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(54) **Title:** INGROUND LIFT

(57) **Abstract:** A modular inground lift is supported by the lift bay floor. The lift includes self contained modules which have their own power units. A telescoping cylinder and locking leg allow the depth of the lift to be shallower than before. The use of VFD to control the motors allows monitoring of the loads, both during raising and lowering. The modular lift includes integral rebar to provide the structural connection with the lift bay floor.

INGROUND LIFT

Background of the Invention

[0001] This application claims priority from United States Provisional Patent Application Serial No. 60/412,483, filed September 20, 2002, which is incorporated herein by reference. This application hereby incorporates by reference United States Patent Application Serial Number 09/884,673, filed June 19, 2001, titled Removable Cylinder Arrangement For Lift, United States Patent Application Serial No. 10/055,800, filed October 26, 2001, titled Electronically Controlled Vehicle Lift And Vehicle Service System, United States Patent Application Serial Number 10/056,985, filed January 25, 2002, titled System for Detecting Liquid In An Inground Lift, and United States Patent Application Serial Number 10/123,083, filed April 12, 2002, titled Method And Apparatus For Synchronizing A Vehicle Lift, all of which are commonly owned herewith.

[0002] Heavy duty inground lifts are well known in the art. Such lifts typically have at least a pair of spaced apart cylinders located at least partially within a below ground pit. It is also know to have more than two spaced apart jacks in a single bay.

[0003] Depending on the needs, typically one of these jacks is fixed in place and the others are moveable longitudinally, within an elongated pit. The moveable jack is typically carried by a trolley which is supported by spaced apart tracks located slightly below the level of the floor or other surface surrounding the lift. It is known for the lift housing to be made from concrete walls and floor poured in place in a trench, or to be a self contained containment housing which in disposed in a trench. In either case, the tracks are disposed atop the walls in a manner that the force from the load on the jack is transmitted to the housing walls, and through the housing walls to the housing floor, which in turn is supported by the soil and gravel located in the pit. In this configuration, it is the bottom of the pit that provides the support for the jacks to carry the vehicle.

[0004] Single stage cylinders require the lift pit to be dug over ten feet deep. The construction of a concrete pit can take about three months due to the cure time of the concrete and the sequential timing of pouring the pit floor, pit walls and the floor.

Brief Description of the Drawing

[0005] The accompanying drawings incorporated in and forming a part of the specification illustrate several aspects of the present invention, and together with the description serve to explain the principles of the invention. In the drawings:

[0006] FIG. 1 is a perspective, partially cut-away view of a heavy duty inground lift according to teachings of the present invention.

[0007] FIG. 2 is a perspective, exterior view of the inground lift of FIG. 1.

[0008] FIGS. 3A-C and 4A-D illustrate typical equipment foundation requirements.

[0009] FIG. 5 includes a top, side, and end view of the housing, and an enlarged fragmentary view of overlapping sections of the housing of the inground lift of FIG. 1.

[0010] FIG. 6 is a cross-sectional view through the housing of the inground lift of FIG. 1, showing the carriage supported by the side tracks.

[0011] FIG. 7 is a cross-sectional view through a telescoping cylinder of the inground lift of FIG. 1.

[0012] FIG. 8 is a diagrammatic illustration of a hydraulic circuit of the inground lift of FIG. 1.

[0013] FIG. 9 is a perspective view of the telescoping locking leg of the inground lift of FIG. 1.

[0014] FIG. 10 is a perspective view of the telescoping locking leg of FIG. 9.

[0015] FIG. 11 is an enlarged, fragmentary view of the upper locking mechanism illustrated at detail A of FIG. 10.

[0016] FIG. 12 is a top view of the upper locking mechanism of FIGS. 10 and 11.

[0017] FIG. 13 is a fragmentary cross-sectional view of the telescoping locking legs taken along line B-B of FIG. 12.

[0018] FIG. 14 is a perspective view of the control panel of the of the inground lift of FIG. 1.

[0019] FIG. 15 is a perspective view of an alternate control panel of the inground lift of FIG. 1.

[0020] FIG. 16 illustrates rate of adjustment versus the angle of the joystick.

[0021] Reference will now be made in detail to the present preferred embodiment of the invention, an example of which is illustrated in the accompanying drawings.

Detailed Description of the Invention

[0022] Referring now to the drawings in detail, wherein like numerals indicate the same elements throughout the views, FIG. 1 is a perspective, partially cut-away view of a heavy duty inground lift 2 including two modules 4 and 6, each having its own respective power unit (seen only in module 4 as power unit 8). The depicted embodiment has a capacity of 30,000 lbs. Lift 2 includes control panel 10, located in any desired location.

[0023] Modules 4 and 6 includes respective telescoping jacks 12 and 14, the construction and operation of which are substantially the same, although jack 12 is moveable longitudinally within housing 16 while jack 14 is fixed within housing 18. The mechanism of jack 12 that allows longitudinal movement is well known in the art. Jack 12 is carried by carriage or trolley 20, as seen also in FIG. 6, and includes wheels 22 supported by spaced apart tracks 24 and 26. Tracks 24 and 26 are each an inwardly opening channel having a generally "C" shaped cross section, in which the wheels 22 are located. The lower, horizontal legs of tracks 24 and 26 surmount a member having a 90° cross section, with one leg 28 underlying the track and a longer, downwardly depending leg 30 oriented generally vertically. Leg 30 is secured to sidewalls 16a of housing 16.

[0024] Carriage 20 is moved by chains 32 which are ultimately driven by the hydraulic motor and gear reducer assembly 34 located as appropriate, in the depicted embodiment at one end of housing 16. Moving shingles 36 travel with carriage 20, covering the top of housing 16 regardless of the location of jack 12. The horizontal position of jack 12 is monitored by any appropriate device, such as string potentiometer, diagrammatically illustrated as 38, secured at one end to a fixed location.

[0025] In the present invention, all the support for the load carried by jacks 12 and 14 is provided by the lift bay floor 40, rather than by the sidewalls 16a and the bottom of the trench. The present invention includes structure which interacts in conjunction with the lift bay floor 40 to transfer substantially all of the load to the lift bay floor 40. In the depicted embodiment, floor 40 is constructed to have the necessary structural capacity with the necessary underlying supporting layer providing the foundational support.

[0026] Since sidewalls 16a (including the endwalls) do not carry the load from jack 12, they are not vertically load bearing. The sidewalls 16a are thus constructed to resist external side and bottom loads to maintain the integrity of the cavity. A liquid detecting system, as disclosed in United States Patent Application Serial Number 10/056,985 for System for Detecting Liquid In An Inground Lift may be utilized.

[0027] As can be seen in FIGS. 1-6, sidewalls 16a have been strengthened, in the depicted embodiment by the inclusion of a plurality of spaced ribs 42 extending vertically from proximal the bottom 16b to proximal the upper edges of sidewalls 16a. Although the present invention contemplates any side wall configuration adequate to resist the side and bottom loading, the depicted embodiment includes ribs 42 having a tapered section 42a at their respective upper ends, blending back into the generally planar upper edges of sidewalls 16a. In the depicted embodiment, a slit 42b is formed in section 42a to accommodate material movement resulting from the forming process. The number, spacing and location of ribs may vary as appropriate.

[0028] As seen in FIG. 5, in the depicted embodiment: housing 16 also includes an internal frame 16c which provides support to sidewalls 16a. Frame 16c may be located in any desired location to provide such support, including for example, proximal the lower portion of sidewalls 16a.

[0029] Also seen in FIG. 5, in the depicted embodiment: housing 16 is made of sections which overlap vertically, such as shown at 44, which are skip welded. The ends 16d are identical sections, including two 90° corners and "legs" of different length extending therefrom, with side sections welded to each leg. The overall length of housing 16 is selected as desired and the appropriate number of side panels assembled together with the ends 16d.

[0030] A coating is applied to the inside and outside of housings 16 and 18, which comprises a thin (about 1/8 inch) high dielectric material. As will be readily appreciated, the coating resists corrosion of the steel housing 16. The coating is also beneficial in allowing the use of skip welding, sealing the seams in between welds.

[0031] Referring to FIGS. 2-4, as mentioned above, lift 2 includes structure which interact in conjunction with the lift bay floor 40 to transfer substantially all of the load to the lift bay floor 40. In the depicted embodiment, floor 40 is constructed to have the necessary structural capacity with the necessary underlying supporting layer providing the foundational support. In the depicted embodiment, members 46, including reinforcing bars (also known as rebar), extend from the upper portion of the housings.

[0032] The physical characteristics of such members, such as location, size, quantity and orientation, are determined so as to provide the necessary interaction between them and the surrounding lift bay floor 40 to provide the load transfer required. As seen in FIGS. 3A-C and 4A-D, rebar is arranged in a pattern sufficient to provide the necessary structural strength and integrity for lift bay floor 40 to support lift 2 with jacks 12 and 14.

[0033] FIGS. 3A-C and 4A-d illustrate the typical equipment foundation requirements, including the placement of gravel and other typical material. FIGS. 3A-C are an end view, a top view and a side view, respectively, of module 4 installed in trench 122. Bottom of housing 16b is disposed within trench 122 on top of a substrate of pea gravel 124. Discrete material 126, pea gravel in the embodiment depicted, is disposed adjacent the lower portion of sidewalls 16a. Upper surface

128 is surface compacted after module 4 and the pea gravel is in place in the trench 122. Rigid material 130 is disposed overlaying the pea gravel.

