United States Patent [19]

Galloway

[11] 3,858,688

[45] Jan. 7, 1975

[54] **SELF-CONTAINED MOBILE EXTENDABLE TOWER**

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[73] Assignee: **G. W. Galloway Company**, Los Angeles, Calif.

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[21] Appl. No.: **261,081**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 233,613, March 10, 1972, abandoned.

[52] **U.S. Cl.** ..... **187/9**, 91/171, 182/141, 187/17, 254/89 H

[51] **Int. Cl.** **B66b 9/20**

[58] **Field of Search** ..... 187/9, 17; 182/16, 63, 182/141, 112, 13, 19, 14; 180/6.3; 254/89 R, 89 H, 93 R, 93 L; 60/97 E; 91/171, 189, 412

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Assistant Examiner—James L. Rowland
Attorney, Agent, or Firm—Sellers and Brace

[57] **ABSTRACT**

A self-contained mobile extendable tower for transferring loads, including workmen, between ground and higher levels utilizing a plurality of multiple stage mast assemblies maintained accurately synchronized despite non-uniform load distribution by simple electrical sensor means carried by the load platform. The platform is suspended from yoke means projecting upwardly from the platform and having its upper ends connected to the last stage of the respective mast assemblies. A common prime mover, such as an internal combustion engine or an electric motor, is coupled by a reversible transmission to separate reversible pumps supplying a respective one of the masts with pressurized fluid. The chassis on which the tower is supported is self-propelled and steerable from a control station on the load platform.

34 Claims, 10 Drawing Figures

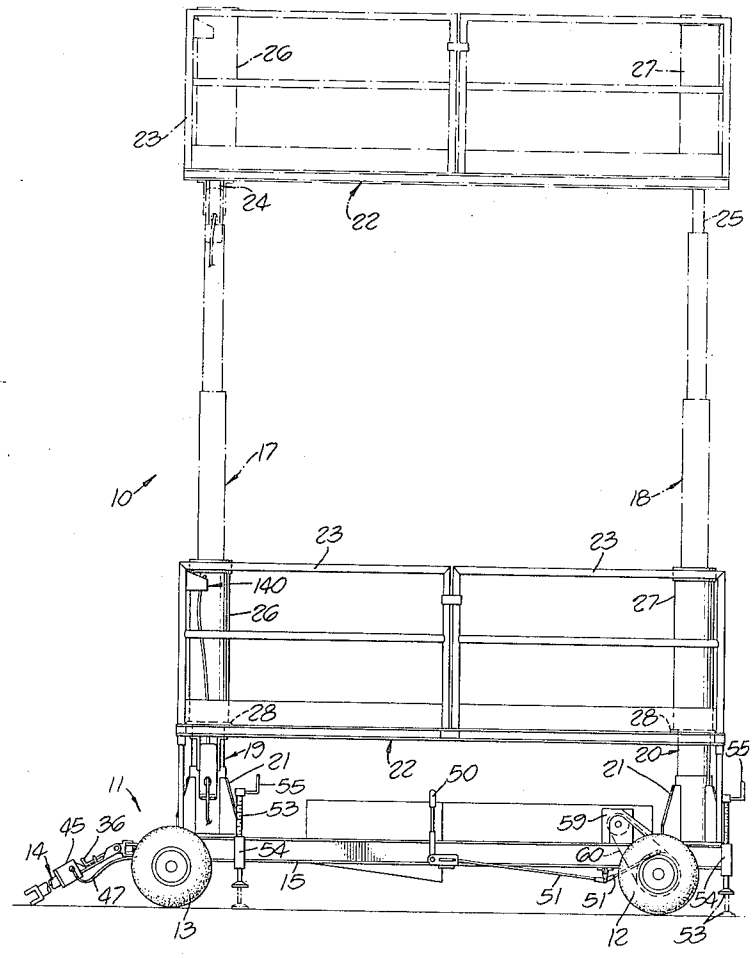


FIG. 1.

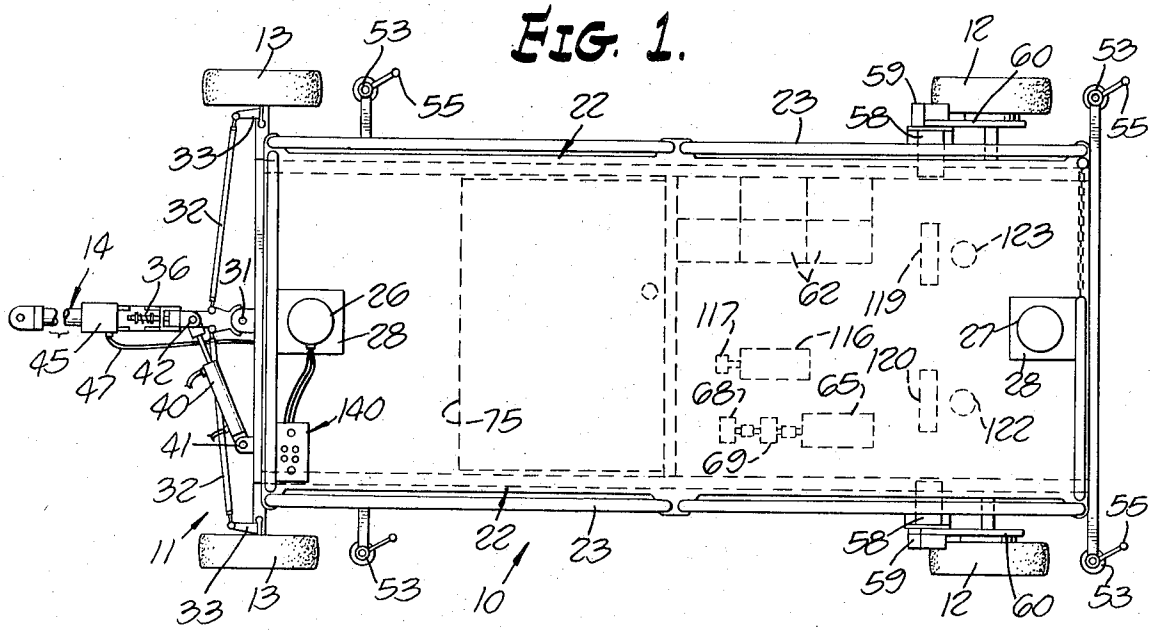
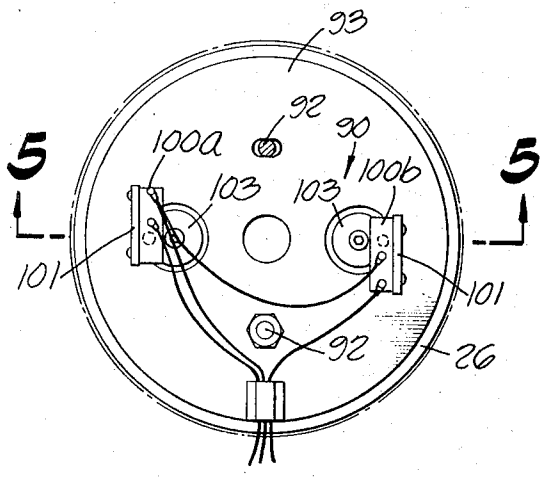


FIG. 4.



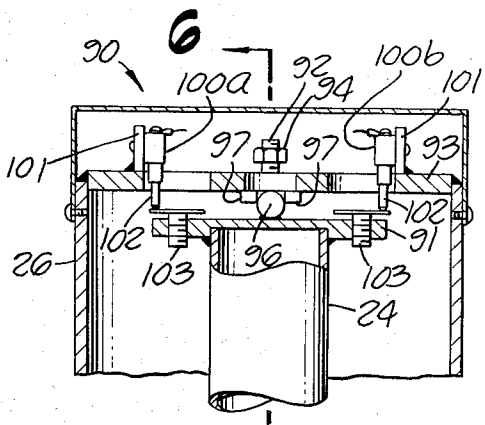


FIG. 5.

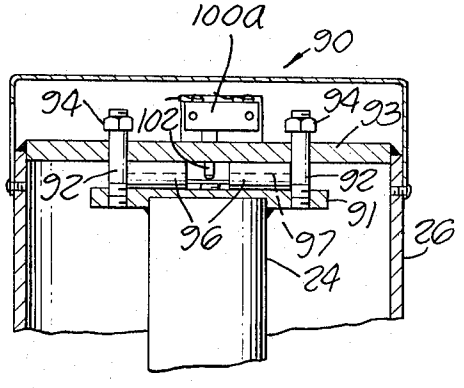


FIG. 6.

