, 164, 166, 168, 170, 172, 174, 176, 178, 180, 182, 184 of the relay control circuit of Fig. 11 operates normally open contacts, as shown in Fig. 12, for completing a circuit through the bypass valves 148a and 148b associated with the pumps 140a and 140b respectively. These normally open contacts are indicated at 162' through 186' in the outboard car and 162'' through 186'' in the inboard car. It should be noted that the inboard car does not include contacts for the roll control relays 170 and 172, since only the outboard car platen is raised and lowered during the roll operation. Thus it will be seen that when many of the control relays are actuated, the bypass valves are closed to provide hydraulic fluid from the pumps to the various control cylinders and drive motors.

Since the forward and aft drive of the two longitudinal cars 66 and 68 results in the movement of a considerable mass, it is desirable that there be a braking action for decelerating the mass when the STOP buttons are actuated. This is accomplished hydraulically by means of a pressure relief valve arrangement as shown in Fig. 10. The relief valve, indicated at 190, is arranged to be normally closed to the flow of hydraulic fluid

but is forced open when the pressure of the hydraulic fluid exceeds some predetermined limit, for example, 3,000 psi. The valve 190 is connected across the drive motors 100 by means of four check valves 192, 194, 196, and 198. The arrangement is such that the drive motors 100 operate as pumps when driven by the inertia of the moving longitudinal cars. When the control valve 154 is closed, the motors 100, depending upon the direction the motors are rotating, force fluid through either the check valve 192 or 194 to the inlet side of the relief valve 190. The outlet side of the relief valve 190 returns to either one side or the other of the drive motors by the check valves 196 and 198. The check valves are arranged to limit flow of fluid in one direction through the relief valve 190. This arrangement provides dynamic braking in that the motors act as pumps driving fluid through the relief valve 190 until the mass of the moving system has decelerated to the point that the relief valve closes and the drive motors cease to rotate.

WHAT WE CLAIM IS:—

1. A method of transporting and positioning a prefabricated structural module in a construction dock, comprising:

a) moving the module at least once transversely of the dock on at least one set of rail mounted transverse cars having at least the operational modes of forward and reverse and in respect of module-supporting portions of said transverse cars lift and descend;

b) moving the module at least once longitudinally of the dock on at least one set of rail-mounted transport cars having the operational modes of forward and reverse; and

c) imparting pitch and/or roll and/or yaw to the module whilst it is upon the transport cars by moving module-supporting portions of said transport cars relative to the rail-engaging wheels thereof, whereby to position the module relative to other structure for assembly thereto.

2. A method as claimed in claim 1 comprising transferring the module from the transverse cars to the transport cars and vice versa by utilising the descend and lift operational mode of said cars to deposit the module on to a support at an intersection of the rails upon which the transverse and transport cars are mounted and to thereafter raise the module from said supports on to the other said car.

3. A method as claimed in claim 1 or 2, comprising delivering the module to the dock in a first orientation and rotating it within the dock to a second orientation before depositing it upon the transverse cars.

4. Apparatus for transporting and positioning a prefabricated structural module in a construction dock, comprising:

a) at least one set of transverse cars mounted on rails extending transversely of the dock and having portions adapted to support the module the cars having at least the operational modes of forward, reverse and in respect of the module-supporting portions, lift and descend;

b) at least one set of rail-mounted transport cars mounted on rails extending longitudinally of the dock and having portions adapted to support the module the cars having the operational modes of forward and reverse and means for imparting selectively pitch, roll and yaw to the module whereby to position the module relative to other structure for assembly thereto.

5. Apparatus as claimed in claim 4 comprising a preset support at an intersection of the rails upon which the transverse and transport cars are mounted, said supports being adapted to receive the module during transfer thereof between the transverse and transport cars.

6. Apparatus as claimed in claims 4 or 5 comprising means for rotating the module within the dock from a first orientation to a second orientation before it is deposited on the transverse cars.

7. Apparatus as claimed in any of claims 4 to 6 wherein there are two sets of said transport cars mounted on rails spaced apart transversely of the dock and control means for controlling conjointly movement of the two sets of cars and the module-supporting portions thereof, whereby in operation to impart pitch and/or roll and/or yaw to a module supported upon and bridging said cars.

8. Apparatus as claimed in claim 4 wherein a transverse or transport car comprises a plurality of wheel pairs and a chassis, hydraulic drive means for driving the associated car in either direction along the rails upon which it is mounted, hydraulic lift means including first and second groups of hydraulic cylinders connecting the chassis of the car to the wheels for raising and lowering the chassis relative to the rail, the load-supporting portion being mounted on the chassis, the first group of cylinders being positioned adjacent one end of the car and the second group of cylinders being positioned adjacent the other end of the car, each group of cylinders comprising at least one pair of cylinders, all the cylinders in a group being interconnected hydraulically to each other so that hydraulic fluid pressure is equalized in all the cylinders of a group, the cylinders of each pair being positioned adjacent opposite sides of the car, means controlling the flow of hydraulic fluid under pressure separately to the two groups of cylinders and spring means interconnecting one wheel of each pair on one side of the car with the other wheel of each pair on the other side of the car, the spring means being arranged to resist unequal vertical movement

but is forced open when the pressure of the hydraulic fluid exceeds some predetermined limit, for example, 3,000 psi. The valve 190 is connected across the drive motors 100 by means of four check valves 192, 194, 196, and 198. The arrangement is such that the drive motors 100 operate as pumps when driven by the inertia of the moving longitudinal cars. When the control valve 154 is closed, the motors 100, depending upon the direction the motors are rotating, force fluid through either the check valve 192 or 194 to the inlet side of the relief valve 190. The outlet side of the relief valve 190 returns to either one side or the other of the drive motors by the check valves 196 and 198. The check valves are arranged to limit flow of fluid in one direction through the relief valve 190. This arrangement provides dynamic braking in that the motors act as pumps driving fluid through the relief valve 190 until the mass of the moving system has decelerated to the point that the relief valve closes and the drive motors cease to rotate.