[0034] The installation is the same for module 6. FIGS. 4A, C and D are an end view, a top view and a side view, respectively, of module 6 installed in trench 132. Bottom of housing 18b is disposed within trench 132 on top of a substrate of pea gravel 134. Discrete material 136, pea gravel in the embodiment depicted, is disposed adjacent the lower portion of sidewalls 18a. Upper surface 138 is surface compacted after module 6 and the pea gravel is in place in the trench 132. Rigid material 140 is disposed overlaying the pea gravel as seen in FIGS. 4C & D.

[0035] FIG. 4B is an enlarged, fragmentary illustration of members 46, some 46a of which installed at the time of manufacture of module 6, others 46b of which are installed at the time of installation. Ends of some members 46c are disposed (and preferably epoxied) in holes drilled into the edges of a previously poured floor section 142 adjacent the trench into which the lift bay floor will be poured, or extend into the slab reinforcement for the adjacent area of floor to be poured.

[0036] Although rigid insulation is illustrated adjacent the housings 16 and 18, such is not necessarily placed there. The thickness of the surrounding lift bay floor 40 slopes from its nominal thickness to an increased thickness proximal the housings 16 and 18. Although FIGS. 3A-C and 4A, C & D illustrate pea gravel disposed well beyond the sides of the housings 16 & 18, extending beyond the top of the trench in which housings 16 & 18 are disposed, such is not necessarily placed there.

[0037] With such construction, full support of lift 2 and jacks 12 and 14 is provided by the lift bay floor 40. The modules, each being self contained, allows great flexibility in locating and installing the lift.

Since the support is provided by the lift bay floor 40, there is no need to pour a structural concrete floor in the pit bottom for lift support, wait several weeks for it to cure, pour pit walls, wait several weeks for curing, and then pour the lift bay floor also followed several weeks for curing. The present invention allows the inground lift to be installed with a single pour, significantly reducing the installation time. It also makes retrofitting old lifts much easier.

[0038] Returning to FIG. 1, modules 4 and 6 each include a respective power unit, only seen as 8 in FIG. 1 for module 4. In the depicted embodiment, power unit 8 is fixedly mounted, and does not move with jack 12. Power unit 8 includes a motor and hydraulic pump which supplies hydraulic fluid to and from telescoping cylinder 48. Jack 12 includes telescoping locking leg 50, which is connected at the top to saddle 52 which is carried by cylinder 48. Locking leg 50 is designed to hold saddle 52 (and any vehicle thereon) in place in the event of loss of pressure within cylinder 48. Jack 14 has the same cylinder and locking leg construction.

[0039] Referring to FIG. 7, cylinder 48 includes three concentric sections 48a, 48b and 48c. Section 48a includes a flange 48a' which is carried by carriage 20. Upon the application of pressurized hydraulic fluid to the internal cavity 54 of cylinder 48, sections 48b and 48c extend in synchronized motion from section 48a. Synchronized relative movement of all sections of cylinder 48 avoids the bump that typically occurs at the transition between sections when a multiple section cylinder extends one section at a time, and avoids the control difficulties associated therewith, such as stage capacity issues, speed changes, abrupt stops.

[0040] The fluid pressurizes cavities 54, 54a and 54b, which are in communication with each other. Synchronous motion results from fluid located in cavity 48d being forced into internal cavity 56, which is not in fluid communication with cavities 54, 54a and 54b, through passageways 56a. This fluid forces section 48c to extend the same amount in order to maintain internal cavity 56 at a constant volume. Since the annular area of cavity 48d is equal to the annular area of the difference between the outer diameter of section 48c and the inner diameter of section 48c, the linear displacement of sections 48b and 48c are equal. Spring loaded valve 58 includes stem 58a which contacts wall 60 when the sections 48a, 48b and 48c are collapsed within each other, thereby equalizing the pressure between cavities 54, 54a and 54b, and cavity 56.

[0041] FIG. 8 diagrammatically illustrates a hydraulic circuit, generally indicated at 62, of the inground lift 2 of this depicted embodiment. shown in FIG. 1. Motor 64 drives hydraulic pump 66. Pressure relief valve 68 prevents overpressure. When motor 64 is on, rotating to raise jack 12, fluid flows past air pilot operated check valve 70, in the position shown, past velocity fuse 72 (which prevents hydraulic pressure from flowing from cylinder 58 too fast in the event of a leak downstream of fuse 72) and into cavity 54 of cylinder 48, thereby raising it. Each motor/pump is controlled by a respective variable frequency drive (VFD) motor controller to effect raising and lowering of each lift.

[0042] Jack 12 is powered down. Valve 70 is moved to the down position, and motor 64 is energized to run pump 66 in the opposite direction, thereby pulling fluid from cylinder 54. Valve 74 prevents pump 66 from removing the fluid too fast, preventing a vacuum.

[0043] As shown in FIGS. 9-13, each jack includes a respective telescoping locking leg 50, which prevents unintended downward movement of the lift. The telescoping aspect of telescoping locking leg 50 allows an overall shorter length as with telescoping cylinder 48, thereby reducing the depth of the trench that has to be dug for modules 4 and 6.

[0044] Telescoping locking leg 50 is carried by flange 82 extending from the outside of cylinder 48, and includes upper leg 76 which is telescopingly disposed relative to and, in the depicted embodiment, within lower leg 78. Lower locking mechanism 80 is carried by flange 82, and guides lower leg 78 as it moves through the opening (not numbered) as lift 12 is raised and lowered. Lower locking mechanism 80 includes pivoting latch 84 which is normally biased into engagement with a series of vertically aligned windows and steps 86, resembling a ladder, by spring 88. Engagement of latch 84 with any of the steps 86 prevents lift 12 from lowering beyond that step, thereby providing a positive mechanical lock, preventing downward movement of the lift. In order to lower the lift intentionally, latch 84 is held in its disengaged position by actuation of air cylinder 90.

[0045] Upper leg 76 includes a plurality of stop blocks 92 disposed as pairs on opposite sides of upper leg 76. Lower edge 92a of each block 92 is generally flat and perpendicular to the vertical sides of upper leg 76, while upper edge 92b of each block 92 is inclined. Upper end 94 of lower leg 78 includes a flange 96 which upper locking mechanism 98. Upper locking mechanism 98 includes two spaced apart pivotably mounted latches 100 and 102 which are pivotably mounted to flange 96 by pivots 104. Latches are biased toward each other by spring 106 into an engaged or locked position as best seen in FIG. 12. In the engaged position, the edges of latches 100 and 102 are parallel with the corresponding adjacent surface of upper leg 76. As upper leg 76 is extended, upper edges 92b of each pair of blocks will force latches 100 and 102 outwardly as blocks 92 pass. Latches 100 and 102 will return to the engaged position once they reach the lower edges 92a of blocks 92.

[0046] As lift 12 is raised, upper leg 76 will be the first leg to move, traveling upwardly by virtue of being connected to saddle 52. Stops 92 are spaced about 24 inches down from the top of upper leg 76 and the safety stops are not needed before upper leg 76 has extended that far. Once the extension of upper leg 76 has caused latches 100 and 102 to reach the last set of blocks 92, with latches 100 and 102 in the engaged position, upper leg 76 will stop telescoping from lower leg 78 and lower leg 78 will begin extending from lower locking mechanism 80. Upper leg 76 is interconnected to lower leg 78 by rod 108 which allows movement therebetween until upper leg 76 has extended the desired/designed amount. At that point, rod 108 will pull lower leg 78 upward as saddle 52 pulls upper leg 76 upward with it.

[0047] In order to lower the lift intentionally, latches 100 and 102 are held spaced apart, constrained from over travel by stops 110 and 112 by actuation of air cylinder 114, which is pivotably connected to each latch 100 and 102.

[0048] When motor 64 is energized to raise jack 12, the configuration of lower locking mechanism and upper locking mechanism permits the upward movement without applying any pressure, with latch 84 periodically engaging steps 86 and latches 100 and 102 engaging lower blocks 92. When motor 64 is energized to lower jack 12, air cylinders 90 and 114 are energized simultaneously and latches 84, 100 and 102 are held in disengaged positions allowing telescoping locking leg 50 to retract.

[0049] The vertical positions of jacks 12 and 14 are respectively monitored by any appropriate devices, such as string potentiometers (not shown).

[0050] Referring to FIG. 14, there is shown a perspective view of the control panel 10 of lift 2. Control panel 10 includes display 116, joy stick 118, and key pad 120. An alternate control panel is illustrated in FIG. 15.

[0051] In the depicted embodiment, key pad 120 comprises four electric switches or keys generally corresponding to the keys disclosed in

United States Patent Application Serial No. 10/055,800 for Electronically Controlled Vehicle Lift And Vehicle Service System. In the embodiment depicted in this application, the controls disclosed in United States Patent Application Serial No. 10/055,800 and United States Patent Application Serial Number 10/123,083, are used herein, with the appropriate modification to accommodate the operation of the present lift. For example, since the present lift may include an odd number of lifts, synchronization may be done in many different ways, such as controlling two of the lifts relative to one.

