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Wallace et al.

[11] **3,713,544**

[45] **Jan. 30, 1973**

[54] SYSTEM FOR CONTROLLING A BOOM

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[21] Appl. No.: **191,435**

[52] **U.S. Cl.** **212/5**, 214/142, 212/49, 212/69, 212/6

[51] **Int. Cl.**.....**B66c 17/06**

[58] **Field of Search** 214/146.5, 142; 212/10, 11, 212/17, 5, 6, 66, 67, 68, 69, 48, 49, 145

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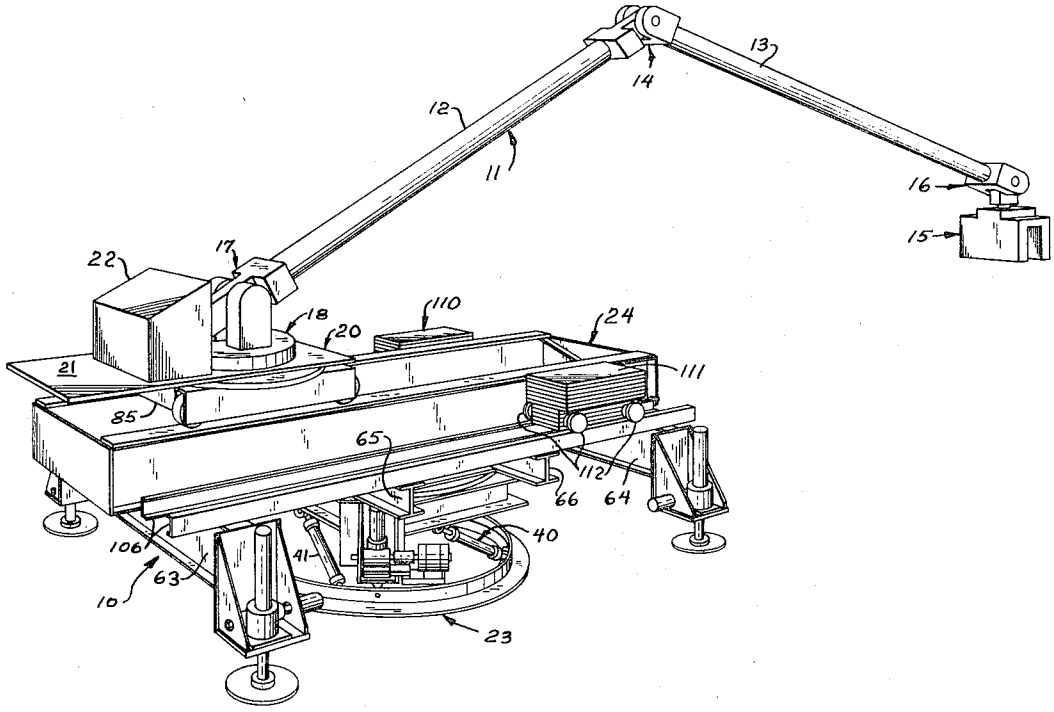
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[57] **ABSTRACT**

A system for controlling a boom has an undercarriage adapted for placement on the ground and a superstructure mounted on the undercarriage for rotation about a vertical axis. The undercarriage includes means for adjusting the elevation of and for leveling the superstructure, means for controlling the azimuth of the superstructure, and means for resisting torsion induced in the superstructure. The superstructure includes corner outrigger jacks for support in addition to that provided by the undercarriage, and it has a frame to which are mounted elongated parallel rails. A movable carriage is mounted on the rails by means of preloaded pressure wheels to prevent deflection of the carriage from the horizontal and to eliminate relative rotational motion between the carriage and rails. A pair of side counterweights are also mounted on the superstructure on rails to either side of rails supporting the carriage. The counterweights are connected to the carriage by flexible links to move in an opposite direction than the carriage so as to counterbalance the weight of the boom on the undercarriage.