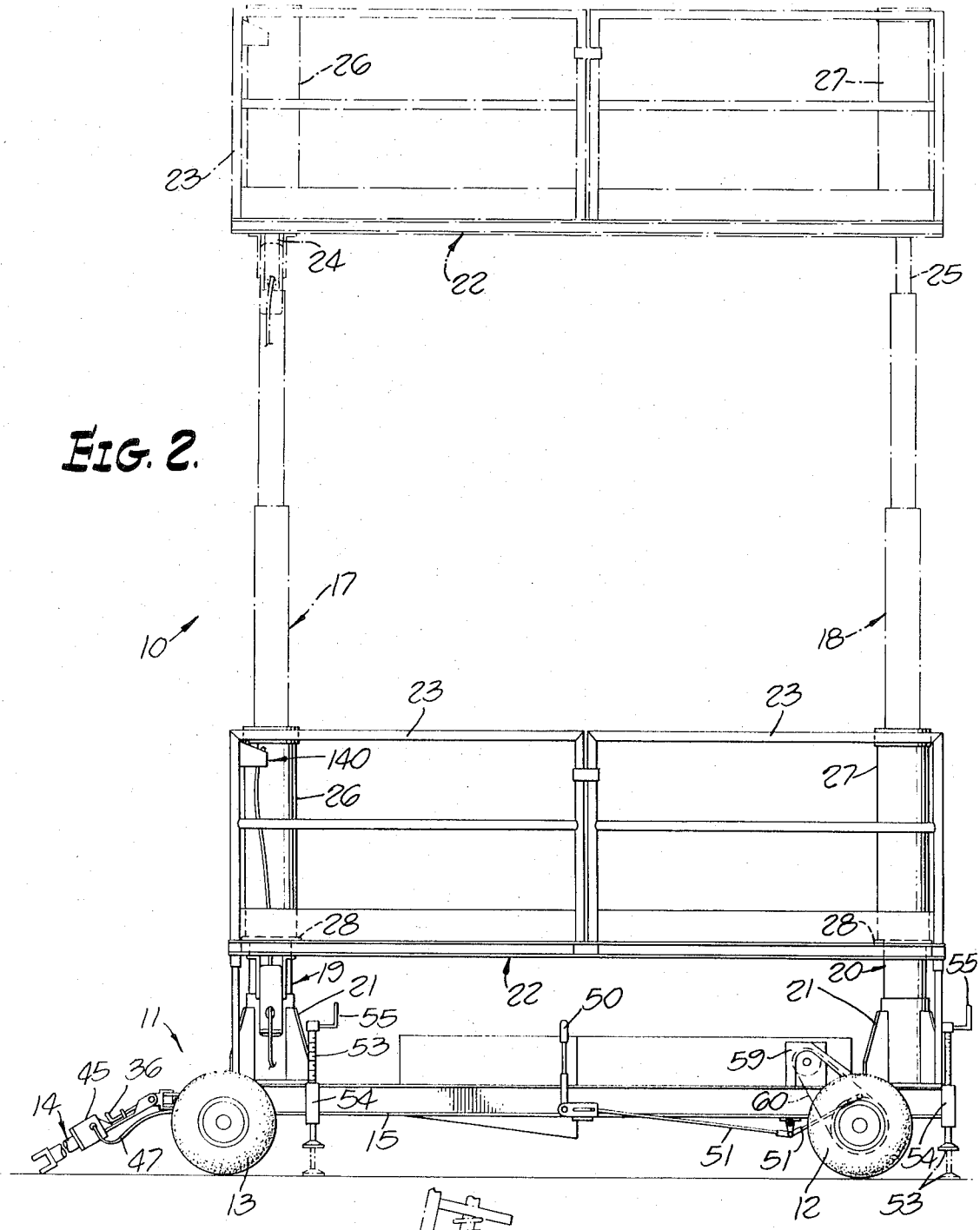

26
27
23
24
22
25
17
10
18
23
23
140
26
27
28
28
19
21
22
50
21
20
55
11
55
53
59
45
36
60
14
54
15
51
51
54
47
13
12
53

FIG. 2.

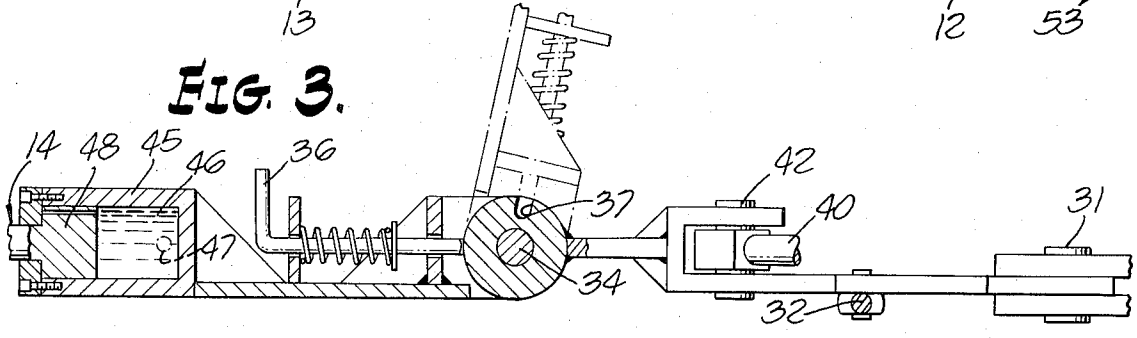
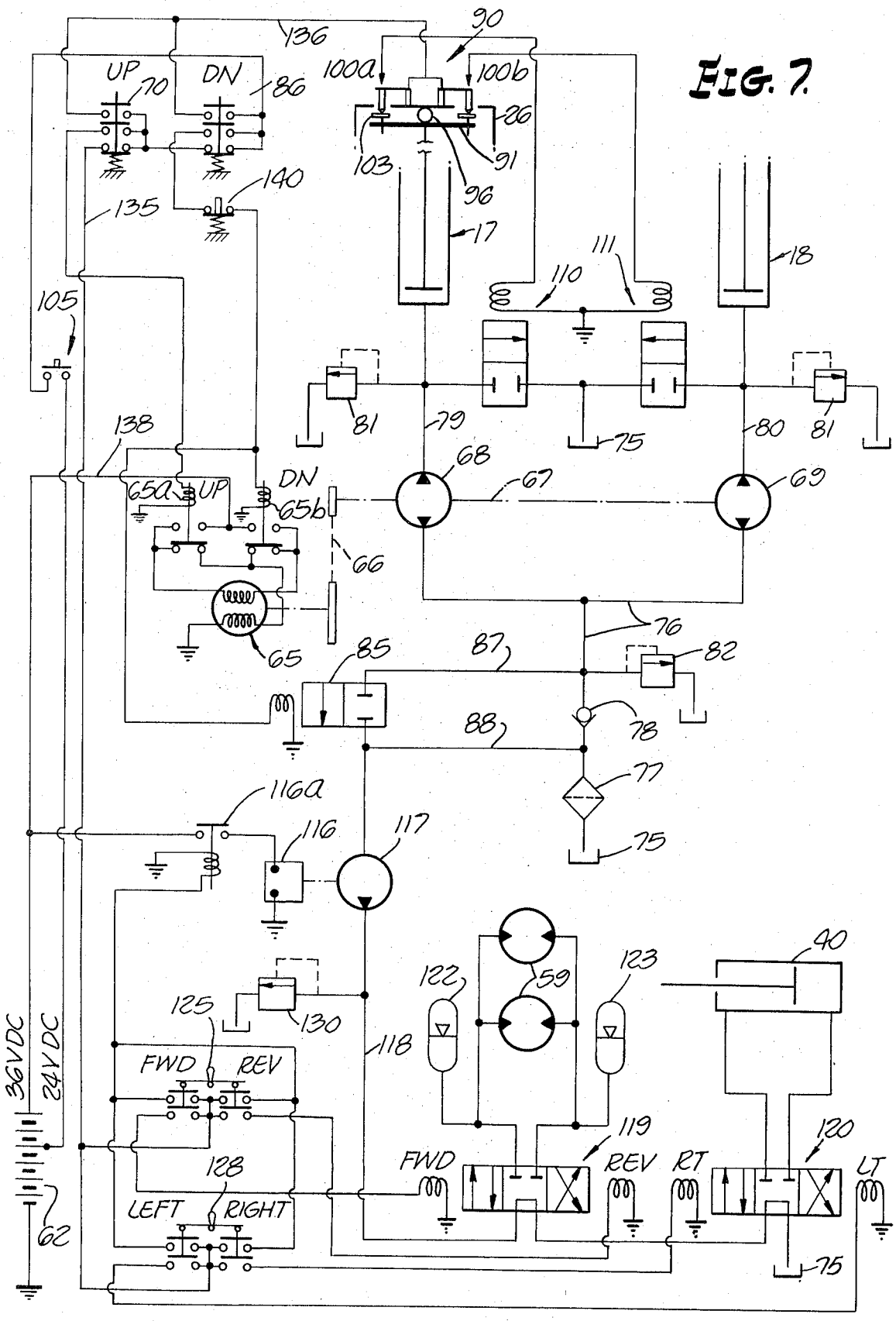

14
48
45
46
36
37
42
40
31
47
34
32

FIG. 3.