[0052] When the control of lift 2 is in the operation mode, rather than an information mode, the lift 2 may be placed in the positioning mode or the lifting mode. In the positioning mode, the joystick is used to place the adapters in contact with the axle or other part of the vehicle being lifted. This involves the horizontal positioning of any horizontally moveable lift, such as jack 12, and the vertical positioning of each jack to the proper vehicle contacting height. After proper positioning, the control is switched to the lifting mode and the vehicle is lifted. In the positioning mode, the control allows selection between horizontal and vertical positioning for any jack which is horizontally moveable, and selection of vertical positioning for any fixed jack.

[0053] In the depicted embodiment, positioning is controlled by the joystick in combination with the key pad for appropriate mode selections. In the two jack configuration depicted, there are three screens: one for vertical positioning of the front, fixed jack, one for vertical positioning of the rear jack, and one for horizontal positioning of the rear jack.

[0054] In the depicted embodiment, to set the position for the rear jack, the control system is scrolled to the appropriate screen, and the joystick is used to make the adjustment. In the horizontal positioning mode, the VFD controls the horizontal positioning motor to move the jack 12 to the desired horizontal position. Using the position sensor, such as the output of the string potentiometer, the control can determine the horizontal position. The control may be programmed with specific horizontal locations for locating the jack, which can remember frequently used horizontal locations such as corresponding to wheelbase dimensions. This may be done, for example, by programming stop points at which the jack is stopped, and following release and reengagement of the deadman joystick, caused to move until the next programmed stop location is reached, going through this process until the desired programmed stop location is attained. With appropriate safety safeguards, the control could drive the lift to a preprogrammed horizontal position rather than stopping at each point. In one embodiment, all programmed stop locations are set to the maximum position, rendering them ineffective.

[0055] Since the control is done through the respective VFD for each module, the current to the motor may be controlled precisely. The control can monitor the current draw and stop the movement in the event that too much current is drawn, such as in an over torque situation if the lift encounters an obstruction or if the lift reaches either end of its horizontal travel and is physically unable to move further. If an over current condition is encountered, the lift control shuts down operation and goes into a troubleshooting mode using screen displays to guide the operator to resolution of the problem.

[0056] Once the jack 12 is in the proper horizontal position, the vertical position of jack 12 is adjusted. The control is toggled to the appropriate mode, and the joystick is used to raise the saddle. The same VFD drives the vertical movement motor and the control torque limits the motor by limiting current to prevent any lifting of the vehicle with just the one lift. This allows the operator to bring the adapters into the proper contact with the axle.

[0057] The other jacks are then adjusted to the appropriate position. In the depicted embodiment, the control is switched to position front jack 14 vertically to bring the adapters into the proper contact with the axle. The torque is limited by limiting the current to prevent any lifting of the vehicle.

[0058] Once the jacks are in proper position, the control is switched to the lifting mode. Since for most vehicles, the axles are not in the same plane, the control establishes an offset for maintaining a level datum referenced to the vehicle, using the position information indicated by each jack's vertical position sensor, in the depicted embodiment a string potentiometer. It is noted that any suitable position sensor or control algorithm to determine position may be used.

[0059] In the lifting mode, each jack may be controlled individually, such as when there is a need to raise one axle relative to the other. The default lifting mode, though, is the raising of all jacks synchronously. In the default "all" mode, the joystick is moved to raise or lower all lifts together. Preprogrammed heights may be provided. In the lift mode, the VFD is not current limited. Although not as accurate as current limited control, each power unit has its own hydraulic relief valve.

[0060] The rate of adjustment made by the joystick varies with the angle of the joystick, as seen in FIG. 16. The rate of adjustment is programmable as desired.

[0061] To lower the lifts, the respective VFDs of each module drives the motors in reverse. In one embodiment, each motor is driven to matching speeds. Other control algorithms may be used. For example, the approximate load could be determined by the current and speed. Different down gains could be used in the control algorithm.

[0062] **UNITED STATES PATENT APPLICATION SERIAL NO. 10/055,800, ELECTRONICALLY CONTROLLED VEHICLE LIFT AND VEHICLE SERVICE SYSTEM**

[0063] This section of this application contains the disclosure from United States Patent Application Serial No. 10/055,800, filed October 26, 2001, titled Electronically Controlled Vehicle Lift And Vehicle Service System, incorporated by reference in the priority document. References in this section to figures 101-114 correspond to figures 1-14 of the 10/055,800 application, respectively. Although the reference numerals in this section which are used to identify items disclosed within figures 101-114 overlap with the reference numerals used earlier in this application with respect to figures 1-16 hereof, the reference numerals used in this section refer to items in figures 101-114.

[0064] The invention of S/N 10/055,800 relates generally to vehicle lifts and their controls, as well as to vehicle service systems having such vehicle lifts and controls. The invention of S/N 10/055,800 is disclosed in conjunction with a unique electronic control which is simple and intuitive to operate, which may be stand alone or networked to other lift controls of the vehicle service system.

[0065] Hydraulic and electro-mechanical (screw) vehicle lifts for raising and lowering vehicles are well known. While the design and configuration of vehicle lifts vary, they all are used primarily for servicing vehicles. They must all have some type of control system to effect the raising and lowering function.

[0066] Prior art control systems for hydraulic lifts typically include an electric switch wired in series with the pump motor for raising the lift and a manually operated lowering valve for lowering the lift. Raising and lowering a vehicle into position requires a series of steps. Raising a vehicle with such a hydraulic lift requires depressing the electric switch to raise the vehicle, followed by operating the lowering valve to lower the lift to the locking mechanism. To lower a vehicle beyond the locking mechanism, such as to the ground, the first step is disengagement of the latches, which may be manually, electrically or pneumatically disengaged. The technician must first raise the lift off of the latches, and then either manually disengage the latches, or operate an electric switch or a pneumatic valve through a lever. The technician next operates the lowering valve while continuously operating the electric switch or pneumatic valve to hold the latches disengaged.

[0067] The vehicle lift and the area close by the lift, within which the technician moves and works on the vehicle is generally called the lift bay or service bay. To use the vehicle lift properly and safely, the technician needs accurate information regarding the safe operation and maintenance of the lift, such as for example vehicle lift points, operating conditions of the lift, maintenance and trouble shooting information. While working on a vehicle, a technician needs immediate access to current and accurate information regarding operating the lift and servicing the vehicle.

[0068] Typically, the information needed by a technician is not available at the lift bay. While the needed information is generally available as manuals or other printed form, such are frequently not kept in the service bay, if kept anywhere at all, and may be outdated. To obtain the information, the technician is thus usually required to leave the bay and locate the information. A technician may be unwilling to leave the bay to locate the information, since this adds another step to the technician's work schedule. A technician works more efficiently if everything needed to work on the vehicle is within the bay. Time spent by a technician away from the bay to obtain information, parts, process paper work, etc. detracts from the efficient performance of service on the vehicle.

[0069] Instruction on proper lift use is important for new technicians or new lifts. In such training situations, instruction may not occur at all if much effort is required to learn or teach the use of the lift or to locate the relevant instructional material. Instruction may be given by other technicians who may themselves not be aware of the proper operation of the lift, relying instead on their own understanding of operating the lift.

[0070] Proper lift maintenance is also important. Routine maintenance needs to be performed to keep a lift operating properly and safely. Although the need for preventative maintenance arises from the usage of the lift, information on preventative maintenance of lifts is not always readily available. Routine maintenance schedules may be kept independent of the lifts, and the technician does not know while he is in the lift bay whether routine maintenance needs to be performed. Maintenance information regarding repair or trouble shooting information is also typically not kept in the lift bay, resulting in limited or inefficient use of such important resource materials.

[0071] Although vehicle lifts define the service bay and are the focal point for servicing a vehicle, vehicle lifts themselves are considered secondary to other equipment used to service a vehicle. The view of the capabilities of a vehicle lift and its control has been limited to the raising and lowering functions, and has not extended to other functions. Thus, vehicle lifts and their controls have not been considered by those skilled in the art for providing access to information needed by the technician, or for collecting and transmitting information relative to operation of the lift of the servicing of the vehicle.

[0072] The inventors of S/N 10/055,800 have recognized that the overlooked vehicle lift and its control can meet the unrecognized needs for electronic delivery of information to and from the lift bay. The advent by the invention of S/N 10/055,800 of providing the ability to access, collect and transmit information by the vehicle lift control in addition to providing the lift functions, creates the new need to be able to revise the new non-lift functions of a lift control completely independent of the lift functions of the lift control. Because vehicle lifts are subject to third party certification, any changes to hardware or software which controls the lift functions, even if the changes only affect the non-lift functions, require recertification.

Brief Description of the Drawings

[0073] The accompanying drawings incorporated in and forming a part of the specification illustrate several aspects of the invention of S/N 10/055,800, and together with the description serve to explain the principles of the invention of S/N 10/055,800. In the drawings:

[0074] Fig. 101 is a perspective view of a two post vehicle lift with control in accordance with the invention of S/N 10/055,800.

[0075] Fig. 102 is a perspective view of a four post vehicle lift with control in accordance with the invention of S/N 10/055,800.

[0076] Fig. 103 is a perspective view of the control assembly of a vehicle lift in accordance with the invention of S/N 10/055,800.

[0077] Fig. 104 is a front view of the control assembly of Fig. 103.

[0078] Fig. 105 is a side view of the control assembly of Fig. 103.

