

A TRAVELLING STAGE ASSEMBLY
FOR USE IN DOCKS

This invention relates to a travelling stage assembly particularly for use in docks.

A known assembly for positioning a travelling stage intended for use when coating the bottom of a ship in a dock includes a boom mounted on a vehicle body travelling on tracks. The boom is arranged to be vertically and transversely rotatable on the vehicle body and has a length such that the free end or tip of the boom can reach the bottom of a ship. A stage which workers can mount, is attached to the tip of the boom. The stage is rotatable around an axis perpendicular to the boom tip with the stage always being maintained in a horizontal plane, in spite of vertical and transverse rotational movements of the boom. The operator of the travelling stage controls four mechanical movements, i.e. the direction and speed of travel of the vehicle body, raising and lowering of the boom, transverse swivelling of the boom and swivelling of the stage, so as to move the workers situated on the stage to an arbitrary working position on the ship's bottom or hull.

The known apparatus is fully operated and controlled by means of a manually controlled hydraulic drive. A high level of skill is required in order continuously and smoothly to move the travelling stage along a curved face of the bottom. This is not too difficult when preliminary treatment and coating of the bottom plate are carried out manually with the use of such a travelling stage. However, when an automatic rust removing machine is mounted on the travelling stage, the stage should be operated and controlled more accurately than can be done manually. Accordingly, when rust on the curved face of the bottom plate is to be removed with such an automatic rust removing machine, the machine cannot fulfill its full function if the stage is manually operated and controlled. Continuous movement of the stage along the curved face of the hull requires simultaneous manipulation of the four mechanical movements or operations, i.e. the travelling of the vehicle, the raising and lowering of the boom, the swivelling of the boom,

and the swivelling of the stage which is very difficult to accomplish manually. This prevents the mounting on the travelling stage of automatic devices for surface-treating and coating the bottom plate, which devices should be moved at a predetermined speed, while predetermined distance and positional relationships are maintained between the bottom and these automatic devices during movement along the bottom.

According to the present invention there is provided a travelling stage assembly comprising:

a travelling stage supported in a swivelling manner at the free end of a boom that is mounted on a vehicle body capable of travelling along tracks on a side wall of a dock, so that the boom can be rotated in a vertical plane and swivelled in a horizontal plane with respect to the vehicle body;

a travelling drive device for controlling travel of the vehicle body;

a vehicle body sensor for detecting the position and speed of travel of the vehicle body;

a vertical drive device for controlling the vertical plane rotation of the boom;

a boom swivelling drive device for controlling the horizontal plane swivelling of the boom;

a boom sensor for detecting the vertical and swivelling angles of the boom;

a stage swivelling drive device for controlling the swivelling of the stage;

a stage sensor for detecting the swivelling angle of the stage;

a distance sensor for detecting the distance between the stage and the bottom or hull of a ship;

an input device to which various desired conditions, including the desired travel of the vehicle body, the desired vertical and swivelling movements of the boom and the desired swivelling of the stage, are set; and

a central processing unit connected to receive values representative of the desired conditions set at the input device and values detected by the respective sensors and operative to supply drive signals to the respective drive devices thereby to provide automatically controlled operation of the travelling stage.

In such an assembly, the dock-site travelling stage can be automatically operated and controlled, thereby to permit automatic devices for surface-treating and coating the bottom of a ship to be used when mounted on the travelling stage.

5 In steering the dock-site travelling stage, a microcomputer preferably controls the four mechanical movements, that is, the travelling of the vehicle body, the vertical plane rotation of the boom, the swivelling movement of the boom and the swivelling movement of the stage.

10 The microcomputer used in the preferred embodiment of the present invention comprises signal generator means such as encoders which detect the operational states of the travelling stage and inform the microcomputer of the states. In addition to the signal generator means, data can be externally supplied to the microcomputer by, for example, the operator who can supply data as to the kind and procedure of work to be done. Furthermore, signals from the distance sensor and a working machine
15 mounted on the stage can be supplied to the microcomputer. Not only can the travelling stage be controlled, but the travelling stage and a working machine mounted thereon can be controlled together in an interlocked manner. The method of control and which items are to be controlled may be flexibly changed in accordance with changes in the program contents or
20 programs in the microcomputer. The preferred apparatus is actuated by means of a user program, a clock circuit, and a monitor program incorporated in a central processing unit of the microcomputer. Data designated by the operator, data detected and supplied by the encoders as to the states of the travelling stage and data from a working machine, such as
25 an automatic bottom plate coating machine, mounted on the travelling stage are processed to generate signals for controlling the operation of the travelling stage. In other words, the microcomputer detects the operational states of the travelling stage and the automatic bottom plate coating machine mounted thereon according to detector signals from the detectors, thereby to generate control signals according to which the travelling stage
30 and automatic bottom plate coating machine perform a well-matched operation. The operator can supply, to the input device, the sequence and range of work to be done, the kind of working machine to be used (such as an

automatic bottom plate coating machine or rust removing machine), and other data. A signal from the microcomputer for controlling the travelling stage is sent to the stage drive device such that the operation of the dock-site travelling stage is automatically controlled.