FIG. 7.


136
90
100a
100b
UP
70
DN
86
26
103
91
96
17
140
135
111
110
18
105
81
79
75
80
81
138
68
67
69
65a
UP
DN
65b
66
65
76
85
87
82
88
78
77
75
116a
116
117
125
130
118
122
59
123
40
FWD
REV
119
120
FWD
REV
RT
LT
128
LEFT
RIGHT
62
36VDC
24VDC
75

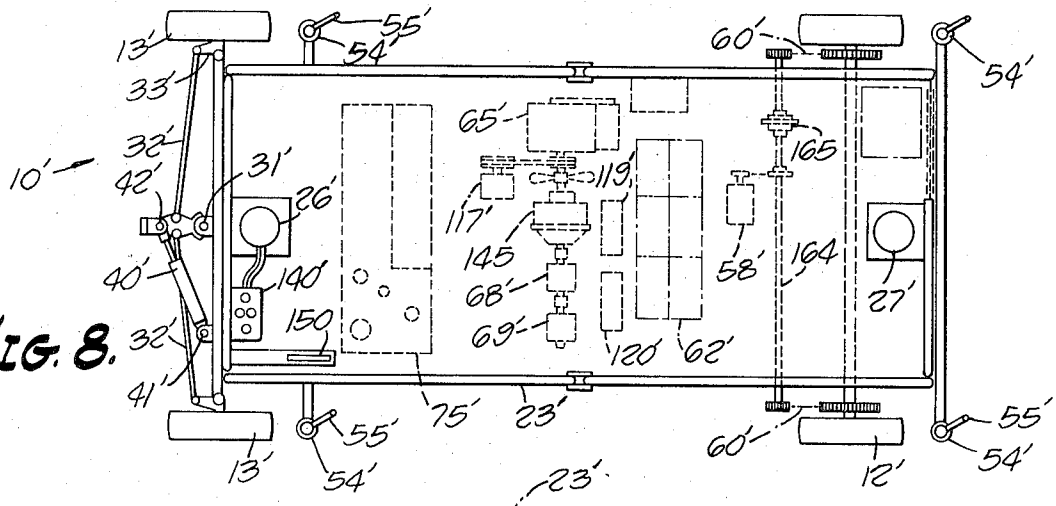

13'
33'
32'
42'
10'
31'
26'
40'
140'
150
32'
41'
55'
54'
65'
119'
117'
145
68'
69'
120
62'
58'
164
165
27'
60'
54'
55'
54'
75'
23'
60'
12'

FIG. 8.

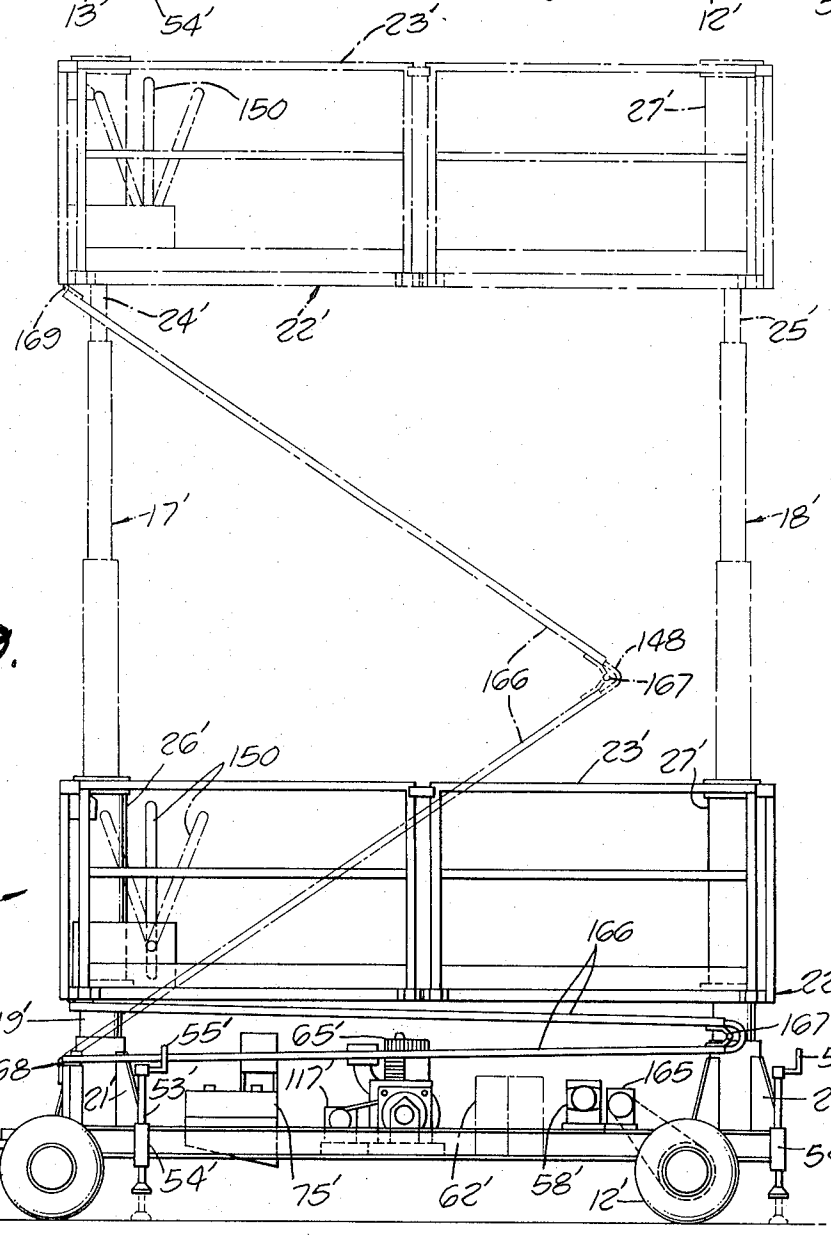
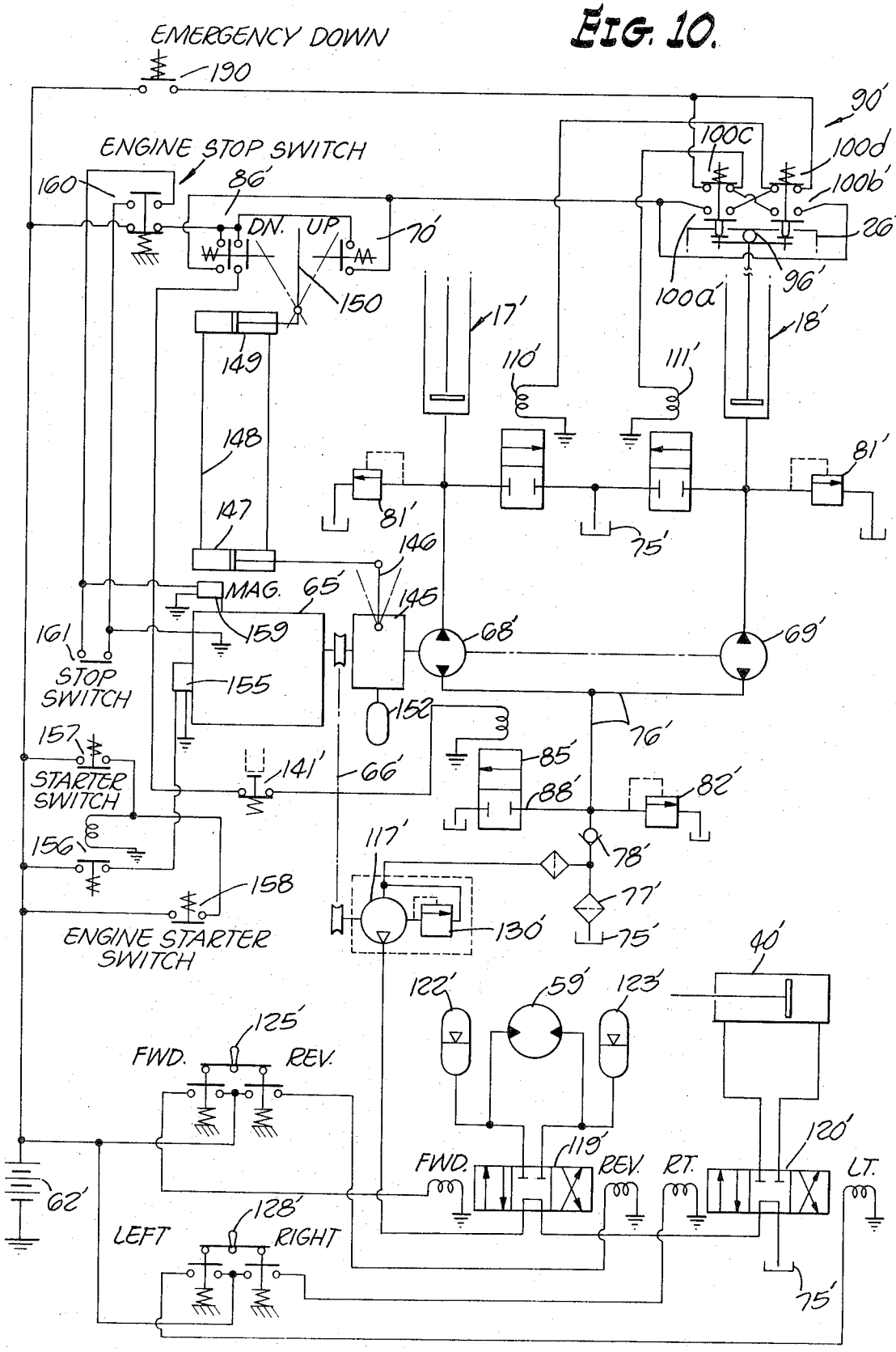