[0079] Fig. 106 is a partially exploded perspective view of the control assembly of Fig. 103.

[0080] Fig. 107 is a partially exploded perspective view of the rear of the enclosure of the control assembly of Fig. 103.

[0081] Fig. 107A is an exploded perspective of the display assembly and computer processor board.

[0082] Fig. 108 is a front view of the back plate of the control assembly of Fig. 103.

[0083] Fig. 109 is a partially exploded perspective view of the control assembly of Fig. 103 illustrating the back plate attached to a vehicle lift post.

[0084] Figs. 110A and 110B are, respectively, front and side views of the back plate of a slave control illustrating an alternate embodiment including a pneumatic quick disconnect and a communications port

[0085] Fig. 111 is a partially exploded perspective view of an alternate embodiment of electrical connections to the control assembly at the back plate.

[0086] Fig. 112 is a schematic diagram of an embodiment of a control in accordance with the invention of S/N 10/055,800.

[0087] Fig. 113 depicts the display screen and key pad of a control in accordance with the invention of S/N 10/055,800.

[0088] Fig. 114 is diagrammatic illustration of a vehicle service system which includes a plurality of vehicle lifts in accordance with the invention of S/N 10/055,800.

[0089] Reference will now be made in detail to the preferred embodiment of the invention of S/N 10/055,800, an example of which is illustrated in the accompanying drawings.

Detailed Description of the Invention of S/N 10/055,800

[0090] Referring now to the drawings in detail, wherein like numerals indicate the same elements throughout the views, Fig. 101 illustrates a perspective view of an asymmetric two post vehicle lift with an overhead cable equalization, generally indicated at 2. Although an asymmetric two post lift is illustrated, the invention of S/N 10/055,800 is not limited to such. Lift 2 includes two spaced apart columns or posts 4 connected at their respective tops by overhead beam 6. Each post 4 carries a respective carriage 7 which is moveable vertically along the respective post 4. Extending from each carriage 7 are two respective arms 8, shown pivoted to positions adjacent each other. In the embodiment depicted, each end 8a of arms 8 include flip up adapter 10 which engages the underside of the vehicle to be lifted. In this embodiment, adapters 10 have three positions which permit quick and easy contact with the pickup points on a variety of vehicles. Arms 8 may have any of a wide range of configurations which engage a vehicle in a variety of ways. Lift 2 includes power unit 12 which functions, in response to the control, to raise and lower arms 8. Power unit 12 can be any convenient power source suitable to raise and lower arms 8. In the embodiment depicted, power unit 12 is attached at the top end of one of posts 4 and includes electric motor 12a which drives hydraulic pump 12b. Hydraulic fluid for the hydraulic circuit is contained in reservoir 12c.

[0091] Although not shown, a spotting dish may be used with lift 2 to locate the vehicle in the appropriate position relative to columns 4.

[0092] On one of posts 4, lift 2 includes control assembly, generally indicated at 16. A slave control assembly 16a may be located on the other post 4, the operation of which will be described below.

[0093] FIG. 102 illustrates a perspective view of a four post vehicle lift, generally indicated at 20. Lift 20 includes four spaced apart columns or posts 22, with control assembly 16 mounted to one of posts 22.

Although not shown, slave control assembly 16a may also be located on one of the other posts 22. Lift 20 includes lifting platform 23 comprising a pair of runways 24, each being carried at both ends by a respective post 22 through a respective yoke 25 which is movable vertically along posts 22. As is well known, the vehicle to be lifted is driven onto runways 24 so that runways 24 engage the vehicle's tires. Lift 20 includes a power unit 26, located at one of the rear posts of lift 20, which functions in response to the control to raise and lower runways 24. Power unit 26 can be any convenient power source suitable to raise and lower runways 24. In the embodiment depicted, power unit 26 includes electric motor 26a which drives hydraulic pump 26b. Hydraulic fluid for the hydraulic circuit is contained in reservoir 26c.

[0094] Although the two lifts depicted in Figs. 101 and 102 illustrate specific configurations of structures which engage the vehicle to be lifted, numerous configurations of structures currently exist and may be developed in the future. As used herein, movable lift engagement structure means those vertically movable parts of a vehicle lift which engage a vehicle in any manner so as to move the vehicle vertically in either direction, and includes, for example, arms 8 and runways 24. Although the two lifts depicted are surface lifts, the use of the control of the invention of S/N 10/055,800 is not limited to surface lifts.

[0095] Before describing control assembly 16 in detail, it is noted that although control assembly 16 is depicted as being attached to a post of a vehicle lift, it may be mounted separate from the lift which it controls, such as on wall or on a separate stand.

[0096] Turning now to FIG. 103, control assembly 16 of the invention of S/N 10/055,800 is illustrated. Control assembly 16 includes enclosure 28 which houses the control itself. Enclosure 28 is made of any suitably material. In the depicted embodiment, enclosure 28 is made of an industrial grade, glass filled polypropylene which has high impact resistance and is resistant to chemicals common to a garage where vehicles are serviced.

[0097] In the embodiment depicted, enclosure 28 includes first recessed area 30 having walls 30a extending inwardly toward a generally flat panel 30b which comprises display screen 32. Alternatively, display screen 32 could be omitted, as for slave control assembly 16a, and flat panel 30b could be formed integrally with enclosure 28 of the same material. Enclosure 28 carries user interface 31 comprising display screen 32 and key pad 34. Display screen 32 is disposed generally vertically at the rear thereof. In the embodiment depicted, display screen 32 is a LCD display, although any suitable display maybe used. By recessing display screen 32, glare is reduced.

[0098] Key pad 34 is disposed in first recessed area 30 below display screen 32. Key pad 34 is depicted as a generally flat panel which is tilted 30^{o} up from horizontal, although any angle convenient to use may be used. Recessing key pad 34 aids in preventing accidental operation. As will be described in more detail below, key pad 34 comprises a keyboard with momentary contact switches underlying a flexible membrane which keeps contamination out of the switches. Any suitable user interface may be used, including for example, a touch screen display which functions as a switch to generate the desired signals upon touching the screen in the appropriate location. As will be described in detail below, in the embodiment depicted, key pad 34 comprises four keys formed as membrane switches. Although four keys are particularly suited for the particular embodiment depicted, it will be appreciated that more or less keys may be used. As used herein, key pad and keyboard include any user input device, including text input, touch screen input, etc.

[0099] Second recessed area 36 is disposed below first recessed area 30 having a generally vertical rear wall 38. Rear wall 38 includes opening 40 shaped complementarily to what ever component is to be disposed therein. In the embodiment depicted in FIG. 103, opening 40 is a rectangle, shaped complementarily to a standard rectangular ground fault circuit interrupt electrical outlet 42. Rear wall may also be formed without an opening.

[00100] Control assembly 16 includes electrical disconnect switch 44 disposed along a side thereof. Switch 44 functions as an on/off switch which can be locked in the off position and as an emergency stop switch. When switch 44 is turned off, there is no power to control assembly 16 beyond switch 44 so that the lift cannot be operated and electrical outlet 42 is not powered. This allows a single lift bay to be shut down, such as for servicing, rather than shutting down any other devices on that same electrical circuit.

[00101] Enclosure 28 includes opening 46 along one side thereof, which permits the necessary electric and pneumatic connections to the interior of enclosure 28. As illustrated below, such electrical and pneumatic connections may be made to control assembly 16 in a variety of ways, some through opening 46 and some not through opening 46. Visible through opening 46 is back plate 48, described below.

[00102] Enclosure 28 includes access panel 50 which snaps into place as shown in access opening 52. Access opening 52 allows access to the fasteners which secure back plate 48 in place. In one embodiment of the present invention, particularly for use with a two post vehicle lift, the locking mechanism is located directly behind access panel 50 to allow access thereto for manual latch disengagement in the event of a power outage. If access through access opening 52 is not necessary, access opening

52 and access panel 50 may be omitted, having in place thereof an integrally formed panel.

[00103] FIG. 104 is a front view and FIG. 105 is a side view of control assembly 16. Electrical and pneumatic lines 56 can be seen in FIG. 105 extending into the interior of enclosure 28 through opening 46.

[00104] FIG. 106 is a partially exploded perspective view of control assembly 16. Back plate 48 is illustrated spaced slightly behind and aligned with enclosure 28. Access panel 50 is shown exploded out from opening 52. Fasteners 60 secure enclosure 28 to back plate 48.

[00105] FIG. 107 is a partially exploded perspective view of the rear of enclosure 28. Mounting holes 62 receive fasteners 60 (FIG. 106) to secure enclosure 28 to back plate 48. Wall 64 physically separates the area which is accessible through access opening 52 from the electrical components which are disposed below wall 64. Assembly 66 is secured to enclosure 28 by fasteners 70.

[00106] Referring also to FIG. 107A, which is an exploded perspective view of assembly 66, assembly 66 includes second computer processor 106, the components which it comprises being carried by a circuit board which is physically separate from the main circuit board which carries first computer processor 104. Assembly also includes display screen 32 and display protective cover 68. Second computer processor 106 is connected to first computer processor 104 (carried by back plate 48, as described below) by cable 72a which is plugged into connector 72. Second computer processor 106 carries removable memory module 106a.