8 Claims, 10 Drawing Figures



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SHEET 1 OF 4

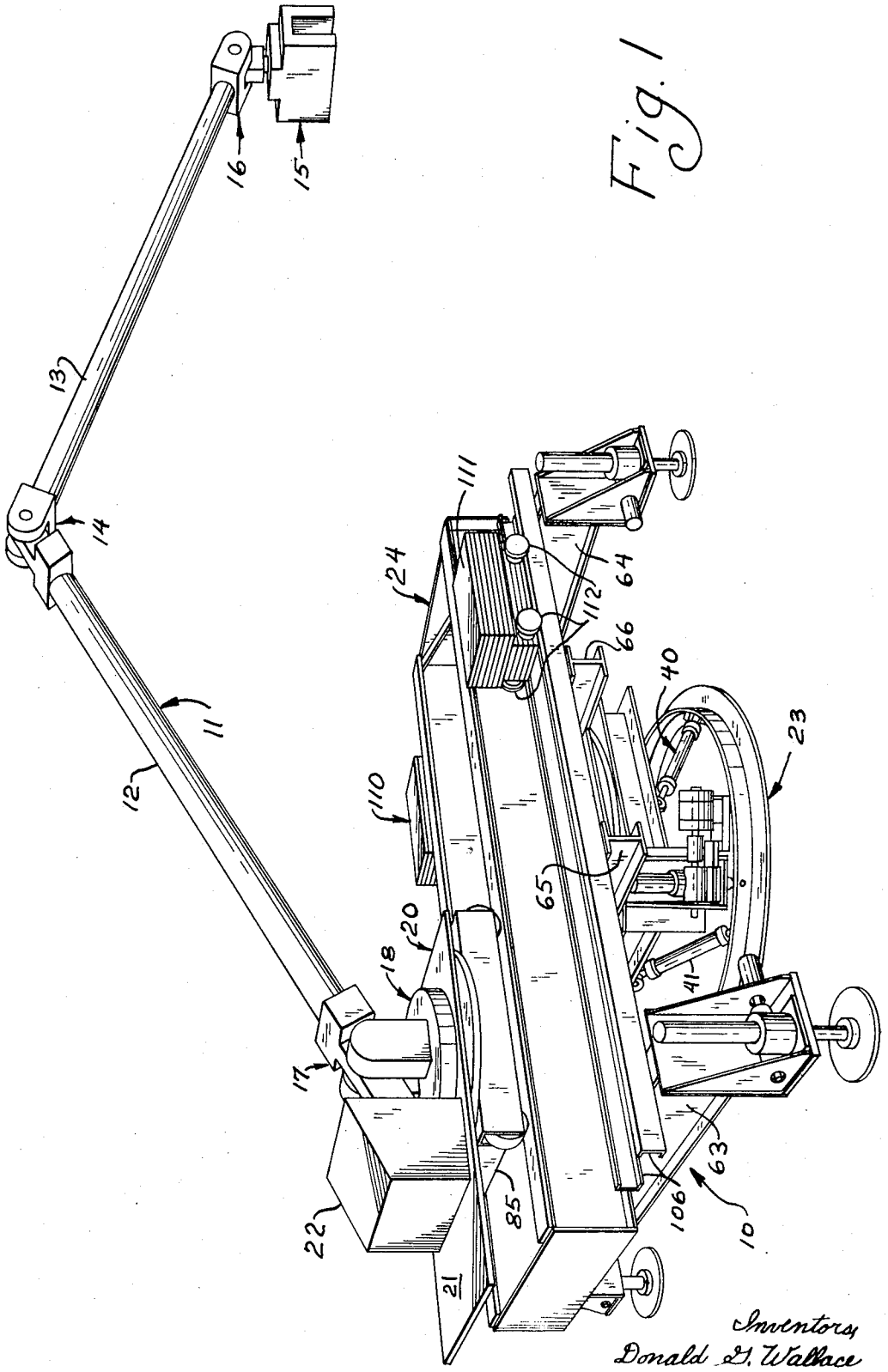


Fig. 1

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Attorneys

Fig. 2

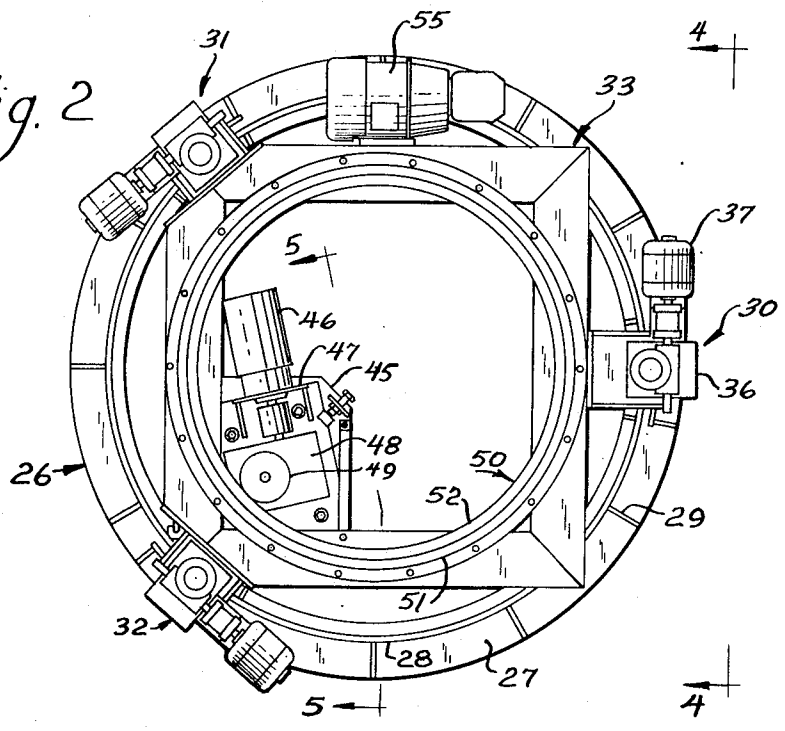


Fig. 3

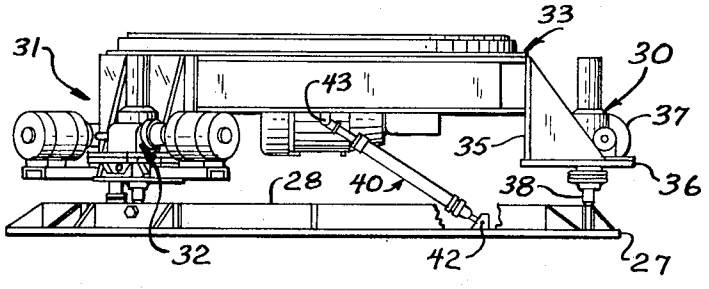


Fig. 4

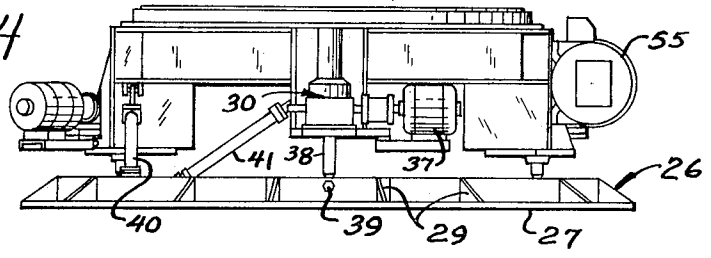
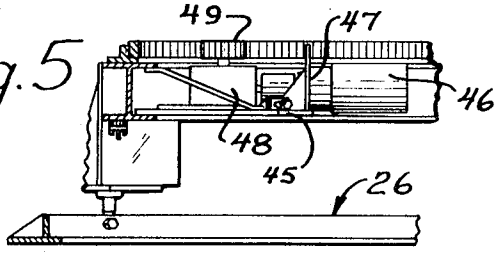