23'
150
27'
169
24'
22'
25'
17'
18'
148
166
167
26'
150
23'
27'
10'
166
22'
19'
55'
65'
167
168
21'
53'
117'
165
55'
21'
54'
13'
54'
75'
62'
58'
12'

FIG. 9.

FIG. 10.


EMERGENCY DOWN
190
ENGINE STOP SWITCH
160
86'
DN.
UP
70'
150
90'
100c
100d
100b'
26'
100a'
96'
17'
18'
110'
111'
149
148
147
146
145
81'
75'
MAG.
65'
159
161
STOP SWITCH
155
68'
69'
152
76'
157
STARTER SWITCH
141'
66'
85'
88'
82'
156
158
ENGINE STARTER SWITCH
117'
78'
77'
130'
40'
122'
59'
123'
125'
FWD.
REV.
62'
119'
120'
LT.
RT.
128'
LEFT
RIGHT

SELF-CONTAINED MOBILE EXTENDABLE TOWER

This is a continuation-in-part of application Ser. No. 233,613, filed Mar. 10, 1972, now abandoned.

This invention relates to hydraulically extendable towers, and more particularly to a self-contained mobile extendable tower apparatus utilizing a plurality of multistage telescopic masts to support the load platform and characterized by its overall simplicity, the provision of high precision automatic means for maintaining the platform level despite non-uniform distribution of the load, and unidirectional prime mover means equipped to drive hydraulic fluid pumps in either direction depending on the desired direction of load movement.

There have been many proposals heretofore to provide load lifting devices utilizing two or more masts operating in parallel to transfer loads between different elevations. These various proposals have been beset by many problems including the highly vexatious problems of constraining the mast systems to operate in synchronism, particularly under unequal load distribution conditions and other variables well known to those experienced in the art. These proposals have included the expedient of using identical mast assemblies supplied with pressurized fluid by identical pumps driven from a common motor. Under ideal conditions such a system provides reasonably satisfactory results. However, a system of this type is highly sensitive to leakage occurring in one or more of the fluid circuits and unavoidably occurring after a period of use. Any leakage is greatly aggravated by variations in load distribution on the platform. Furthermore, either non-uniform loading or leakage is accumulative during repeated cycling with well known serious consequences.

Other proposals for synchronizing and correcting for out of phase operation of two or more masts for various reasons utilize synchronizing control expedients of a wide variety including slave cylinder sensing devices, cable systems interconnecting the upper ends of each mast with servo valve mechanisms, and various level sensing mechanical linkages connected to fluid control valves for each mast. These various systems are subject to many shortcomings including their characteristic complexity, the use of many components subject to tolerance variations, wear and damage, as well as their high initial and maintenance costs and the need for skilled technicians to maintain and service them.

In view of the foregoing and other shortcomings and disadvantages characteristic of previously designed hydraulic lifting apparatus, it is a primary object of the present invention to provide a greatly improved mobile extendable tower apparatus functioning in a simple highly reliable foolproof manner avoiding the aforementioned and other disadvantages of prior constructions. In a typical embodiment, the lifting apparatus utilizes the frame of a low height chassis to rigidly support a plurality of multistage masts cooperating to support a work platform from their upper ends. Preferably, the platform is suspended by yoke means sized to telescopically embrace the larger stage of each mast. These yokes project upwardly from the opposite ends of the platform and, in a preferred arrangement, are substantially as long as the individual stages of the mast thereby permitting the platform to be lowered close to ground level when the masts are fully retracted. The self-propelled chassis includes a complete self-

contained power system for the chassis as well as for the hydraulic system. The latter utilizes a single prime mover having a reversible drive to identical positive displacement pumps each connected to a respective one of the masts and including automatic level control means effective to maintain the platform level under uniformly distributed loading condition. Since these ideal conditions seldom prevail in practice, the invention tower includes automatic precision synchronizing means for maintaining the platform level despite unequal load distribution conditions. This self-levelling and synchronizing means typically comprises a pair of sensitive switches responsive to tilting of the platform in either direction from the horizontal to bleed fluid from the highest mast. As the platform is restored to horizontal, fluid bleeding is discontinued. The electrical tilt sensor comprises a pair of precision switches which are connected to simple on-off solenoid bleed valves.

The tower chassis may be propelled forwardly and rearwardly by separate hydraulic motors connected to each of its rear wheels and may be steered by a hydraulic cylinder connected to the steering control linkage for the front wheels. The chassis can be propelled and steered at all times except when the tower assembly is being raised or lowered. In the second embodiment a single motor is connected to a pair of chassis wheels via a differential unit. In one illustrative embodiment, the two pumps serving the tower masts are driven by a reversible d.c. motor powered by batteries carried on the chassis, whereas in a second illustrative embodiment the pumps are driven by an internal combustion engine or a direct current motor coupled to the pumps by the reversible transmission means. All components for the tower as well as the chassis are controllable by a control station located on the platform and suitably connected to the chassis by a multiple conductor electrical cable and/or hydraulic fluid lines interconnecting slave motors.

In an alternate control system, the electrical tilt sensor comprises a pair of precision switches which are connected to simple on-off solenoid bleed valves located at the base of the tower. This system is electrically energized through the switch on the platform which is turned on when the reversing control lever of the transmission unit is moved from the neutral position into either the up or the down position. A second set of tilt sensing switches on the column is used for emergency lowering of the platform when the electric motor or internal combustion engine is inoperable for any reason. These switches are activated from the platform upon closing the emergency down switch and thereby open both balancing solenoid valves normally operated as bleed valves. However, should one mast lower faster than the other the solenoid valve for that column closes until the platform is level and then opens.

It is therefore a primary object of the invention to provide an improved rugged and highly reliable self-propelled self-contained mobile tower assembly.

Another object of the invention is the provision of a high capacity extendable mast assembly utilizing a plurality of multistage masts and having improved simplified means for maintaining the load platform level despite non-uniform load distribution.

Another object of the invention is the provision of an extendable tower apparatus utilizing a pair of multi-

stage supporting masts having improved means for maintaining the platform level and wherein the platform proper is suspended from yoke means projecting upwardly from the opposite ends of the platform.