[00107] FIG. 108 is a front view of back plate 48. Back plate 48 includes mounting holes 74 for securing back plate 48 (and control assembly 16) to a lift post or other selected mounting surface. Back plate 48 may be provided with a variety of auxiliary mounting brackets for

attaching various components thereto, not all of which are used for each lift model on which control assembly 16 may be used.

[00108] In the embodiment depicted, back plate 48 carries all major components of the control except for assembly 66 and key pad 34, including carrying main circuit board 76, which carries first computer processor 104, electrical transformer 78, motor contactor 80 and audible signal sounder 82.

[00109] Referring now to FIG. 109, there is shown a partially exploded perspective view of control assembly 16, with back plate 48 mounted to post 4. Trough 98 is shown covering any electrical and pneumatic lines, such as illustrated at 56 in FIG. 106.

[00110] In the particular embodiment depicted in FIG. 109, post 4 carries locking mechanism 86 which is controlled by solenoid 88. Locking mechanism 86 includes pivoting latch 90 which is normally biased into engagement with a series of vertically aligned windows and steps, resembling a ladder, carried by carriage 7 (not shown in FIG. 109). Engagement of latch 90 with any of the steps prevents the moveable lift engagement structure from lowering beyond that step, thereby providing a positive mechanical lock, preventing downward movement of the vehicle. In order to lower the vehicle intentionally, latch 90 is held in its disengaged position by actuation of solenoid 88.

[00111] Solenoid 88 is sufficient for use with two post light duty lifts, with one on each post. Each solenoid must be actuated. However, for other lift applications, such as the two or four post heavy duty lifts, the locking mechanism is actuated pneumatically. Disengagement of the pneumatic locking mechanism is accomplished through actuation of a solenoid operated pneumatic valve (not shown) which is pneumatically connected to each locking mechanism to disengage the latch. The pneumatic solenoid valve may be disposed within enclosure 28, or

elsewhere on the lift, so long as the solenoid is electrically connected to the lift control. If the pneumatic solenoid valve is disposed within enclosure 28, pneumatic connections to connect to the pneumatic source and to connect the pneumatic solenoid valve to the latching/locking mechanisms must be provided. In such case, the pneumatic connections may be located internal or external to enclosure 28, such as extending from a side.

[00112] In case of power failure or other malfunction, in order to lower the vehicle beyond the discrete increments defined by locking mechanism 86, latch 90 must be manually disengaged. In the embodiment depicted in FIG. 108, back plate 48 is oriented such that latch 90 is disposed within access opening 84 (see FIG. 108). This aligns access opening 52 with latch 90, allowing access thereto by removal of access panel 50.

[00113] Figs. 110A and 110B are front and side views of the back plate 48a of a slave control assembly 16a, described in detail below. A slave control assembly uses the same enclosure 28 as master control assembly 16, but lacks most of the electronic components of master control assembly 16 as seen in FIG. 108, having only a key pad (not shown in 110A and 110B) connected by a cable (not shown) to master control assembly 16. A slave control assembly does not have a display screen, having a flat panel in its place in enclosure 28. Figs. 110A and 110B illustrate an embodiment of back plate 48a having pneumatic threaded NPT connector 92 extending through opening 40 in place of electrical outlet 42. A pneumatic source (not shown) is connected to the back side of connector 92 in any suitable manner. Back plate 48a also includes a communications port 94 carried by bracket 96 in place of electrical disconnect switch 44. Communications port 94 can simply be connected to a telephone line or a computer communications network, allowing voice or computer connection therethrough. A

pneumatic connection and a communication port may be placed in almost any position on either control assembly 16 or slave control assembly 16a, in any opening as illustrated in the figures, for example openings 40 or 46, or in openings added to enclosure 28.

[00114] FIG. 111 illustrates another embodiment configuration of electrical connections to control assembly 16. Bundle 98 includes electrical cables as well as a pneumatic tube, which are illustrated running vertically along and over the top of back plate 48. Electric power is provided by cable 99. This configuration can be used when control assembly 16 is mounted to a wall, a wall bracket or a post, such as are typical for use with inground lifts.

[00115] Turning now to FIG. 112, there is shown a schematic of one embodiment of control 100. Components of control 100 which, in this embodiment, are part of the master control panel, schematically indicated as dashed line 102, are housed within enclosure 28 of control assembly 16. Control 100 includes first computer processor 104, carried by first printed circuit board 76 (see FIG. 108), which comprises first control logic which configures first computer processor 104 to selectively control the raising and the lowering of the movable lift engagement structure of the vehicle lift. Control 100 also includes second computer processor 106, in this embodiment carried as part of assembly 66, which comprises second control logic which configures second computer processor 106 to enable display of data and which also comprises maintenance control logic, described in detail below. Control 100 also includes motor contactor 80 and key pad 34. Optionally, slave control panel, generally indicated at 108, may be provided, including second key pad 34a but not including a second display screen.

[00116] Control 100 receives, generates and transmits a variety of condition signals which are indicative of various respective lift conditions related

to the operation of the vehicle lift. As used herein, a signal includes an electric current or electromagnetic field used to convey data or effect an action, including for example, voltage, current, data imposed on a carrier signal and any more advanced signal forms, as well as the simple closing or opening of a switch of an electric circuit.

[00117] As illustrated in FIG. 112, key pad 34 is electrically connected to first computer processor 104 and transmits user input thereto as signals. In response to such transmitted user input, in the operation mode, first computer processor 104 selectively controls the raising and lowering of the moveable lift engagement structure.

[00118] Referring now to FIG. 113, there is shown display screen 32 and key pad 34 in their relative positions as carried by enclosure 28 (shown partially transparent). As mentioned above, the depicted embodiment of key pad 34 comprises four electric switches or keys 110, 112, 114 and 116, in the form of momentary contact switches overlaid by a flexible membrane, which are also known as membrane switches. User input is delivered to key pad 34 by depressing the appropriate key or sequence of keys.

[00119] In the depicted embodiment, each key 110, 112 and 116 performs more than one function. Which function is performed by each key 110, 112 and 116 depends on which mode of operation of control 100 has been selected or enabled by actuation of key 114. Key 114 is functional to cause control 100 to switch between the operating mode and the information mode, as described below in more detail.

[00120] Key 110, which includes up arrow indicia, is functional to cause the moveable lift engagement structure to raise, or to scroll up through a menu displayed on display screen 32 depending on the mode of operation of control 100. While in the operating mode, key 110 is actuated by depressing it, thereby transmitting a signal which enables

the control logic of first computer processor 104 to generate a “raise” control signal in response thereto. The “raise” control signal energizes motor contactor coil 118 which closes the contacts of motor contactor 80, providing power to motor 12a thereby driving pump 12b and raising the moveable lift engagement structure. Vertical position sensors (not shown) could be provided and the user could be allowed to input through a user interface a selected height. Control 100 could then interrupt upward movement of the moveable lift engagement structure once the selected height is reached, despite continued actuation of key 110. It is noted vertical position sensors could also be used as a continuous position feedback system for individual control of the carriage or yoke.

[00121] Once the moveable lift engagement structure has been raised to a desired position, it may be lowered a bit so that latch 90 engages one of a plurality of steps formed between vertically aligned windows (not shown), resembling a ladder, which provides a positive mechanical lock preventing downward movement of the moveable lift engagement structure. Key 116, which includes “lower to lock” and “select” indicia, is functional to cause the moveable lift engagement structure to lower to the locks, or to select a menu option displayed on display screen 32, depending on the mode of control 100. While in the operating mode, actuation of key 116 transmits a signal which enables the control logic of computer processor 104 to generate a lower control signal in response thereto. The lower control signal opens lowering valve 120, which in the depicted embodiment is a solenoid operated valve, allowing the moveable lift engagement structure to lower. Since latch 90 is normally biased toward engagement, the moveable lift engagement structure can travel downwardly a short distance until latch 90 engages the next step.

[00122] Key 112, which includes down arrow indicia, is functional to cause the moveable lift engagement structure to lower, or to scroll down through a menu displayed on display screen 32, depending on the mode of control 100. While in the operating mode, key 112 is actuated by depressing it, thereby transmitting a signal which enables the control logic of first computer processor 104 to generate a signal to disengage latches 90 and to generate a "lower" control signal. In the depicted embodiment, latches 90 are held in a disengaged position by actuation of each respective solenoid 88. Alternatively, as described above, latches 90 may be operated pneumatically and disengaged by actuation of a solenoid valve providing pressure to pneumatic cylinders to hold latches 90 in a disengaged position. With latches 90 in the disengaged position, first computer processor 104 generates a "lower" control signal as described above, opening lowering valve 120, thereby lowering the moveable lift engagement structure.

[00123] It is noted that when the moveable lift engagement structure is to be lowered from a position at which latches 90 are in engagement with a step, the moveable lift engagement structure first needs to be raised to separate latches 90 from the step to relieve the force. In such a situation, the user will first actuate key 110 to raise the moveable lift engagement structure a distance sufficient to relieve the forces, and the actuate key 112 to lower the moveable lift engagement structure as far as desired. Alternatively, control 100 may be configured to do this automatically in response to actuation of key 112 when starting from the "lowered to locks" position.