Fig. 5



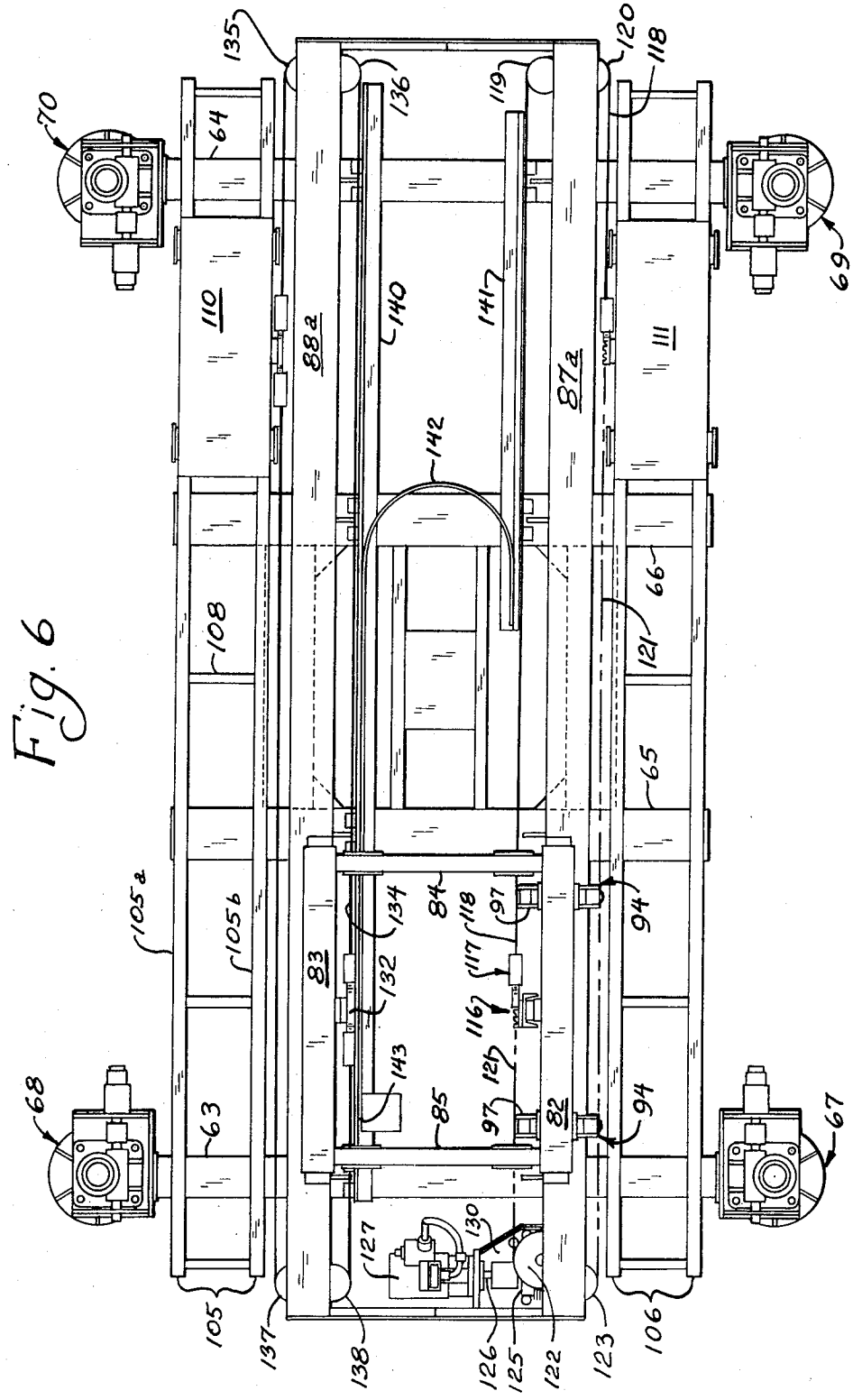

135
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Fig. 6

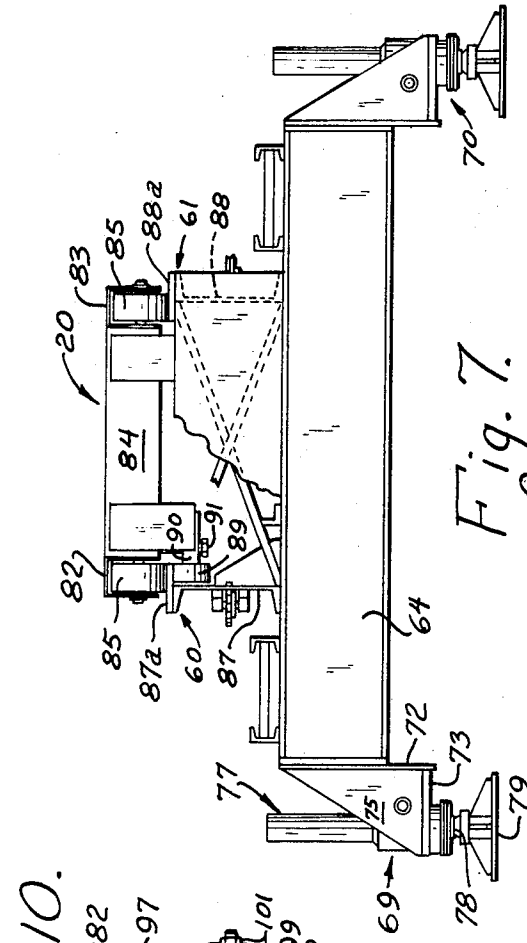


Fig. 7.

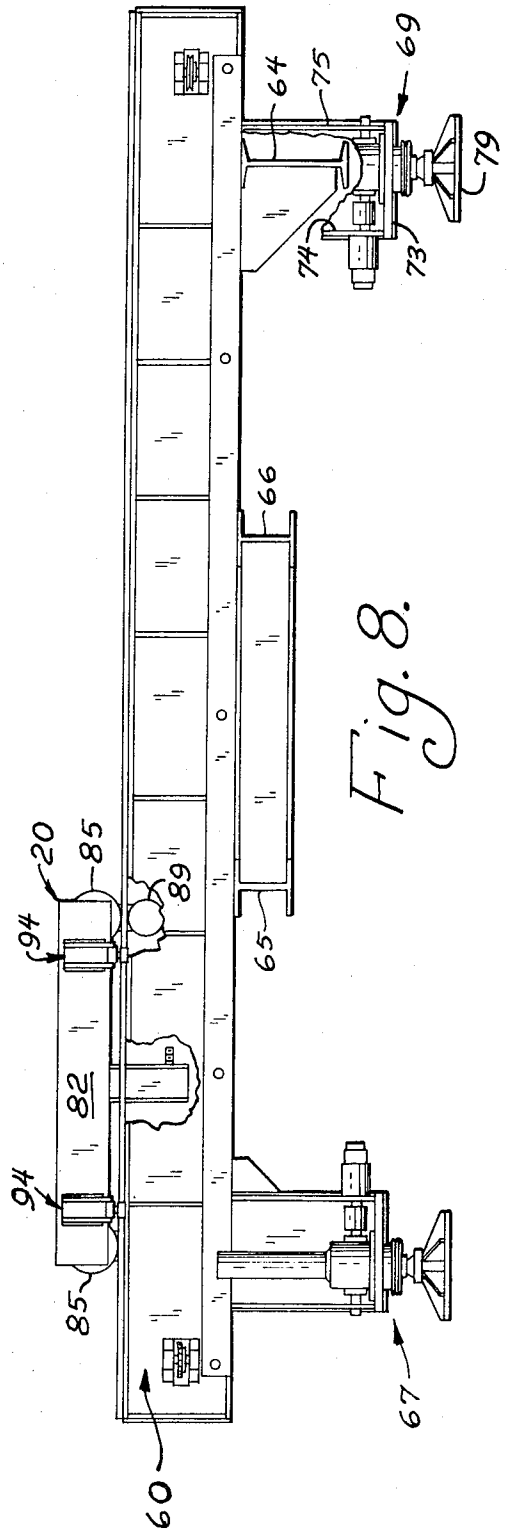


Fig. 8.

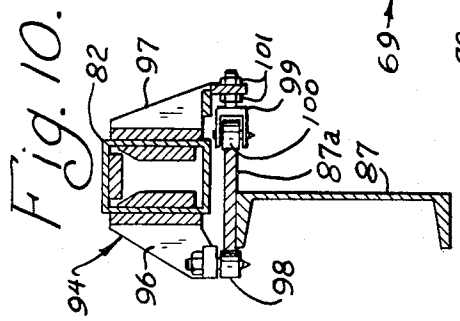


Fig. 10.

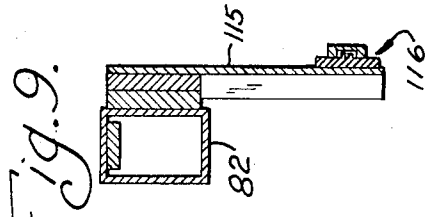


Fig. 9.

SYSTEM FOR CONTROLLING A BOOM

BACKGROUND OF THE INVENTION

The present invention relates to a system for controlling the motion of a boom. In its broader aspects, the system of the present invention may be used to control booms of fixed length, telescoping booms or articulated booms. Further, the implement located at the distal end of the boom does not form an essential part of the inventive system as it could be a tool or a mechanism for attaching to a parcel or load to be moved, as in materials handling applications.