Another object of the invention is the provision of a self-powered lifting apparatus utilizing a plurality of multistage masts powered by unidirectional prime mover means coupled to a separate fluid pump for each mast through reversible transmission means.

Another object of the invention is the provision of lifting apparatus employing a plurality of multistage masts arranged in parallel and powered by unidirectional prime mover means for supplying or releasing equal quantities fo fluid to and from the masts, depending on the direction of mast movement, via separate positive displacement pumps selectively driven in either direction by reversible transmission means coupling said pumps to the prime mover means.

Another object of the invention is the provision of a mobile large capacity multi-mast load lifting apparatus powered entirely from an on-board internal combustion engine driving separate synchronized pumps for each mast through a single reversible power transmission unit and operable to lock the load at any selected level by placing the power transmission unit in neutral.

Another object of the invention is the provision of a multi-mast lifting apparatus equipped with emergency control means for lowering the load platform by simultaneously bleeding fluid from both masts through identical bleed ports and including means for automatically closing either bleed port so long as the associated mast is lower than the other thereby to maintain the load platform substantially level during emergency lowering conditions.

Another object of the invention is the provision of lifting apparatus utilizing a plurality of telescopic masts and electrical sensor means for detecting and compensating for non-uniform operation of the masts.

Another object of the invention is the provision of an extendable tower supported by a plurality of multistage masts movable in either direction by pressurized fluid flowing through reversible positive displacement pumps coupled to reversible drive means and driven by a common prime mover.

Another object of the invention is the provision of an automatic braking system for the tower chassis and a smooth acceleration and deceleration drive to the tower chassis.

These and other more specific objects will appear upon reading the following specification and claims and upon considering in connection therewith the attached drawing to which they relate.

Referring now to the drawing in which a preferred embodiment of the invention is illustrated:

FIG. 1 is a top plan view of one illustrative embodiment of the invention mobile lifting apparatus;

FIG. 2 is a side elevational view of FIG. 1 showing the platform partially extended in dot and dash lines and fully retracted in full lines;

FIG. 3 is a fragmentary view, partially in section, of the steering mechanism showing the tongue in full lines in its lowered hauling position and locked in an elevated non-hauling position in dot and dash lines;

FIG. 4 is a top plan view on an enlarged scale of the platform tilt sensor device;

FIG. 5 is a fragmentary vertical sectional view taken along line 5—5 on FIG. 4;

FIG. 6 is a view similar to FIG. 5 but taken along line 6—6 on FIG. 5;

FIG. 7 is a schematic view of the hydraulic system and of the controls for the chassis as well as for operating the tower assembly;

FIG. 8 is a top plan view of a second illustrative embodiment of the invention;

FIG. 9 is a side elevational view of FIG. 8 corresponding to the showing in FIG. 2; and

FIG. 10 is a schematic view of the hydraulic system and of the controls for the chassis and tower assembly of the second embodiment.

FIRST EMBODIMENT

Referring initially and more particularly to FIGS. 1 and 2, a first embodiment of the invention lifting apparatus, designated generally 10, is shown rigidly supported on a chassis 11 having rear wheels 12, steerable front wheels 13 and a draft tongue 14. The rigid main frame 15 of the chassis serves additionally as the tower base frame to which there is rigidly secured a pair of identical multistage hydraulic mast cylinders 17,18. The larger diameter lower stages 19,20 of this mast assembly are rigidly secured to chassis frame 15 by suitable means including bracing brackets 21.

The load carrying platform 22 is constructed of structural members and preferably includes a suitable guard railing 23. Platform 22 is preferably suspended from the upper ends of the smallest diameter stages of the mast by suitable yoke means. As herein shown, this yoke comprises a pair of similar tubes 26,27 having their closed upper ends secured to the upper end of mast stages 24,25 and their lower ends rigidly anchored to platform 22 as by base plates 28 (FIG. 1).

Referring more particularly to FIG. 1, it is pointed out that chassis 11 may be towed by the hauling tongue 14 which is pivotally connected to the forward end of the chassis frame by pin 31. Steering links 32 interconnect the tongue to steering knuckles 33 fixed to pivotable stub axles for front wheels 13. When the chassis is not being towed tongue 14 may be pivoted upwardly about hinge pin 34 (FIG. 3) and lashed in this retracted position by latch pin 36 having its free end seatable in notch 37. A double action hydraulic cylinder 40 is employed to steer front wheels 13, it being observed from FIG. 1 that one end of this cylinder is pivotally connected to the chassis frame at 41 and that the free end of its piston rod is connected to the tongue at 42.

The forward end of tongue 14 may include an automatic brake control device 45 for the brakes of rear wheels 12. Device 45 includes a chamber charged with brake fluid 46 in communication through a flexible hose 47 with the wheel brake cylinders. So long as the tower is being hauled along the highway, piston 48 is held in its forward position wherein the brakes are released. However, if the hauling vehicle is braked then piston 48 shifts rearwardly under inertia forces and pressurizes fluid 46 to apply the brakes of the rear chassis wheels 12.

When the tower is not in a travel mode the brakes may be set by hand control lever 50 mounted on the side of the chassis frame and connected to the wheel brakes by an operating linkage 51 of any suitable construction. While in use, the tower assembly is firmly stabilized by hand operated out rigger screws 53 (FIGS. 1 and 2). The threaded shanks of these screws are

mounted in threaded bores of brackets 54 and are operated by hand cranks 55.

Rear wheels 12, as herein shown, are driven by reversible hydraulic motors 58 rigidly secured to the chassis frame and connected to the rear wheels by a suitable normally engaged but releasable clutch 59 and a chain drive 60.

Referring now to FIG. 7, there will be described the hydraulic system and the controls therefor. As there shown the power supply comprises six heavy duty storage batteries 62. These batteries provide all power requirements including those of the reversible prime mover, such as motor 65, coupled through the belt drive 66 to a common shaft 67 driving the identical positive displacement pumps 68,69. The power supply to prime mover motor 65 is controlled by a pair of switches 70,86 normally positioned as shown to complete a power supply circuit to the chassis drive motors 59,59 and to steering motor 40 provided the key operated switch 105 is closed. Pumps 68 and 69 are connected to the hydraulic fluid reservoir 75 by conduit 76 leading into each pump and includes a filter 77 and a normally closed check valve 78. The other side of each of the pumps 68,69 is connected to a respective one of the mast assemblies 17,18 by conduits 79,80. Each of these conduits includes a normally closed pressure relief valve 81 discharging back to the fluid reservoir in conventional manner in the event the pressure in the mast exceeds a predetermined safe value. A similar pressure relief valve 82 is shown connected to the supply side of pumps 68,69 and opens if the pressure in line 76 becomes excessive during retraction of the platform.

During lowering of the platform pumps 68,69 are operated in the reverse direction by the reversible prime mover 65, it being understood that the normally closed pilot operated solenoid valve 85 is first energized by closing switch 86 to energize relay 65*b* so that the fluid discharging from pumps 68,69 then passes through conduits 76,87, valve 85 and thence along conduit 88 back to reservoir 75.

The electrical level sensor, designated generally 90, for maintaining platform 22 level even though the load is distributed in a grossly non-unifrom manner, will now be described with reference to FIGS. 4–7. As there shown, the top of the last stage 24 of the multistage mast 17 is provided with a cap plate 91 supporting a pair of upright studs 92,92 projecting loosely through openings in a cap plate 93 for the tubular yoke 26. Keeper nuts 94 are threaded to the upper ends of studs 92 but do not bear against plate 93. A pair of fulcrum cylinders 96 are fixed to plate 91 with their upper side bearing against the underside of the yoke plate 93. Keeper bars 94 (FIG. 5) are welded to plate 93 along either side of the fulcrum cylinders 96 and cooperate therewith in holding the parts properly centered while leaving the platform and yoke tube 26 free to pivot about the upper edge of cylinders 96, when it will be understood extend crosswise of one end of the platform 22. The described pivoting connection between the top mast 17 and one end of the platform, though beneficial, is not essential. Thus, satisfactory results are achieved if fulcrum cylinders 96 are replaced with a low height strip of metal having its upper and lower edges welded to plates 91 and 93.

The electrical sensor proper comprises a pair of normally open micro switches 100*a* and 100*b* rigidly secured to plate 93 by brackets 101. The actuating buttons or plungers 102 of each of the switches project through openings in plate 93 and bear lightly against the broad head of respective adjustable screws 103 carried by plate 91 of mast stage 24. So long as the platform is level both switches 100*a* and 100*b* will be open as shown in FIG. 7.