5 The present invention will now be further described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a general perspective view, with a portion broken away, of apparatus embodying the present invention for controlling a travelling stage;

10 Figure 2 is a block diagram of an automatic operation and control circuit of the apparatus;

Figure 3 shows an angle detector encoder, Figure 3(A) being a plan view thereof, Figure 3(B) being a sectional view in front elevation of a part thereof, and Figure 3(C) being a sectional view in side elevation of a part thereof; and

15 Figure 4 shows a counter for adding, subtracting and accumulating the angle of rotation of a travelling wheel rotation angle, Figure 4(A) being a front view thereof and Figure 4(B) being a side view thereof.

Referring to the accompanying drawings, tracks 1 and 2 are laid on upper and lower portions, respectively, of a side wall of a dock. A vehicle body 3 can travel along the tracks 1 and 2. The vehicle body 3 has a travelling drive device A for controlling travel of the vehicle body 3, a vehicle body sensor 5 including a counter for adding, subtracting and accumulating the angle of rotation of a travelling wheel 4 of the vehicle body 3 to detect the position and speed of travel thereof, and a central processing unit 6 comprising part of a microcomputer.

20 A boom 7 is supported by the vehicle body 3 in a transversely swivelling and vertically rotatable manner. Disposed between the vehicle body 3 and the boom 7 are a boom swivel drive device B for controlling the swivelling of the boom 7, a vertical drive device C for controlling the vertical rotational movement of the boom 7, and a boom sensor 10 having a boom swivelling angle detector encoder 8 for detecting the swivelling angle of the boom 7 and a boom vertical angle detector encoder 9 for detecting the vertical rotational angle of the boom 7.

25 A dock-site travelling stage 11 is mounted on the tip of the boom 7 in

5 a horizontally swivelling manner. The stage 11 is rotatably supported by a shaft 14 that is perpendicular thereto and is attached to the free end or tip of a support rod 13 which is held horizontal by a horizontal shaft 12 attached to the free end or tip of the boom 7. The stage 11 has a stage swivelling drive device D for controlling the swivelling of the stage 11, a stage sensor 15 having a stage swivelling angle detector encoder for detecting the swivelling angle of the stage 11, a distance sensor 16 for detecting the distance between the stage 11 and the bottom plate of a ship,

a drive device E for a working machine such as a coating machine, and a working machine sensor 17 for detecting the operational state of the working machine drive device E.

5 The apparatus includes an input device 18 to which data for the central processing unit 6 is supplied. Various conditions such as the travel of the vehicle body 3, the vertical and swivelling movements of the boom 7, and the swivelling of the stage 11, are previously entered into or set in the input device 18. Data thus set in the input device 18 and data detected by the sensors 5, 8, 9, 15, 16 and 17 is supplied to the central processing unit 6,
10 which supplies drive signals to the respective drive devices A, B, C, D and E.

A travelling control current generating circuit a generates a control current for driving the travelling drive device A. A boom swivelling control current generating circuit b generates a control current for driving the boom swivelling drive device B. A vertical control current generating
15 circuit c generates a control current for driving the vertical drive device C. A stage swivelling control current generating circuit d generates a control current for driving the stage swivelling drive device D. A working machine control current generating circuit e generates a control current for driving the machine drive device E.

20 The central processing unit 6 incorporates a clock circuit for measuring the period of time of operation of the stage 11 to control the speed and acceleration thereof according to a monitor program and a program for controlling the stage.

The data input device 18 is a console through which control data
25 designated by the operator is supplied to the central processing unit 6 of the microcomputer. Control data designated by the operator can include the working speed and working scope of a working machine mounted on the dock-site travelling stage 11 and the type of automatic control (either fully automatic or semi-automatic control). Also, a control program may be
30 prepared and supplied to the central processing unit 6 through the data input device 18.

The sensors 5, 8, 9, 15 and 17 are measuring devices for supplying
35 binary or bit signals representing static and dynamic states of the dock-site travelling stage 11. The central processing unit 6 reads such data from four sensors, i.e. the distance sensor 16 for detecting the distance between the stage 11 and the ship's hull, the stage sensor 15 for detecting the swivelling

angle of the stage, the boom vertical angle detector encoder 9 for detecting the vertical angle of the boom 7 and the boom swivelling angle detector encoder 8 for detecting the swivelling angle of the boom 7, through respective bus controllers 16', 15', 9' and 8' and a data bus 19.