However, the primary purpose for the instant design is for use in controlling the motion of a mold used for forming the walls of a structure in place by reacting a resin and a foaming agent right in the mold, and then building the wall structure by depositing tier upon tier of the plastic foam.

In applications of the type with which the present invention is primarily concerned, the boom is articulated. Once such system was disclosed in a co-owned application of Brenner et al., "System for Foaming Structure in Place", Ser. No. 14,370, filed Feb. 26, 1970.

SUMMARY

In the present system, an undercarriage includes a circular base ring and an upper rectangular frame. The base ring is adapted for placement on the ground, and it increases the tipping circle of the undercarriage. The upper frame of the undercarriage is supported by means of three hydraulic jacks interconnecting the base ring with the upper frame, one of the jacks being setable to control the elevation of the upper frame of the undercarriage. The other two jacks automatically level the upper frame of the undercarriage to a horizontal plane.

First and second hydraulic cylinders are located orthoginally relative to each other, and they are interconnected between the base frame of the undercarriage upper frame to resist torsional stresses.

Secured within the upper frame of the undercarriage is a circular bearing race forming a portion of a main turntable. The other circular bearing race of the turntable is secured to a superstructure. The superstructure has a main frame which is generally rectangular in plan view. At each corner of the superstructure there is a hydraulic supporting jack, and these are arranged to assist the undercarriage in supporting the superstructure by taking up equal portions of the load.

On the top of the superstructure there are two elongated main rails on which are mounted a carriage. The articulated boom is secured to the carriage by means of a second turntable. Thus, the superstructure may be adjusted in azimuth relative to the undercarriage by operation of the main turntable; and once it is set, the outrigger jacks of the superstructure are actuated to hold the superstructure in azimuth.

The upper carriage bearing the articulated boom is mounted to the main rails by means of preloaded wheels to eliminate backlash and to minimize relative movement between the uppercarriage and the main rails except for movement of the carriage along those rails.

A pair of counterweights, one on either side of the main rails, are connected to the carriage and adapted to move respectively on pairs of tracks that are arranged parallel to the main rails. The carriage moves in a direction counter to the movement of the carriage so as to balance the weight of the superstructure on the outrigger jacks and the undercarriage for all positions of the carriage and boom.

The present invention affords considerable flexibility in forming wall structures. For example, circular walls having a radius of curvature of 5 to 20 feet may be formed simply by rotating the upper carriage supporting the boom. Straight wall sections may be formed by adjusting the azimuth of the superstructure and then translating the carriage along the main rails. Further, the inventive system affords increased control of the placement of the distal end of the boom which is important not only in fabricating wall structures in situ, but in other applications, for example in materials handling and placement systems.

Other features and advantages of the present invention will be apparent to persons skilled in the art from the following detailed description of a preferred embodiment accompanied by the attached drawing wherein identical reference numerals will refer to like parts in the various views.

THE DRAWING

FIG. 1 is a perspective view of a boom control system encorporating the present invention;

FIG. 2 is a plan view of the undercarriage;

FIGS. 3 and 4 are side views of the undercarriage of FIG. 2;

FIG. 5 is an elevational view in cross-section of a portion of the undercarriage of FIG. 2 taken through the site line 5—5;

FIG. 6 is a plan view of the superstructure of the system of FIG. 1;

FIGS. 7 and 8 are respectively end and side views of the superstructure;

FIG. 9 is a cross-sectional view of a portion of the carriage to which the counterweights are attached; and

FIG. 10 is a cross-sectional view showing the portion of the arrangement for mounting the carriage to the main rails.

DETAILED DESCRIPTION

Turning first to FIG. 1, there is shown an embodiment of the present invention adapted to control the motion of a boom. The support system is generally designated by reference numeral **10** and the boom **11**. The boom **11** has two articulated sections, a lower section is designated **12** and an upper section is designated **13**. The sections **12**, **13** are connected together by means of an elbow **14**, and at the distal end of the upper section **13** there is located a mold **15** for foaming tiers of structures in place. The mold **15** is connected to the boom section **13** by means of a wrist mechanism **16**.

The base of the lower boom section **12** is pivotally connected as at **17** to a turntable **18** which is mounted to a movable carriage generally designated **20**. A platform **21** is also mounted on the carriage **20** for supporting a control cabinet **22** which houses circuitry for controlling the various motions of the boom **11** and mold **15**. The carriage **20** is movably mounted on the support system **10** which may be separated into two main subassemblies, an undercarriage **23** and a superstructure **24**.

Undercarriage

Turning now to FIGS. 2–5, the undercarriage 23 includes a base ring 26 which is adapted to be placed on the ground to serve as a footing for the undercarriage. The base ring 26 comprises a flat annular base plate 27 and a cylindrical upright wall member 28 welded to the base ring 27 and braced against it by means of triangular braces 29. As will be apparent from further description of the undercarriage, the base ring 26 increases the tipping circle of the undercarriage.