WHAT WE CLAIM IS:—

1. A method of transporting and positioning a prefabricated structural module in a construction dock, comprising:

a) moving the module at least once transversely of the dock on at least one set of rail mounted transverse cars having at least the operational modes of forward and reverse and in respect of module-supporting portions of said transverse cars lift and descend;

b) moving the module at least once longitudinally of the dock on at least one set of rail-mounted transport cars having the operational modes of forward and reverse; and

c) imparting pitch and/or roll and/or yaw to the module whilst it is upon the transport cars by moving module-supporting portions of said transport cars relative to the rail-engaging wheels thereof, whereby to position the module relative to other structure for assembly thereto.

2. A method as claimed in claim 1 comprising transferring the module from the transverse cars to the transport cars and vice versa by utilising the descend and lift operational mode of said cars to deposit the module on to a support at an intersection of the rails upon which the transverse and transport cars are mounted and to thereafter raise the module from said supports on to the other said car.

3. A method as claimed in claim 1 or 2, comprising delivering the module to the dock in a first orientation and rotating it within the dock to a second orientation before depositing it upon the transverse cars.

4. Apparatus for transporting and positioning a prefabricated structural module in a construction dock, comprising:

a) at least one set of transverse cars mounted on rails extending transversely of the dock and having portions adapted to support the module the cars having at least the operational modes of forward, reverse and in respect of the module-supporting portions, lift and descend;

b) at least one set of rail-mounted transport cars mounted on rails extending longitudinally of the dock and having portions adapted to support the module the cars having the operational modes of forward and reverse and means for imparting selectively pitch, roll and yaw to the module whereby to position the module relative to other structure for assembly thereto.

5. Apparatus as claimed in claim 4 comprising a preset support at an intersection of the rails upon which the transverse and transport cars are mounted, said supports being adapted to receive the module during transfer thereof between the transverse and transport cars.

6. Apparatus as claimed in claims 4 or 5 comprising means for rotating the module within the dock from a first orientation to a second orientation before it is deposited on the transverse cars.

7. Apparatus as claimed in any of claims 4 to 6 wherein there are two sets of said transport cars mounted on rails spaced apart transversely of the dock and control means for controlling conjointly movement of the two sets of cars and the module-supporting portions thereof, whereby in operation to impart pitch and/or roll and/or yaw to a module supported upon and bridging said cars.

8. Apparatus as claimed in claim 4 wherein a transverse or transport car comprises a plurality of wheel pairs and a chassis, hydraulic drive means for driving the associated car in either direction along the rails upon which it is mounted, hydraulic lift means including first and second groups of hydraulic cylinders connecting the chassis of the car to the wheels for raising and lowering the chassis relative to the rail, the load-supporting portion being mounted on the chassis, the first group of cylinders being positioned adjacent one end of the car and the second group of cylinders being positioned adjacent the other end of the car, each group of cylinders comprising at least one pair of cylinders, all the cylinders in a group being interconnected hydraulically to each other so that hydraulic fluid pressure is equalized in all the cylinders of a group, the cylinders of each pair being positioned adjacent opposite sides of the car, means controlling the flow of hydraulic fluid under pressure separately to the two groups of cylinders and spring means interconnecting one wheel of each pair on one side of the car with the other wheel of each pair on the other side of the car, the spring means being arranged to resist unequal vertical movement

of the opposite sides of the chassis relative to the wheels.

9. Apparatus as claimed in claim 8 further comprising a separate hydraulic fluid source for each group of cylinders, means for limiting the output pressure of each of said sources to a level insufficient to lift the chassis when subject to the full weight of the load, and means for selectively connecting and disconnecting said pressure limiting means and said sources.

10. Apparatus as claimed in claims 8 or 9 comprising first and second groups of lateral hydraulic cylinders interconnecting the chassis and the module supporting portion of a said car to effect relative horizontal movement thereof, the said groups of cylinders being positioned at opposite ends of the chassis.

11. Apparatus as claimed in claim 4 wherein a said car comprises:—

a) a chassis comprising said module supporting portion;

b) a multiplicity of associated pairs of rail engaging wheels, each pair of wheels respectively being mounted for rotation upon a pair of oppositely spaced frames connected by torsion means to one another, each frame being pivotally connected at one end thereof to said chassis and coupled at the opposed end thereof to said chassis by means adapted to pivot said frames about the axis of rotation of the respective pairs of wheels to enable raising and lowering of said chassis relative to the wheels in said lift and descend operational modes, at least a portion of the multiplicity of pairs of wheels being provided with means to propel said car in the forward and reverse directions.

12. A method for transporting and positioning a prefabricated structural module in a construction dock substantially as hereinbefore described with reference to the accompanying drawings.

13. Apparatus for transporting and positioning a prefabricated structural module in a construction dock substantially as hereinbefore described with reference to the accompanying drawings.

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