5 Data is generated by the vehicle body sensor 5 and the working machine sensor 17 for a working machine, such as a coating machine, mounted on the dock-site travelling stage 11. Such data can be read by the central processing unit 6 through bus controllers 5' and 17'. In this embodiment, however, data from the sensors 5 and 17 is sent to the central
10 processing unit 6 and an interrupt signal is sent to the central processing unit 6 via an interrupt signal line 20 upon each occurrence of such data.

The central processing unit 6 performs data processing and judges the conditions according to the programs, thereby to generate, as bit signals, control signals for operating the dock-site travelling stage 11. Such control
15 signals are sent to the data bus 19, from which the control signals are further sent to latch circuits a', b', c', d' and e' through a bus controller 21. Simultaneously, an address signal sent from the central processing unit 6 passes through an address bus 22 and arrives at a decoder 23 where the address signal is decoded to generate a latch signal, thereby to latch the
20 signal on the data bus 19 in a target latch circuit.

For example, when the central processing unit 6 supplies a signal for swivelling the stage 11 to the data bus 19, this signal passes through the bus controller 21 and arrives at the latch circuits a', b', c', d' and e'. This signal should then be latched in the latch circuit d' and sent to the stage swivelling control current generation circuit d. For this purpose, the central
25 processing unit 6 supplies an address signal, for designating the latch circuit d', to the address bus 22. This address signal is decoded by the decoder 23 and becomes a latch signal. When this latch signal is sent to the latch circuit d' through a signal line 24, the signal on the data bus 19 is latched by
30 the latch circuit d'. At this time, no latch signal is supplied to the other latch circuits a', b', c' and e', and therefore these latch circuits a', b', c' and e' hold therein the signals which they latched on the previous occasion of receipt of a latch signal. Until the latch circuit d' receives another latch signal, the signal latched by the latch circuit d' is held and continuously sent
35 to the stage swivelling control current generating circuit d to generate a control current. This control current drives the stage swivelling drive

device D (for example, a valve in a hydraulic circuit) for swivelling the stage 11 so as to swivel the stage 11 according to the control signal from the microcomputer.

While the flow of data and the operations are as discussed hereinabove, the central processing unit 6 of the microcomputer can process only one item of data (datum) at a time. This is to say, during the time that the central processing unit 6 reads one item of data, other items of data can neither be read nor supplied simultaneously. In the operation of the dock-site travelling stage 11, there are frequently occasions when mechanical movements such as vertical movement of the boom, swivelling movement of the boom and travelling of the vehicle body have simultaneously to be performed in parallel with each other. In view of the foregoing, the respective operations carried out by the microcomputer, such as data reading, data processing and generation of a control signal, are repeatedly executed one by one in succession at a speed much higher than the speed at which the mechanical movements of the dock-site travelling stage 11 are performed. Thus, all mechanical movements of the dock-site travelling stage 11 are, in fact, simultaneously operated and controlled. These successively repeating operations include processing of interrupt data sent from the vehicle body sensor 5 and the working machine sensor 17 for generating a signal representing the state of a working machine such as a coating machine. Other additional sensors may be mounted.

The boom vertical angle detector encoder 9 and the boom swivelling angle detector encoder 8 are operative to generate bit signals corresponding to the boom angles. As shown in Figure 3, bit signal generator means 26, each for generating a bit signal representing a numerical value of a digit corresponding to the boom angle, are concentrically disposed on a bit signal plate 25. A bit signal generator member 27 is disposed opposite to the bit signal generator means 26 with a slight gap therebetween. The bit signal generator member 27 incorporates bit signal generator elements 28, the number of which corresponds to the number of necessary bits. The bit signal generator elements 28 approach and respond to the bit signal generator means 26 to generate an electrical signal. In this connection, the material of the bit signal generator means 26 should be suited to the kind of signal to be generated from the bit signal generator elements 28, and may be magnetic, conductive or dielectric. The bit signal generator elements 28

may comprise ultra-small-size access switches or semiconductive magnetic sensors to generate stable and secure bit signals. The bit signal plate 25 and the bit signal generator member 27 are mounted on a swivelling member to the measured so as relatively to rotate and move according to the swivelling angle of the swivelling member. Thus, the swivelling angle may be directly measured as a bit signal. For such an application, photocoupler encoders are generally used. However, the present apparatus does not use photo sensors, which are susceptible to contamination by, for example, machine oil.

When the bit signal generator elements 28 are positioned precisely opposite to the bit signal generator means 26 representing a certain angle, a bit signal is accurately generated. However, when the bit signal generator elements 28 are positioned at an intermediate position between the bit signal generator means 26 for a certain angle at which the boom is held, and the bit signal generator means 26 for another angle to which the boom has been moved, it is not possible to obtain a bit signal accurately representing the angle. In this apparatus, however, provision is made for angle measurement to be performed even in such a case. As shown in Figure 3(C), the bit signal generator elements 28 are formed in two rows a and b and attached to the bit signal generator member 27. The two rows a and b are positionally shifted by $(\alpha^0 \times n) + \frac{\alpha^0}{2}$ (where $n = \text{about } 1 \text{ to } 5$), where the angular distance of the bit signal generator means 26 is α^0 .