Located at equal angular increments about the base ring 26 are three hydraulic jacks generally designated by reference numerals 30, 31 and 32. An upper frame 33 constructed of steel I-beams in a generally square plan formation (see FIG. 2) is located above the base ring 26; and the upper frame 33 is held in position relative to the base ring 26 by means of the hydraulic jacks 30–32. Referring now to the hydraulic jack 30 seen in FIG. 3, a bracket 35 is welded to one side of the upper frame 33, and it includes a horizontal mounting plate 36 on which a motor 37 forming part of the jack 30 is secured. The jack 30 also includes an extendable piston rod 38 which is pivotally mounted to the upright member 28 of the base ring 26. The hydraulic jack 30 is reversible so that when the piston rod 38 is extended relative to the platform 36, the upper frame 33 is raised, and conversely when the piston rod 38 is retracted the upper frame 33 is lowered relative to the base ring 26.

The remaining hydraulic jacks 31 and 32 are similar in construction to the jack 30 which has already been described so that they need not be described in greater detail for a full understanding of the invention. However, it will be appreciated from FIG. 2 that the brackets supporting the motors for each of these latter two hydraulic jacks are secured to the upper frame 33 at the corners thereof so that the jacks 30-32 are approximately equally angularly spaced about the center of the base ring 26 thus affording a stable support for the upper frame 33. Further, the hydraulic jacks 31, 32 are adapted with a conventional leveling mechanism to maintain them in a horizontal position and thereby insure that the upper frame 33 is always in a horizontal position when these leveling mechanisms are active. In practice, the hydraulic jack 30 is independently controlled by an operator to determine the elevation of the upper frame 33 (which in turn determines the elevation of the superstructures 24), and the leveling mechanisms associated with the jacks 31, 32 then move the upper frame 33 into a horizontal plane. Such leveling mechanisms are known in the art, and they take the form of a pendulum pivotally connected adjacent the jack together with a feedback mechanism sensing the position of the pendulum to raise or lower the jack to place it in a vertical orientation. Thus, the piston rod of each of the jacks 30–32 is pivotally connected to the base ring 26.

Referring now to FIGS. 1, 3 and 4, there are two hydraulic cylinder and piston rod units designated respectfully by reference numerals 40 and 41 each having its cylinder end pivotally connected to the base ring 26 (see reference numeral 42 in FIG. 3) and its rod end pivotally connected to the upper frame 33 (see reference numeral 43 in FIG. 3). Each of the pivotal connections for the hydraulic cylinder and piston rod units 40, 41 is a trunnion mount to permit pivotal motion about a horizontal axis, and the two units 40, 41 are arranged to engage portions of the upper frame 33 which are at right angles relative to each other. The function of these two hydraulic cylinder piston rod units is to resist any turning moment that may occur due to forces exerted on the superstructure. That is, any twisting force exerted on the superstructure would cause a reaction to try to twist the upper frame 33 of the undercarriage relative to the base frame 26, as for example when the turntable 18 is accelerated or stopped. The reaction would tend to twist the undercarriage, and this is prevented by the orthogonally oriented hydraulic cylinder and piston rod units.

Turning now to FIGS. 2 and 5, a mounting plate 45 is secured to the upper frame 33 and it supports a hydraulic motor 46 mounted to it by means of a bracket 47. The shaft of the motor 46 drives a bevel gear housed in a box 48 which are connected to a drive gear 49 adapted for rotation about a vertical axis and placed to engage the teeth on an inner-race of a main turntable interposed between the undercarriage 23 and the superstructure 24. This main turntable is generally designated by reference numeral 50 in FIG. 2, and it includes an outer circular race 51 and a complementary inner circular race 52. The turntable 50 is of the type generally referred to as a "shear ball" turntable, and it includes an inner and outer race which are freely movable relative to each other with low friction because of a ring of ball bearings interposed between them. The drive gear 49 is adapted to drive the inner race 52 of the turntable 50 to adjust the superstructure 24 in azimuth, as will presently be described.

Turning now to FIGS. 2 and 4, an electric motor 55 is mounted to the outer side of the upper frame 33, and the purpose of this motor is to return hydraulic oil to a remote sump for use by the hydraulic motors.

Superstructure

Turning now to FIGS. 6–8 in particular, the superstructure 24 will be described in greater detail. A pair of elongated rails 60, 61 are arranged in parallel relation, and they are secured to first and second transverse cross rails 63, 64 as well as to transverse frame members 65, 66, as best seen in FIG. 6. Each of the transverse frames 63–66 in the illustrated embodiment are I-beams. Located at each end of each of the end frame members 63, 64 is a hydraulic jack, and these are designated respectfully 67–70. Since each of these jacks is similar in structure and operation, only the hydraulic jack 69 will be described in greater detail. At the end of cross frame member 64, there is welded a vertical plate 72, the lower edge of which is attached a horizontal mounting plate 73 by means of triangular braces 74, 75. A hydraulic jack unit 77 is mounted to the horizontal plate 73, and the extendable piston rod thereof 78 extends through that plate and is fitted with a foot 79. In setting up the system, first the elevation of the upper frame 33 of the undercarriage 26 is set by adjusting the jack 30, then the leveling jacks 31 and 32 for the undercarriage are actuated to level the upper frame 33 of the undercarriage. Next, with the outrigger jacks 67–70 in a retracted condition, the azimuth of the superstructure is set by actuating the motor 46 which controls the main turntable 50. With the superstructure thus is a desired elevation, level, and azimuth, the outrigger jacks 67–70 are energized so that their respective feet are lowered to engage the ground, and

then pressure builds up in the hydraulic motor to a preset level so that each of the outrigger jacks assumes a predetermined amount of the load. From this point on the machine is stable, and the turntable with the articulated boom can be moved anywhere along the track and reach out to lengths of up to 20 feet without tipping the machine over.