[00124] Control 100 monitors a variety of lift conditions. As used herein, lift conditions include any condition related to the operation, control or maintenance condition of the lift. Control 100 may monitor some operation conditions through receipt of condition signals from sensors disposed to generate an output signal indicative of the operation

condition associated with that sensor. In the depicted embodiment, optical overhead sensor 122 (see FIG. 101, not seen but generally indicated by arrow, and FIG. 112) is disposed to project a generally horizontal beam across lift 2 just under overhead beam 6, to monitor when the top of the vehicle is proximate overhead beam 6. It is noted that the overhead sensor does not have to be optical. Other sensors 124 and 126 are illustrated in FIG. 112. For lifts which so require, sensor 124 may be a slack cable sensor, to monitor whether lift cables are slack. Also, as may be required for a particular lift, sensor 126 is a toe guard switch, to monitor when carriage 8a is near the floor.

[00125] The number and configuration of such sensors depend on the operation conditions monitored. For example, for inground lifts, a sensor could be provided to monitor the ground water level.

[00126] Other condition signals indicative of operation conditions may be monitored by control 100 without the use of sensors. For example, in the depicted embodiment, control 100 monitors the voltage in each driver circuit for the actuators (in the depicted embodiment, motor contactor coil 118, lowering valve 120, and latching mechanisms 86) as well as regulated and unregulated 24 VDC, and VCC 5 volt input.

[00127] Of course, control 100 may monitor any operation condition. For example, the following may be monitored: vertical position of moveable lift engagement structure, hydraulic and/or pneumatic pressure, force on arms 8, position of arms 8, position of the vehicle, points on the vehicle, out of level conditions, engagement/disengagement of latching mechanism 86, and wear on key components.

[00128] Some operation conditions may be monitored by control 100 only during certain operations, such as monitoring the toe guard sensor only

when the lift is being lowered or the overhead sensor when the lift is being raised.

[00129] Computer processor 104 stores, in a non-volatile memory (such as an EEPROM), certain information regarding historical operation conditions, referred to herein as usage data, which can be used to track the performance of the lift. In the depicted embodiment, usage data stored by computer processor 104 includes the number of times motor contactor coil 118 has been energized (motor starts), the total time motor contactor coil 118 has been energized (motor on time), the number of times lowering valve 120 solenoid has been energized (lowering starts), the total time lowering valve 120 solenoid has been energized (lowering on time), the maximum length of time that lowering valve 120 solenoid has been energized (max lowering on time), the number of times that latch 90 (solenoid 88 or pneumatic valve solenoid) has been energized (latch starts), the total time latch 90 (solenoid 88 or pneumatic valve solenoid) has been energized (latch on time), the maximum length of time that latch 90 (solenoid 88 or pneumatic valve solenoid) has been energized (max latch on time), the number of times that overhead sensor 122 has been tripped (overhead cycles), and the number of times that toe guard sensor 126 has been tripped (lower sensor cycles).

[00130] Monitoring operation conditions involves access to information indicative of the condition being monitored and application of predetermined criteria to that information. Monitoring will result in a defined action if dictated by application of the predetermined criteria. Based on the application of predetermined criteria to the monitored operation conditions, the control logic of computer processor 104 will determine whether an operation fault condition exists, and if so, modify, including inhibit, the operation of the lift from that operation called for by user input, and in certain instances generate an operation

fault indication signal which is transmitted to computer processor 106, which, in the depicted embodiment, enables display of operation fault data, i.e., data indicative of the operation fault condition. Additionally, such predetermined criteria can be applied to usage data.

[00131] Predetermined criteria applied by the control logic of computer processor 104 to operation conditions monitored through sensors, and the resultant actions by control 100 include, but are not limited to:

[00132] 1. If a slack cable sensor is present, any time a slack cable is detected all lift and information display functions of control 100 will be inhibited until the slack cable signal is corrected and audible signal sounder 82 will sound. Computer processor 104 stops transmitting signals to computer processor 106 (such as user input from key pad 34). Computer processor 104 may, however, enable the display of operation default data by computer processor 106 indicative of the slack cable condition.

[00133] 2. If a toe guard switch is present, when the moveable lift engagement structure is being lowered, when the toe guard switch is tripped (indicating the moveable lift engagement structure is proximate the floor, computer processor 104 inhibits further downward movement until key 112 is released and reactuated, after which causes audible signal sounder 82 to beep, as required by certain regulatory bodies. Alternatively, upon tripping of the toe guard switch, computer processor 104 may momentarily pause before continuing the downward movement accompanied by beeps. If the toe guard switch is omitted, beeps may be continuously generated while the lowering valve 120 solenoid is energized

(such as by leaving the board connections for sensor 126 open, simulating a tripped toe guard switch).

[00134] 3. If overhead sensor 122 is tripped and key 110 is actuated, the control logic of computer processor 104 will inhibit further upward movement of the moveable lift engagement structure, and enable the display of operation fault data indicative of the tripped overhead sensor.

[00135] Predetermined criteria applied to operation conditions related to actuators, include, but are not limited to:

[00136] 4. If the motor is supposed to be on, but it is off.

[00137] 5. If the lowering valve is supposed to be open, but it is closed.

[00138] 6. If either of the two latching mechanisms is supposed to be disengaged, but is engaged.

[00139] 7. If the motor is supposed to be off, but it is on.

[00140] 8. If the lowering valve is supposed to be closed, but it is open.

[00141] 9. If either of the two latching mechanisms is supposed to be engaged, but is disengaged.

[00142] For each of the conditions related to the actuators, computer processor 104 will inhibit further movement of the moveable lift engagement structure, will enable the display of operation fault data indicative of the operation fault condition, and will flash LED indicator 128 (see FIG. 108). The display of operation fault data is enabled by a control signal, the operation fault indication signal, from computer processor 104 to computer processor 106, which recalls the associated operation

fault data from the memory module 106a. Actuation of key 112 during the display of operation fault data will enable the display of trouble shooting instructions related to the relevant operation fault condition.

[00143] In monitoring the operation of motor 12c, latches 90 and lowering valve 120, computer processor 104 checks itself for faulty actuator drivers and faulty actuators (in the depicted embodiment, motor contactor coil 118, latch solenoid 88 (or pneumatic valve solenoid), and lowering valve 120 solenoid, although other actuators may be included) by checking the voltage at respective points in voltage divider circuits at each actuator driver output. When an actuator is supposed to be energized, computer processor 104 looks for at least a threshold voltage. If at least the threshold voltage is not present, then either the actuator driver is not delivering the required voltage to the actuator, or the actuator circuit is shorted. To determine whether an actuator is connected, computer processor 104 may also be configured to monitor current at the actuator or actuator driver. Actuator current data could be stored as usage data. When an actuator is not supposed to be energized, computer processor looks for no voltage at the actuator driver.

[00144] At power up, control 100 goes through a series of system checks, based on predetermined criteria, examining the status of all inputs and outputs of control 100 to make sure that they are in the correct state. In the depicted embodiment, this function is performed by computer processor 104. Key pad 34 is checked to make sure no inputs are being generated. More specifically, computer processor 104 checks to see if any of keys 110, 112, 114 or 116 are closed. If second key pad 34a is present, computer processor 104 sees the corresponding keys 110a, 112a and 116a (not identified, but see 34a on FIG. 112) as being in parallel with keys 110, 112 and 116, and are therefore checked at the same time. Key 114a (not identified, but see 34a on FIG. 112), which

corresponds to key 114, is not connected to computer processor 104, preventing changing the mode from slave control assembly 16a. The sensors 122, 124 and 126 are checked to make sure that a fault condition is not being indicated. At the same time, computer processor 104 checks for no voltage at the actuator drivers, indicating that no actuators are engaged.

[00145] During start up, computer processor 104 checks a specific location in its volatile memory to see if a specific key is stored there. If the specific key is stored there, it indicates that the volatile memory has not properly reset, such as might happen with a power glitch. Computer processor 104 terminates start up, inhibits operation of the lift, and enables the display of data indicative of the improper reset by computer processor 106. If the specific key is not stored in the specific volatile memory location, indicating proper reset, computer processor 104 will write the specific key to the volatile memory location.

[00146] After verifying the system status is OK, control 100, which powers up in the operating mode, may be used to control the raising and lowering of the moveable lift engagement structure.

[00147] Additionally, at start up computer processor 106 verifies the presence of an operable memory module 106a. If it is not found, display 32 will so indicate. Control 100 remains in the operating mode, with keys 110, 112 and 116 remaining functional. However, mode key 114 cannot switch modes to the information mode.

[00148] While in the operating mode, upon the transmission of any user input to control 100, such as through key pad 34, which would enable actuation of an actuator, computer processor 104 checks all of the inputs from user interface 31 and all other inputs as at start up to verify that they are in the correct state. Computer processor 104 also energizes all actuator drivers one at a time for a short time, about one

millisecond, long enough for computer 104 to check to make sure that at least the threshold voltage is present in the voltage divider circuits at the actuator driver outputs before proceeding, but not long enough to actuate any of the actuators. When the moveable lift engagement structure is being raised or lowered, if there is any inconsistent user input, such as pressing the up and down keys simultaneously, movement of the moveable lift engagement structure will stop until all user input ceases.

[00149] Control 100, through computer processor 104, periodically monitors the actuator drivers for the correct state. If an actuator is supposed to be energized, computer processor 104 looks for the threshold voltage at that actuator driver. If an actuator is not supposed to be energized, even when another actuator is actuated, computer processor 104 looks for no voltage at that actuator driver.