In addition to the bit signal generator elements 28 representing the boom angle, a normality confirming bit signal generator element 29 is disposed in each of the rows a and b of the bit signal generator elements 28. In addition to the bit signal generator means 26, there is a normality confirming bit signal generator means 30. When the normality confirming bit signal generator means 30 precisely faces the normality confirming bit signal generator elements 29, the element 29 supplies a signal. When such signal is supplied by the normality confirming bit signal generator element 29, it means that the bit signal generator elements 28 in the corresponding bit row a or row b are in a position accurately to measure the boom angle.

A bit signal is normally generated in three combinations of the bit signal generator means 26 and 30 with the a-row bit signal generator elements 28 and 29, the b-row bit signal generator elements 28 and 29, or the a-row and b-row bit signal generator elements 28 and 29. Thus, angle measurement may always be performed, regardless of the positional

relationship between the bit signal plate 25 and the bit signal generator member 27. Furthermore, since such three signal generating states are available, angle detection may be performed with an angle resolving power having an accuracy that is twice that of the bit signal generator means.

5 The angle detector encoder in the present control apparatus is characterized in that it directly generates a bit signal both for a rest angle and a moving angle, thereby to enhance the control efficiency of the microcomputer.

10 The vehicle body sensor or counter 5 for adding, subtracting and accumulating the travelling wheel rotation angle is a mechanical counter incorporating contacts capable of reading a counted value as an electric signal or a bit signal. The counter is designed to add, subtract and accumulate the angle of rotation of the moving wheel 4 according to the travel of the vehicle body 3, namely, forward travel gives rise to addition and rearward travel to subtraction. Thus, a numerical value representing
15 the angle of rotation of the moving wheel 4 is mechanically held by the counter and can be read out as a bit signal at any time. Thus, the position of the vehicle body 3 on the tracks 1 and 2, wherever it may be, can be read out accurately. It is therefore not necessary for the computer to perform
20 such calculation. This reduces the initial setting operations to be performed by the operator, and eliminates the need to provide means to cater for a situation where data in the volatile memory of the computer vanishes when the power supply to the control apparatus is turned off. Such a counter for adding, subtracting and accumulating the angle of rotation of the travelling
25 wheel, as discussed hereinabove, enables simplification of the hardware and software of the microcomputer used in the present apparatus for automatically operating and controlling a dock-site travelling stage. The counter is also effective in providing an automatic operation and control apparatus that is easy to manipulate.

30 As shown in Figure 4, the counter 31 for adding, subtracting and accumulating the angle of rotation of the travelling wheel 4 is arranged so as to be driven by counter drive claws 32 disposed at equal angular intervals concentrically around the axis of the travelling wheel 4. As shown in Figures 1 and 4, the counter 31 is so designed as to count the angle of
35 rotation of the travelling wheel 4. However, the same object may be achieved by directly counting the angle of rotation of a motor or transmission shaft for driving the wheel 4, depending on the structure of the dock-site travelling stage.

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The apparatus described above for controlling a dock-site travelling stage roboticizes the stage whereby the stage can be operated with high accuracy, thereby to enable a delicate automatic working machine, such as an automatic surface treating machine or automatic coating machine, to be mounted and used on the stage.

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CLAIMS

1. A travelling stage assembly comprising:

a travelling stage supported in a swivelling manner at the free end of a boom that is mounted on a vehicle body capable of travelling along tracks on a side wall of a dock, so that the boom can be rotated in a vertical plane and swivelled in a horizontal plane with respect to the vehicle body;

a travelling drive device for controlling travel of the vehicle body;
a vehicle body sensor for detecting the position and speed of travel of the vehicle body;

a vertical drive device for controlling the vertical plane rotation of the boom;

a boom swivelling drive device for controlling the horizontal plane swivelling of the boom;

a boom sensor for detecting the vertical and swivelling angles of the boom;

a stage swivelling drive device for controlling the swivelling of the stage;

a stage sensor for detecting the swivelling angle of the stage;

a distance sensor for detecting the distance between the stage and the bottom or hull of a ship;

an input device to which various desired conditions, including the desired travel of the vehicle body, the desired vertical and swivelling movements of the boom and the desired swivelling of the stage, are set; and

a central processing unit connected to receive values representative of the desired conditions set at the input device and values detected by the respective sensors and operative to supply drive signals to the respective drive devices thereby to provide automatically controlled operation of the travelling stage.

2. A travelling stage assembly substantially as herein described with reference to the accompanying drawings.