The two level sensing switches 100*a*,100*b* are connected in circuit with respective actuating solenoids of normally closed pilot operated fluid venting valves 110 and 111. The inlet sides of these valves are connected to mast 17 and 18 and their discharge sides lead back to fluid reservoir 75. Should the one or the other of the masts 17,18 be higher than the others, it will be understood that the associated one of the microswitches 100*a* or 100*b* will close and energize one of the venting valves 110 or 111 and release fluid from that mast until the platform is level at which time the closed sensing switches will open and de-energize the activated venting valve.

The hydraulic system for the described tower supporting chassis includes a motor 116 driving a pump 117 whenever one or both of switches 125 and 128 are closed to propel and/or steer the chassis. Pump 117 then provides pressurized fluid from tank 75 which flows through the distributing line 118 to the four way tandem-center valves 119 and 120. If these valves are deactivated then their respective spools are in a neutral position and the pressurized fluid supply by pump 117 simply flows through each valve and thence back to the reservoir.

Four way valve 119 controls the flow of fluid to the hydraulic motors 59,59 employed to propel the tower via the rear carriage wheels 12,12, the direction of propulsion depending upon whether valve 119 is energized to the right or to the left. Since it is highly undesirable to start or stop the chassis abruptly, each supply line leading to motors 59 preferably includes an accumulator 122,123 operating in known manner to absorb shocks incident to abrupt operation of valve 119 thereby providing smooth acceleration and deceleration of the chassis. Propulsion of the chassis is controlled by switch 125 normally biased to its open position. If this is pivoted forwardly, the chassis is propelled in this direction, whereas it is propelled rearwardly if the switch is pivoted rearwardly.

Valve 120 controls the steering cylinder 40 for the front carriage wheels 13,13. Normally this valve is in its neutral position but if the normally open switch 128 closed to the right, the front wheels steer to the right whereas if it is closed to the left these wheels steer to the left. A normally closed pressure relief valve 130 is connected to line 118 and opens to relieve pressure in that line if for any reason the fluid pressure becomes excessive.

OPERATION OF FIRST EMBODIMENT

The operation of the described mast assembly will be quite apparent from the foregoing description of its components. Let it be assumed that a load is in position on platform 22 for transfer from near ground level to an elevated height such as 30 feet. The operator, standing at control station 140 at the forward end of the tower, first operates the appropriate control buttons to move tower 10 to a desired position. For example, the key operated switch 105 is closed to supply power to the "up" and "down" control switches 70,86, respec-

tively, as well as to the chassis power control switches **125,128.**

Assuming the operator wishes to move the tower to a particular plane for use he pivots the operating handle of toggle switch **125** forward thereby energizing the power control relay **116***a* or motor **116** of pump **117** and the forward coil of four-way valve **119** to supply pressurized fluid to the drive motors **59.** While holding switch **125** closed in this forward position, the operator may wish to steer the chassis to the right or the left. This is accomplished by pivoting switch **128** to the right or left again energizing motor control relay **116***a* and the respective ones of the control coils of four-way valve **120** to supply fluid to the steering motor **40.** Either one or both of switches **125** and **128** are held closed in either direction so long as the operator wishes to move and to steer the chassis. As soon as he releases his grip of the respective control handles, either or both switches move to their normal or open position.

Once the tower is in position the hand brake lever **50** is set and the stabilizing strut devices **53** are lowered firmly against the ground, or against levelling blocks if it is necessary to use such blocks to assure having platform **22** in a level position as it must be before raising it to an elevated position.

Raising a load present on platform **22** is accomplished by closing the "up" switch **70** and holding it closed against the pressure of the spring biasing the switch to its normal position illustrated in FIG. **7.** So long as the switch is held depressed, its lower pair of contacts are held open thereby deactivating the power supply via conductor **135** to the chassis power units controlled by switches **125** and **128.** Accordingly it is impossible for the operator to move the chassis so long as he is endeavoring to operate the mast assembly in either direction. Closing switch **70** supplies power via conductor **136** to the platform level sensor **90** as well as to the coil of the "up" power relay **65***a*. Energization of relay **65***a* closes the upper pair of contacts thereby supplying power via lead **138** to drive motor **65** and pumps **68** and **69** in a direction to elevate the platform. Equal volumes of pressurized fluids are then withdrawn from tank **75** by these pumps, the fluid flowing upwardly through filter **77,** past check valve **78,** through each of the pumps and via conduits **79,80** into the lower ends of each of the masts **17,18.**

If the load is unevenly distributed on the platform, it is likely that the less heavily loaded mast will extend faster than the other one. Should this occur, the resulting tilting of the platform from a horizontal plane is immediately sensed by one of the levelling switches **100***a* or **100***b*. If mast **17** is less heavily loaded, then switch **100***a* will close briefly, thereby energizing venting valve **110** to release a portion of the fluid flowing to mast **17** and allowing such vented fluid to return to the reservoir. Desirably only a small portion of the fluid flowing to the higher mast is released so that the platform continues to rise substantially at the same rate during the level compensating operation. As the platform approaches or reaches a level condition, switch **100***a* opens so that valve **110** immediately closes.

Should valve **110** overcompensate, then sensing switch **100***b* closes to open valve **111** to vent fluid from mast **18.** It will therefore be evident that the platform continues to rise and that any uneven extension of either mast is immediately sensed and corrected automatically and without attention from the operator.

Once the load is at a desired elevation, switch **70** is opened by the operator and check valve **78** blocks all return flow thereby holding the platform rigidly and firmly in its elevated position.

To lower the platform, the operator holds the "down" switch **86** closed thereby again discontinuing the power supply to the chassis propulsion components by opening the lower pair of contacts of this switch. Closing the upper pair of contacts of switch **86** resumes the supply of power to level sensor **90** via conductor **136** and also supplies power to the "down" control relay **65***b* thereby reversing the polarity of the power supply to motor **65** so that this motor now operates pump **68,69** in the reverse direction to pump fluid out of masts **17,18.** At the same time power supply through the middle pair of contacts of switch **86** energizes solenoid valve **85** to open this valve to by-pass the fluid from each of the masts around check valve **78.**

The energizing power supplied to relay **65***b* will also be observed as flowing through the normally closed safety switch **141.** This switch is mounted on the chassis in the path of the platform and is spring biased to its closed position. However, if the operator holds the "down" control switch **86** closed for too long a period of time the platform will strike the control button of switch **141** and open the switch thereby discontinuing the supply of power to both pump motor **65** as well as to the normally closed valve **85.** It will be recalled that this valve if open permits the fluid discharging from the mast by way of pump **68,69** to flow downwardly through conduits **76,** through the now open valve **85** and back to the reservoir via conduit **88** and filter **77.**

If during lowering of the platform either mast retracts faster than the other the resulting non-level condition of the platform will again operate level control switches **100***a* and **100***b* as necessary to bleed fluid from the higher one of the masts via valves **110** or **111** until the platform **22** is restored to its level condition.

As will be apparent from the foregoing, the platform can be stopped at any level whereupon it is automatically locked in this position by the check valve **78.** So long as the platform is stationary the power supply to the level sensor **90** is deactivated. Accordingly, the operating crew may move freely about the platform and may shift the load onto or off the platform without any possibility of the platform shifting because check valve **78** prevents the discharge of fluid from either mast and pumps **68,69** cooperate in preventing the transfer of fluid from one mast to the other.

SECOND EMBODIMENT

Referring now to FIGS. **8–10** there is shown a second preferred embodiment of the load lifting apparatus and differing only in minor respects from the first described embodiment. Accordingly, the same or similar parts are designated by the same reference characters as in the first described embodiment but distinguished by the addition of a prime. A basic difference resides in the fact that the prime mover **65** comprises a unidirectional power unit such as an internal combustion engine or a direct current motor coupled to the identical hydraulic pump **68',69'** by a reversible hydrostatic transmission **145** of any ssuitable type. A particularly suitable reversible transmission unit sold under the tradename Marshallmatic Model 10 manufactured by the Eaton-Marshall Division of Eaton, Yale & Towne,Inc., Marshall, Michigan. The use of a unidirectional prime

mover in combination with a reversible transmission eliminates the need for reversing switch control mechanism on the platform and permits the use of simple slave cylinder control in lieu thereof. Other changes to be described in greater detail include the provision of a belt takeoff from the prime mover to the hydraulic pump supplying fluid to the chassis power units as well as an improved emergency control accessory and a variation of the automatic level control mechanism. A typical operating arrangement utilizing an internal combustion engine as the prime mover will now be described.