[00150] The occurrence of operation fault conditions are also communicated to the user independent of whether display screen 32 is operative. To communicate such information, a code of beeps and LED flashes may be used. In the depicted embodiment:

[00151] 1. Fast, short beeps/LED: Improper reset and/or slack cable failure.

[00152] 2. Slow 50% duty cycle beeps/constant on LED: Toe-guard/overhead limit sensor tripped.

[00153] 3. One short beep/LED flash, then pause: Motor is supposed to be off, but it is on.

[00154] 4. Two short beeps/LED flashes, then pause: Lowering valve is supposed to be closed, but it is open.

[00155] 5. Three short beeps/LED flashes, then pause: One of the two latching mechanisms is supposed to be disengaged, but is engaged.

[00156] 6. Four short beeps/LED flashes, then pause: The other of the two latching mechanisms is supposed to be disengaged, but is engaged.

[00157] 7. Five short beeps/LED flashes, then pause: Motor is supposed to be on, but it is off.

[00158] 8. Six short beeps/LED flashes, then pause: Lowering valve is supposed to be open, but it is closed.

[00159] 9. Seven short beeps/LED flashes, then pause: One of the two latching mechanisms is supposed to be engaged, but is disengaged.

[00160] 10. Eight short beeps/LED flashes, then pause: The other of the two latching mechanism is supposed to be engaged, but is disengaged.

[00161] Of course, operation fault conditions may be communicated independent of display screen 32 in other ways, such as a recorded or synthesized voice.

[00162] In the depicted embodiment, all of the functions which control the operation of the lift (which does not include display of data by display screen 32) while control 100 is in the operating mode, are performed by first processor 104 independent of second processor 106. For example, the control logic is resident on first processor 104; sensors which monitor operation conditions are connected to computer processor 104; operation conditions not monitored through sensors are monitored through computer processor 104; the predetermined criteria on which the generation of an operation fault indication signal is based

is resident on first processor 104; operation fault indication signals are generated by computer processor 104; communication of operation fault conditions independent of display screen 32 is done by computer processor 104; computer processor 104 generates the signals which enable second computer processor 106 to enable display of messages corresponding to operation fault conditions on display screen 32; and actuation of audible signal sounder 82 is done by computer processor 104.

[00163] Thus, control 100 is configured so that computer processor 104 controls all lift operations regardless whether computer processor 106 is present or functional. By configuring the lift operation control to be resident in a single computer processor and fully operational to control the lift independent of other processors which provide non-lift operation functions, changes may be made to the non-lift operation functions and any associated processors, programming and hardware without affecting or requiring changes to the lift operation control. Since lifts and controls for lift operation are subject to third party certification, this separation of the functions between lift operation control and non-lift operation functions allows changes to be made to the non-lift operation functions without requiring rectification of the lift operation control.

[00164] As previously mentioned, control 100, and more specifically computer processor 106 in the embodiment, depicted is also configured to enable display of data, in the depicted embodiment, through display screen 32. In this embodiment, control 100 has two modes, the operating mode, as described above, and the information mode. As previously indicated, control 100 powers up in the operating mode. To switch to the information mode, key 114 is actuated thereby transmitting a “mode” signal which enables computer processor 104 to transmit a signal to computer processor 106. In response to the signal from computer

processor 104, computer processor 106 will transmit an appropriate responsive signal to computer processor 104. Upon receipt of the acknowledging responsive signal, computer processor 104 will enter the information mode. The same "handshake" protocol is followed in switching from the information mode to the operating mode.

[00165] While in the information mode, key pad 34 is not functional to control the lift operation, although computer processor 104 continues to monitor the operation conditions as described above. In the information mode, computer processor 104 transmits user input from key pad 34 to computer processor 106 to enable display of data in response thereto.

[00166] As mentioned above, keys 110, 112 and 116 are each configured to perform at least two functions: One set of functions may be performed while in the operating mode and a second set of functions may be performed while in the information mode. While in the information mode, the selection of data to be displayed is menu driven. In the information mode, display screen 32 displays menu options and keys 110 and 112 are used to scroll up or down through the menu. In this mode, key 116 is functional to select the menu option to which the user has scrolled.

[00167] Computer processor 106 is configured to enable display of lift data in response to user input received from key pad 34 via computer processor 104. Lift data as used herein includes any data relevant to the operation or control of the lift. The display of such lift data can include various display techniques to draw attention to or to emphasize desired aspects of the lift data being displayed, such as flashing graphics.

[00168] Lift data includes usage data and operation fault data, as described above. Lift data also includes data which instructs the user in regard to

the lift (instructional data). Instructional data includes information on how to use the lift (use instruction data), on safety practices and warnings relevant to operation of the lift such as displaying safety decal information (safety data), and on how to troubleshoot operation of the lift (troubleshooting data).

[00169] In the depicted embodiment, lift data also includes maintenance data. Maintenance data includes maintenance notice data indicating that a maintenance condition exists and maintenance instruction data which includes information on maintaining the lift.

[00170] As mentioned above, computer processor 106 includes maintenance control logic which is operative to generate a maintenance condition indication signal, based on predetermined criteria, which enables display of maintenance data indicative of the maintenance condition. Maintenance conditions include conditions that call for preventative maintenance and conditions that call for repair maintenance.

[00171] In the depicted embodiment, the predetermined criteria used to base the generation of a maintenance condition indication signal is based on the passage of time: A specific maintenance condition indication signal is generated when the predetermined time period for that specific maintenance condition has passed. The following table provides examples of predetermined time period criteria for the indicated maintenance condition:

Maintenance Condition	**Time period (days)**
Check Cables/Sheaves for Wear	7
Inspect Adapters for Damage	7
Inspect Pads for Damage	7
Inspect Front Wheel Stops	7
Inspect Ramp Chocks	7

Check Locking Latch Operation	7
Clean Slip Plate/Radius Gauge	7
Check Level of Runway	30
Lube Turning Radius Guide	30
Check Equalizer Tension	30
Lubricate Guide Barrel(s)	30
Check All Bolts for Tightness	60
Check Anchor Bolt Tightness	90
Check Power Unit Fluid Level	180

[00172] These time periods are purely illustrative. In this example, reminders for daily maintenance conditions (i.e., maintenance conditions that should be addressed daily) are set at 7 days, rather than daily. The weekly reminder may include an indication that the maintenance needs to be performed daily. Not all of the maintenance conditions listed in this table applies to all lift types. Additionally, different time periods may also apply for different lift types. The user selects the lift type in the information mode, which identifies the predetermined criteria applicable to the particular lift type. Lift type is also relevant to whether the latches 90 are mechanically operated by solenoid 88 or whether a solenoid operated pneumatic valve is used, so the proper actuation voltage is applied by the associated actuator driver.

[00173] As used herein, predetermined criteria, as related to maintenance conditions, includes criteria based on solely on the passage of a period of time, as well as criteria based on varying parameters related to the operation or environment of the lift, such as usage data. Such predetermined criteria includes, for example, algorithms which correlate usage data to the maintenance requirements of the lift as may be empirically developed. Additionally, such predetermined criteria may be based on operation fault data.

[00174] Upon generation of a maintenance condition indication signal, accompanied by display of the maintenance notice data, the user may either actuate the "select" key 116, which will then enable display of maintenance instruction data regarding that maintenance condition, or actuate the mode key 114, which will place control 100 in the operating mode. The maintenance condition may be reset at the appropriate display by input from the user through key pad 34, preferably only after the indicated maintenance has been performed. The maintenance notice data will be displayed once a day, for example in the morning when the lift has been powered up for the day. Each subsequent day after the initial display of the maintenance notice data, if the maintenance condition has not been reset, the display will indict the number of days the maintenance condition has been passed due. Alternatively, display of the maintenance notice data may be scheduled for a particular time of the day, which is particularly beneficial in case control 100 is left on overnight.

[00175] Control 100 includes time management functions. Control 100, through computer processor 106, includes a timer function which displays lapsed time on display screen 32 in all operation modes. The timer may be started and stopped by actuating the appropriate key while in the information mode. Alternatively, the time may be started automatically upon placing a vehicle on the lift and/or raising the lift. Control 100 also includes and displays date and time information, and an alarm which can be set to beep at a preset time on a one time or daily basis.

[00176] In addition to lift data, computer processor 106 is configured to enable display of vehicle lift point data, which is data indicating the location of the proper lift points for a vehicle. In depicted embodiment, vehicle lift point data is available for most vehicles less than twenty years old.

In this embodiment, vehicle lift points are displayed in conjunction with a graphical representation of the vehicle.

[00177] While in the depicted embodiment, selection of vehicle lift point data displayed is done by user input to key pad 34, the display of vehicle lift point may be enabled in other ways. For example, data on the type of vehicle may be scanned, or transmitted by an RF or IR transmitter on the vehicle.

[00178] Control 100 may also be configured to display and receive various other data. Computer processor 106 may be configured to display service data regarding the vehicle. Service data includes any data relevant to performing service on the vehicle, such as instructions on servicing, service bulletins, specifications, time required for defined service, parts list, etc. Service data may include data about the service history of the specific vehicle. Control 100 may be configured to order parts based on input from the user from the facility's parts department, or even order directly from a parts supplier, with an appropriate communications connection, described below. Control 100 may be configured to keep track of the service performed and interface with an invoicing system.