Turning now to the structure of the carriage 20, and particularly to FIGS. 7 and 8 wherein the turntable 18, control cabinet 22 , etc. have been removed for clarity, it includes first and second longitudinal side frame members 82 and 83 which are rigidly secured together by transverse frame members 84 and 85 (seen in FIG. 1). Each of the longitudinal members 82, 83 is in the shape of an inverted trough, and at either end thereof are journaled upper wheels, all of which are designated 85.

As best seen in FIG. 7, each of the main rails 60, 61 includes a doubly-flanged beam (designated respectively 87 and 88) with the flanges extending outwardly. To the top of the upper flanges of the beams 87, 88, there are secured flats, designated respectively 87a and 88a, each having an inwardly-extending portion serving as the actual rail surface for the carriage 20, opposing each of the upper wheels 85 of the carriage 20 is a second wheel located beneath the flat (87a, 88a) associated with the upper wheel, see the lower wheel designated 87 in FIG. 7 located beneath the flat 87a. The lower wheel 89 is bonded to the transverse frame member 84, and it is journaled on a movable shaft 90 which may be raised by means of a bolt 91 to exert a predetermined compression, with the upper wheel 85 on the flat 88 and thereby to preload the wheels which move the carriage 20 longitudinally of the main rails 60, 61. EAch of the other wheels on the carriage 20 is similarly preloaded to avoid deflection in the orientation of the carriage 20 under varying loads on the boom. That is, any load that is applied to the working end of the boom is offset by the preload on the wheels that support the carriage 20, the preload being applied to the main rails 60, 61 on the superstructure 24.

In addition to the preloaded mechanism for preventing deflection of the carriage 20 out of its horizontal plane, there is also a preload applied to the carriage 20 to prevent its rotating about a vertical axis. There are four such preload structures for maintaining the carriage 20 in correct azimuth, two of which are seen in the side view of FIG. 8 and designated generally by reference numeral 94, although this structure is not shown in FIG. 7 to more clearly show the structure for preloading against tilting of the carriage 20.

Turning to FIG. 10, one of the preload mechanisms 94 is seen in greater detail, and it is seen to include a first bracket mounted to one side of the longitudinal frame 82 of the carriage 20, and this bracket is designated 96. A second bracket 97 is mounted to the other side of the longitudinal frame member 82. Mounted to the bracket 96 is an idler roller 98 which is freely rotatable about a vertical axis and engages the outer side of the upper flat 87*a* of the main rail 60. Secured to the bracket 97 is a yoke 99 in which there is rotatably mounted a second roller 100 which engages the inner side of the flat 87*a* and is freely rotatable about a vertical axis. The yoke 99 is adjustable relative to the bracket 97 by means of bolts 101 to exert a predetermined preload on the longitudinal frame 82 of the carriage 20 by compressing the flat 87*a*. By spacing four similar preload mechanisms about the chassis for the carriage 20, a suitable preload is maintained on that carriage to prevent deflection of the carriage about a vertical axis.

Referring to FIGS. 1, 6 and 7, there are located on either side of the main rails 60, 61 a pair of tracks designated respectively 105 and 106 which are secured to the transverse frame members 63–66 of the superstructure. The pair of tracks 105 is formed of inwardly-facing channel members 105*a* and 105*b* which are held apart at a predetermined distance by spacer bars 108. The other pair of tracks 106 is similar in structure. Each of the pairs of tracks 105, 106 supports a counterweight, and these are designated respectively 110 and 111 in FIG. 1. The counterweights 111, as illustrated, are mounted on wheels 112 so that the counterweight 111 moves along the pair of tracks 106. The motion of the counterweights 110, 111 is in a direction parallel to but opposite the translation of the carriage 20. That is, each of the counterweights 110, 111 is connected to the carriage 20 in a manner which will presently be described and which enables the counterweights to equalize the load applied to the undercarriage for all positions of the carriage 20.

Referring to FIG. 9, the longitudinal frame member 82 of the carriage 20 has attached to its inner side of depending angle iron 115 to the inside of which there is an anchor mechanism 116 for securing a flexible link (to be added in FIG. 6 and designated 117). Referring to FIG. 6, the flexible link 117 includes a steel cable 118 extending to the right of the anchor 116 and around first and second idler pulleys 119 and 120 suitably mounted to the main rail 60 and then attached to the counterweight 111. The cable 118 extends through the beam 87. To the left of the anchor 116 is a roll chain 121 (which must be added to the drawing) which extends about a driven sprocket 122, an idler sprocket 123 and is attached to the counterweight 111. The driven sprocket 122 is driven through a right-angle gear 125 which, in turn, is energized by a shaft 126 of a motor 127. The motor 127 and right-angle gear 125 are mounted on a plate 130 which is secured to the superstructure.