It will be understood that the gasoline powered engine 65' is coupled directly to the reversible transmission unit 145 having its output coupled directly to a common shaft driving pumps 68',69'. A power takeoff belt 66' located between the engine and transmission drives pump 117' and provides a supply of pressurized fluid for the power driving and steering components of the chassis so long as the prime mover is operating.

Transmission unit 145 is provided with a reversing control lever 146 shown in its neutral position and having an operating connection to the piston of a slave cylinder 147. The latter is connected in a closed fluid circuit 148 with a control cylinder 149 connected to a control lever 150. When lever 150 is pivoted to the right, lever 146 on the transmission is likewise pivoted to the right and transmission unit 145 is then operative to drive pumps 68',69' in a direction to supply equal quantities of pressurized fluid to masts 17',18' to elevate the load platform 22'.

Likewise if control lever 150 on the platform is shifted to the left as viewed in FIG. 10 the transmission control lever 146 is pivoted in the same direction to its alternate position reversing the direction in which pumps 68' and 69' are driven. It will be understood that when control levers 146 and 150 are in neutral position an automatic check valve in the transmission unit blocks the circulation of fluid within the transmission means with the result that the transmission remains stationary and the platform is held firmly at any elevation occupied when the transmission was placed in neutral. This condition is also assured by check valve 78' in the fluid supply line leading to the inlets of pumps 68' and 69'. The transmission also preferably includes an accumulator 152 connected to its internal fluid circuit and effective to absorb shockloads accompanying operation of control lever 146.

Referring to FIG. 9, it will be understood that the flexible hoses 148 interconnecting cylinders 147 and 149, as well as all electric leads extending between the platform and the chassis are preferably enclosed in two or more protective housings or ducts 166 arranged end to end and movably interconnected by hinge means 167. Likewise one of their remote ends is hinged at 168 to the chassis and the other is hinged at 169 to the platform. It will therefore be appreciated that these hoses and electrical leads are fully protected at all times and that foolproof trouble free means is provided for extending and retracting the same as the platform rises and descends.

Engine 65' is provided with a starter motor 155 connected in circuit with a starter relay 156 which may be energized by a normally open manual switch 157 on the platform or a similar switch 158 at ground level. Likewise a magneto 159 for the engine may be shortcircuited to stop the engine from either stop switch 160 at ground level or a second switch 161 located at the control station on the platform.

The automatic self-levelling control for the platform 90' is generally similar to that described for the first embodiment but differs in the provision of an extra pair of switches 100*c* and 100*d* operatively associated respectively with microswitch 100*a*' and 100*b*'. When the platform is in a level condition switches 100*a*' and 100*b*' are open, whereas switches 100*c* and 100*d* are closed. Normally, switches 100*c*,100*d* remain inactive because the emergency switch 190 is open. The purpose of the emergency switch 190 is to permit the operator to lower the platform in an emergency even though the prime mover is disabled or inoperative for any reason.

OPERATION OF SECOND EMBODIMENT

In use, the second embodiment operates as follows. The operator first starts engine 65' by closing either of the starter switches 157 or 158 thereby closing relay 156 and supplying power to the starter motor 155 for the engine. As soon as the engine starts power is delivered via belt 66' to drive pump 117' and provide a supply of pressurized fluid from the supply reservoir 75' for the chassis power units. The lifting apparatus may now be moved to a place of use by operating the control switch 125' to either the forward or reverse position from its normal open position thereby diverting pressurized fluid to drive the single propelling motor 59' forwardly or rearwardly depending upon the direction of closure of switch 125'.

Referring to FIG. 8 it will be observed that the propelling motor 58' has a power connection to a drive shaft 164 equipped with a differential 165. One side of the differential is connected by a chain drive 60' to drive one of the chassis wheels whereas the other side of the differential drives a similar chain 60' connected with the other propelling wheel. If the operator wishes to steer the front wheels he operates control switch 128' to the left or the right to operate the four-way control valve 120' supplying pressurized fluid to the opposite ends of steering cylinder 40' in the same manner as described above in connection with the first embodiment. If both switches 125' and 128' are in neutral position, as they normally are, then the output of pump 117' merely circulates through the respective four-way valve 119',120' and returns to the reservoir so long as these valves are in neutral position. Any excess fluid pressure developed by the pump is relieved by the pressure relief valve 130'.

Once the apparatus is in the desired position of use, the stabilizing struts 53' (FIG. 9) are lowered from the chassis frame and a check is made to determine that the load platform is level. Platform 22' may now be raised from a control station 140' on the platform by shifting control lever 150 to the right, as viewed in FIGS. 8 and 10, thereby closing switch 70' and simultaneously shifting the piston of cylinder 149 to the left which is effective to shift the piston of slave cylinder 147 to the right. The closing of switch 70' arms the contacts of switch 100*a*', 100*b*' of the platform level control device 90'. Likewise the movement of the transmission control lever 146 to the right shifts transmission 145 to drive pumps 68' and 69' in a direction to supply equal quantities of pressurized fluid to each of the masts 17',18'. The platform together with its load is now elevated.

Should either end of the platform start to rise at a faster rate than the other end, the tilt so produced acts to close one or the other of the level control switches **100***a'*,**100***b'* thereby energizing the solenoid of one of the bleed valves **110'**,**111'** to bleed a portion of the fluid being supplied to the higher mast until the level condition of the platform is restored. As this occurs, the closed one of the level switches opens with the result that the open bleed valve recloses.

Once the platform is in elevated position the operator restores the control lever **150** to its neutral position and thereby shifting the transmission **145** to its neutral position. Fluid cannot return to the reservoir from either mast because this is positively blocked by check valve **78'** in the supply line to the two pumps.

If the operator wishes to shift the work platform to a lower level he merely operates control lever **150** to the left as viewed in FIG. **10** closing switch **86'** to re-arm the level control switches **100***a'*,**100***b'*. At the same time the transmission control lever **146** is shifted to the left to operate pumps **68'**,**69'** in the reverse direction. These pumps then pump fluid from each of the masts and return it to the reservoir via conduit **87'**, bleed valve **85'** and conduit **88'**, valve **85'** remaining in its open position so long as switch **86'** is closed. Should either end of the platform lag behind the other during the descent switches **100***a'*,**100***b'* operate in the same manner as described above to bleed additional fluid from the higher mast until the level condition is restored.

Let it now be assumed that an emergency exists by virtue of the failure of the prime mover while the platform is in a raised position. In this event, workmen on the platform can lower the platform without need of the prime mover. An operator merely closes the normally open emergency switch **190** thereby supplying power to the normally closed pair of microswitches **100***c*,**100***d* of the level control mechanism **90'**. Immediately that switch **190** closes power is supplied to each of the solenoid bleed valves **110'**,**111'** thereby opening these valves and allowing equal quantities of fluid to bleed from each of the masts and return to the reservoir **75.** Should either end of the platform start to lag the higher end will operate to open the associated one of switches **100c**, **100**d thereby de-energizing the solenoid of the relief valve for the mast under the lower end of the platform thereby closing that valve and allowing the higher end of the platform to approach a level condition whereupon valve **110'** reopens. It will therefore be understood that switches **100***c*,**100***d* operate in the reverse manner of switches **100***a'*,**100***b'*.

While the particular self-contained mobile extendable tower herein shown and disclosed in detail is fully capable of attaining the objects and providing the advantages hereinbefore stated, it is to be understood that it is merely illustrative of the presently preferred embodiment of the invention and that no limitations are intended to the detail of construction or design herein shown other than as defined in the appended claims.

I claim:

1. Apparatus for moving a load between different levels comprising in combination: a horizontal load platform, a main frame underlying said platform, a plurality of multistage mast assemblies arranged in parallel and interconnecting said main frame and the opposite ends of said platform and including an elongated horizontal axis pivot connection extending transversely of and interconnecting one end of said platform and one of said mast assemblies, separate hydraulic pumps of identical displacement connected in circuit with a respective one of said mast assemblies to supply pressurized fluid thereto and operable in either direction by common prime mover means to extend and retract said mast assemblies in unison, normally closed electrically actuated bleed valve means for bleeding fluid from the higher one of said ram assemblies as necessary to maintain said platform level despite the non-uniform loading of said mast assemblies during both extension and retraction of said platform, and non-level sensor means connected to said platform and responsive to pivotal movement of said platform about the axis of said pivotal connection to operate a selected one of said bleed valve means to bleed fluid from any higher one of said mast assemblies as necessary to maintain said platform level.