The other counterweight 110 is similarly attached to the longitudinal frame member 83 of the carriage 20 except that the link joining them is not driven. That is, an anchor 132 is attached to the inner side of the frame member 83, and it secures both ends of a steel cable 134 (which must be added to FIG. 6) which extends around a first pair of idler pulleys 135, 136, is attached to the counterweight 110, and then extends about a second pair of idler pulleys 137, 138.

Thus, as the motor 127 energizes the driven sprocket 122, the carriage 83 will be translated in one direction and the counterweight 111 will be translated in an opposite direction by means of a flexible link 117. At the same time, the motion of the carriage 20 will cause the other counterweight 110 to be translated in the same direction as the counterweight 111. The placement of the counterweights 110, 111 and their weight is such as to counterbalance the weight of the boom 11, carriage 20, etc. relative to the vertical center of the machine.

Turning now to FIG. 6, a first elongated angle iron 140 is mounted to the transverse frame members 63–66 of the superstructure parallel with the main rails 60, 61. Spaced from the guide member 140 is shorter guide member 141 which is secured to the transverse frame members 64 and 66 of the frame of the superstructure. A flexible metallic band 142 is rigidly secured to the guide member 140 as at 143, and it is bent around in the shape of a U to bear against the opposing guide member 141. The distal end of the flexible band 140 is designated by reference numeral 143, it is secured to the carriage 24. The sheet metal 142 thErefore moves with the carriage 24 as it traverses the main rails.

As the carriage moves back and forth, the piece of sheet metal winds and unwinds as guided by the members 140, 141; and any hoses or cables feeding power or materials to the carriage or boom are fed through hoses which are attached to the sheet metal band 142. Motion of the turntable on which the boom is mounted is restricted to one continuous revolution so that no more than one complete twist is ever applied to any of the hoses or cables. In this manner, the length of the hoses or cables remains fixed, and for all positions of the carriage along the main rails, there is no tension induced on the hoses or cables, and these hoses or cables do not interfere with the motions of the undercarriage or superstructure.

Having thus described in detail a preferred embodiment of our system, persons skilled in the art will be able to modify certain portions of the structure which has been illustrated and to substitute equivalent elements for those which have been disclosed; and it is therefore, intended that all such modifications and substitutions be covered as they are embraced within the spirit and scope of the appended claims.

I claim:

1. A system for controlling a boom comprising: an undercarriage including a base adapted to engage and rest on the ground, an upper face, and extendable means supporting said upper frame above said base and for leveling said upper frame relative to a horizontal plane; a superstructure including a frame, a pair of elongated rails on said frame, a plurality of hydraulic jacks on said frame for engaging the ground and assuming equal portions of at least some of the weight of said superstructure; first controllable turntable means mounting said superstructure to said undercarriage, means for adjusting said superstructure in azimuth when said undercarriage is in place; a carriage on said rails of said superstructure; boom means on said carriage and means for moving said carriage along said rails.

2. The system of claim 1 wherein said extendable means of said undercarriage comprises a plurality of first jacking means, each of said first jacking means having a piston rod pivotally connected to one of said base and said frame and a cylinder and pivotally connected to the other of said base and said frame, one of said jacks being controllable to determine the elevation of said upper frame relative to said base of said undercarriage, and the others of said first jacking means being operative to level said frame relative to a horizontal plane.

3. the system of claim 1 wherein each of said rails includes an elongated beam having an inwardly extending flat and wherein said carriage includes means for mounting said carriage on said flats of said rails comprising a plurality of support wheels resting on the upper sides of said flats and a set of pressure wheels mounted beneath said flats and opposing said upper wheels, and means for urging opposing pairs of wheels together to place said flat in compression and thereby preload the mounting of said carriage to inhibit deflection of the same from its predetermined horizontal plane.

4. The system of claim 3 wherein said means for mounting said carriage to said rails further comprises preloaded roller means engaging the lateral portions of said flats to induce compression therein and to preload said carriage against deflection about a vertical axis relative to said rails.

5. The system of claim 1 further comprising counterweight means mounted for movement on said superstructure and connected to said carriage to move in an opposite translatory direction relative to the movement of said carriage along said rail to counterbalance the weight of said carriage and boom relative to the center of said superstructure.

6. The system of claim 5 wherein said counterweight means includes first and second weights, second and third pairs of rails mounted on said superstructure frame on opposite sides of said first-named rails, said first and second weights each including wheels for mounting respectively on said second and third rails for movement therealong in a direction opposite to the direction of translation of said carriage.

7. The system of claim 1 further comprising a flexible piece of sheet metal adapted for flexing in a horizontal plane and means for guiding said sheet metal, one edge of said sheet metal being secured to said superstructure and the other end of said sheet metal being secured to said carriage, whereby flexible cables and the like may be attached to said sheet metal piece in communication from said superstructure to said carriage.

8. A material handling system comprising: articulated boom means; a first turntable for supporting said boom at its base; a carriage having wheels and supporting said first turntable; a superstructure including a pair of elongated rails and outrigger jack means at the corners thereof for assisting in supporting the same, said carriage being mounted on said rails; counterweight means means for balancing the weight of said carriage and boom means by the counterweight means in response to the location of said carriage on said rails; an undercarriage including a ground engaging base ring to increase the tipping circle of said system and leveling means for leveling the same; and a second turntable for mounting said superstructure to said undercarriage for rotation about a vertical axis.

* * * * *