2. Apparatus as defined in claim **1** characterized in that said non-level sensor means is closely adjacent the upper end of one of said mast assemblies.

3. Apparatus as defined in claim **1** characterized in that said non-level sensor means is mounted on the upper end portion of one of said mast assemblies.

4. Apparatus as defined in claim **1** characterized in that said sensor means includes an electric switch connected in circuit with electrical operating means for said bleed valve means and normally so positioned that said bleed valve means is closed to block the escape of fluid from all of said mast assemblies so long as said platform is level and operable to open the bleed valve means of the highest one of said mast assemblies when said platform is not substantially level.

5. Apparatus as defined in claim **1** characterized in that said main frame is rigidly secured to a chassis having steerable front wheels and hydraulically power driven rear wheels, and control means for said power driven rear wheels and including accumulator means for cushioning initiation and cutoff of pressurized fluid to said power drive thereby to assure smooth starting and stopping of said chassis.

6. Apparatus as defined in claim **1** characterized in that said prime mover means comprises a reversible electric motor.

7. Apparatus as defined in claim **6** characterized in that said prime mover means comprises a reversible direct current motor energized from batteries carried by said main frame.

8. Apparatus as defined in claim **1** characterized in the provision of hydraulically powered chassis means supporting said main frame, and means for selectively operating at any time either said mast assemblies to change the level thereof or said hydraulically powered chassis means.

9. Apparatus as defined in claim **8** characterized in that said hydraulically powered chassis means includes accumulator means in circuit with the pressurized hydraulic fluid powering said chassis means effective to provide smooth starting and stopping thereof.

10. Apparatus as defined in claim **1** characterized in the provision of folding protective means hingedly interconnecting said platform and said main frame and protectively enclosing portions of the controls for said prime mover and said pumps.

11. Apparatus as defined in claim **10** characterized in that said folding protective means comprises a plurality of elongated rigid members hingedly connected together in end to end relation with one end movably sup-

ported at said platform and the other end movably supported at said main frame, and flexible control means protected and supported by said rigid members and interconnecting control means for said apparatus located on said platform and other portions of said apparatus located on said main frame.

12. Apparatus as defined in claim 1 characterized in that said prime mover means comprises unidirectional power generating means coupled to said separate hydraulic pumps by reversible power transmission means.

13. Apparatus as defined in claim 12 characterized in that said main frame comprises a hydraulically powered steerable chassis, and fluid pump means having a driving connection with said unidirectional power generating means in advance of the drive connection of the latter to said reversible power transmission means.

14. Apparatus as defined in claim 12 characterized in the provision of control means on said platform operable to stop and start said power generating means at will from an operating control station on said platform irrespective of the elevation thereof above ground level.

15. Apparatus as defined in claim 1 characterized in that said prime mover means comprises an internal combustion engine coupled to said separate hydraulic pumps by reversible power transmission means.

16. Apparatus as defined in claim 15 characterized in the provision of control means for shifting said power transmission means between a neutral position, forward drive position and reverse drive position from a control station located on said platform.

17. Apparatus as defined in claim 16 characterized in that said control means includes hydraulic motor means located in part on said platform and in part on said main frame.

18. Apparatus as defined in claim 1 characterized in that said main frame is mounted on steerable front wheels and hydraulically driven rear wheels.

19. Apparatus as defined in claim 18 characterized in the provision of hydraulically powered means for steering said front wheels from a control station on said platform.

20. A tower assembly as defined in claim 19 characterized in the provision of means for deactivating the operation of said mast assemblies so long as power is being supplied to propel and/or to steer said chassis.

21. A tower assembly as defined in claim 19 characterized in the provision of means for automatically rendering the drive means for the pumps connected in circuit with said mast assemblies ineffective to drive said pumps while said hydraulically powered means for said front and rear wheels is activated.

22. A mobile chassis-supported extendable tower assembly for moving a load between different levels, said tower assembly comprising a main chassis frame closely spaced above the ground, a load platform overlying said main frame including a plurality of inverted upright yoke means overlying said platform and having the lower ends thereof fixed to said platform near the opposite ends thereof, multistage mast assemblies having their lower ends rigidly secured to said main frame and their upper ends secured to the upper end of a respective one of said yoke means, said mast assemblies having a retracted height corresponding generally to the height of said yoke means, power-driven pressurized fluid means for extending and retracting said masts in synchronism by pressurized fluid supplied to each of said mast assemblies, said last mentioned means including electrical level sensor means mounted on said platform effective to sense tilting of said platform away from the normal horizontal plane thereof and electrically connected to normally closed fluid bleed valves for each of said mast assemblies supported independently of said platform and automatically operable to bleed fluid from the higher one of said mast assemblies when and as necessary to restore said platform to the level condition thereof during both extension and retraction of said platform, said assembly being fully self-contained and operable from a source of power carried by said chassis.

23. A tower assembly as defined in claim 22 characterized in that said electrical sensor means comprises a pair of electrical switches spaced from one another in a plane parallel to a plane common to the axes of said mast assemblies and respectively responsive to a clockwise and counterclockwise tilting of said platform away from the normal horizontal position thereof to open one or the other of an associated one of said fluid bleed valves until said platform has been restored to the level condition thereof.

24. A tower assembly as defined in claim 22 characterized in the provision of check valve means located in the fluid supply to said mast assemblies and effective to hold said platform locked in any elevated position thereof despite a failure in the operating condition of said power driven means, and manually actuated means operable to bleed fluid from each of said mast assemblies to lower the same in synchronism.

25. A tower assembly as defined in claim 22 characterized in that said power driven means includes similar reversible positive displacement pumps for each of said mast assemblies coupled to a common prime mover for operation in unison, check valve means between a source of hydraulic fluid and the inlet to said pump means to prevent reverse flow of fluid to the fluid source upon the unintended failure of said prime mover, and manually actuated fluid venting means between said check valve means and said pump means operable to lower said platform as the fluid in said mast assemblies escapes therefrom via said pump means and thence through said fluid venting means.

26. A tower assembly as defined in claim 22 characterized in the provision of manually controlled hydraulic motor means for driving an axially aligned pair of said chassis wheels and including accumulator means for cushioning acceleration and deceleration of said chassis.

27. A tower assembly as defined in claim 22 characterized in the provision of separate reversible hydraulic motors driving a respective one of the chassis wheels to propel said mobile tower assembly forwardly and rearwardly at the operator's option.

28. A tower assembly as defined in claim 27 characterized in the provision of reversible hydraulic means for steering said tower assembly to the right and to the left from a control station on said platform.

29. A mobile extendable tower assembly comprising a heavy duty chassis having an elongated rigid main frame, an elongated load supporting platform overlying said main frame, similar upright tubular housings having their lower ends fixed to the opposite ends of said platform, a pair of multi-stage mast assemblies having their smaller ends secured to the interior upper ends of said housings and extending downwardly therethrough

to fixed anchorages at the opposite ends of said chassis main frame, a prime mover coupled to separate reversible pump means operable to supply pressurized fluid to a respective one of said mast assemblies to raise and lower the same in unison, normally closed bleeder valve means supported independently of said platform for venting fluid from any higher one of said mast assemblies if said platform tilts away from a horizontal plane lengthwise thereof thereby to restore the level condition of said platform, and high sensitivity non-level sensor means including two pairs of electric contactors connected in circuit with a source of electrical energy and said bleeder valve means and operable to bleed fluid from any higher one of said mast assemblies during both extension and retraction of said platform as necessary to restore said platform to a level condition upon sensing a non-level condition of said platform.

30. A tower assembly as defined in claim **29** characterized in that said prime mover is coupled to said reversible pump means by reversible transmission means.

31. A tower assembly as defined in claim **29** characterized in the provision of means for lowering said platform independently of the operation of said prime mover and under the control of said non-level sensor means.

32. A tower assembly as defined in claim **29** characterized in that said pairs of contactors are mounted at the upper end of one of said tubular housings.

33. A tower assembly as defined in claim **32** characterized in that said prime mover means comprises an internal combustion engine.

34. A tower assembly as defined in claim **33** characterized in the provision of manually operable control means on said platform for starting and stopping said engine.

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