[00179] Control 100 may be configured to receive information identifying the user, such as through key pad 34, through a card reader or any means, and to keep track of the user's time spent on the particular job. Control 100 may further be configured to require input of an authorized user identification before the lift may be operated.

[00180] Lift data is stored in a non-volatile electronic memory. Such electronic memory may be a physical storage device such as a hard drive, tape drive, etc. Such electronic memory may also be a memory module, such as an EEPROM, or the like. In the depicted embodiment, usage data, as well as the predetermined criteria for operation conditions and

lift type information are stored in a non-volatile memory of computer processor 104.

[00181] Instructional data and maintenance data are stored in memory module 106a carried by computer processor 106. The predetermined criteria related to maintenance conditions is also stored in a memory associated with computer processor 106. This allows changes to these data and criteria to be made without affecting any aspect of computer processor 104.

[00182] Any other data displayable by control 100 is also stored in a memory.

[00183] Referring now to FIG. 114, there is diagrammatically shown vehicle service system 200 which includes a plurality of vehicle lifts 202, with each vehicle lift 202 having a moveable lift engagement structure (not shown in FIG. 114) and an associated electronic control 204. Each electronic control 204 includes control logic configured to selectively control the raising and the lowering of the movable lift engagement structure of that vehicle lift, as described above. Each control 204 is connected to computer communication network 206. Also connected to computer communication network 206 is central memory 208 and central computer processor 210. Alternatively, central memory 208 may be connected to network 206 by being connected directly to central computer processor 210.

[00184] The functions performed by computer processor 106 described above are performed for the plurality of lifts by central computer processor 210 and memory 208. User input from the respective user interfaces (not shown in FIG. 114) are transmitted by the respective lift controls 204 over network 206 to central computer processor 210, which responds by transmitting the appropriate data or response to the respective lift control 204. Operation fault indication signals, as described above, are generated as appropriate by the respective lift

controls 204 and transmitted over network 206 to central computer processor 210, enabling display of operation fault data. Central computer processor 210 responds by transmitting the appropriate operation fault data to the respective lift control 204 for display local at the associated vehicle lift 202.

[00185] Operation fault data, instructional data and maintenance data are stored in memory 208, as may be vehicle lift point data. Central computer processor 210 includes the maintenance control logic which, as described above, is operative to generate a maintenance condition indication signal, based on predetermined criteria, which enables display of maintenance data indicative of the maintenance condition. The predetermined criteria related to maintenance conditions is applied by central computer processor 201. For predetermined criteria based on usage data, central computer processor 210 "looks" at the respective usage data collected by the respective control 204. As with computer processor 106 as described above, storing the predetermined criteria in memory 208 provides greater flexibility to revising the criteria. By centralizing the data in memory 208, implementing revisions for all lifts is simpler. For example, revisions could be downloaded from the internet or other external communication.

[00186] Alternatively, central computer processor 210 may be omitted, with memory 208 providing common memory storage of data and maintenance control logic for the second computer processors (corresponding to computer processor 106 as described above) of all lift controls 204. This provides the advantages of a central memory.

[00187] Although as described above, the lift controls 204 networked to vehicle service system 200 all maintain the operation control logic locally (e.g., each has a respective first computer processor corresponding to computer processor 104 as described above), which is preferable, alternatively the operation control logic could be centrally located,

with inputs and outputs being communicated over the network and with the user remaining local at the associated lift. Sensor outputs could be delivered over the network, while actuators could remain driven locally upon appropriate signal from the central computer processor 210.

[00188] Other equipment may be connected to network 206. For example, in addition to lift controls 204, equipment and tools which are suitable for use in servicing a vehicle or with a vehicle service system may be fitted with an electronic control appropriate for that tool and connected to the network.

[00189] Other computer systems could be connected to network 206, or network 206 could be part of or connected to a larger computer communication network to which other computer systems are connected. Such other computer systems could include for example parts ordering system, accounting/billing system, scheduling systems, etc. The network could be connected to other networks, such as the internet, for various reasons, such as to place parts orders or to download service data.

[00190] **UNITED STATES PATENT APPLICATION SERIAL NO. 10/123,083, Method And Apparatus For Synchronizing A Vehicle Lift**

[00191] This section contains the disclosure from United States Patent Application Serial Number 10/123,083, filed April 12, 2002, titled Method And Apparatus For Synchronizing A Vehicle Lift, incorporated by reference in the priority document. References in this section to figures 201-206 correspond to figures 1-6 of the 10/123,083 application, respectively. Although the reference numerals in this section which are used to identify items disclosed within figures 201-206 overlap with the reference numerals used earlier in this application

with respect to figures 1-16 hereof, the reference numerals used in this section refer to items in figures 201-206.

[00192] The invention of S/N 10/123,083 relates generally to vehicle lifts and their controls, and more particularly to a vehicle lift control adapted for maintaining multiple points of a lift system within the same horizontal plane during vertical movement of the lift superstructure by synchronizing the movement thereof. The invention of S/N 10/123,083 is disclosed in conjunction with a hydraulic fluid control system, although equally applicable to an electrically actuated system.

[00193] There are a variety of vehicle lift types which have more than one independent vertically movable superstructure. Examples of such lifts are those commonly referred to as two post and four post lifts. Other examples of such lifts include parallelogram lifts, scissors lifts and portable lifts. The movement of the superstructure may be linear or non-linear, and may have a horizontal motion component in addition to the vertical movement component. As defined by the Automotive Lift Institute ALI ALCTV-1998 standards, the types of vehicle lift superstructures include frame engaging type, axle engaging type, roll on/drive on type and fork type. As used herein, superstructure includes all vehicle lifting interfaces between the lifting apparatus and the vehicle, of any configuration now known or later developed.

[00194] Such lifts include respective actuators for each independently moveable superstructure to effect the vertical movement. Although typically the actuators are hydraulic, electro-mechanical actuators, such as a screw type, are also used.

[00195] Various factors affect the vertical movement of superstructures, such as unequal loading, wear, and inherent differences in the actuators, such as hydraulic components for hydraulically actuated lifts. Differences in the respective vertical positions of the independently

superstructures can pose significant problems. Synchronizing the vertical movement of each superstructure in order to maintain them in the same horizontal plane requires precisely controlling each respective actuator relative to the others to match the vertical movements, despite the differences which exist between each respective actuator.

Brief Description of the Drawing

[00196] The accompanying drawings incorporated in and forming a part of the specification illustrate several aspects of the invention of S/N 10/123,083 , and together with the description serve to explain the principles of the invention of S/N 10/123,083 . In the drawings:

[00197] Fig. 201 is a schematic diagram of an embodiment of a control in accordance with the invention of S/N 10/123,083 , embodied as a hydraulic fluid control system including the controller and hydraulic circuit.

[00198] Fig. 202 is a control diagram showing the complete raise control including the raise circuit and the position synchronization circuit for a pair of superstructures.

[00199] Fig. 203 is a control diagram showing the complete lower control including the lowering circuit and the position synchronization circuit for a pair of vertically superstructures

[00200] Fig. 204 is a control diagram showing the lift position synchronization circuit for two pairs of superstructures.

[00201] Fig. 205 is a control diagram illustrating the generation of movement control signals for raising each superstructure of each of two pairs.

[00202] Fig. 206 is a schematic diagram of another embodiment of a control in accordance with the invention of S/N 10/123,083 showing the

controller and a different hydraulic circuit different from that of Fig. 201.

[00203] Reference will now be made in detail to the present preferred embodiment of the invention of S/N 10/123,083 , an example of which is illustrated in the accompanying drawings.

Detailed Description of the Invention of S/N 10/123,083

[00204] Referring now to the drawings in detail, wherein like numerals indicate the same elements throughout the views, FIG. 201 illustrates a vehicle lift, generally indicated at 2. Lift 2 is illustrated as a two post lift, including a pair of independently moveable actuators 4 and 6 which cause the respective superstructures (not shown) to move. In the depicted embodiment, first and second actuators 4 and 6 are illustrated as respective hydraulic cylinders, although they may be any actuator suitable for the control system. First and second actuators 4 and 6 are in fluid communication with a source of hydraulic fluid 8. Pressurized hydraulic fluid is provided by pump 10 at discharge 10a. Each actuator 4 and 6 has a respective proportional flow control valve 12 and 14 interposed between its actuator and source of hydraulic fluid 8.

[00205] The hydraulic fluid flow is divided at 16, with a portion of the flow going to (from, when lowered) each respective actuator 4 and 6 as controlled by first and second proportional flow control valves 12 and 14. As illustrated, isolation check valve 18 is located in the hydraulic line of either actuator 4 or 6 (shown in FIG. 201 in hydraulic line 20 of actuator 6), between 16 and second flow control valve 14 to prevent potential leakage from either actuator 4 or 6 through the respective flow control valve 12 and 14 from affecting the position of the other actuator.

[00206] Isolation check valve 18 can be eliminated if significant leakage through first and second flow control valves 12 and 14 does not occur.

In the embodiment depicted, equalizing the hydraulic losses between 16 and actuator 4, and 16 and actuator 6, makes it easier to set gain factors (described below). To achieve this, an additional restriction may be included in hydraulic line 20a between 16 and actuator 4 to duplicate the hydraulic loss between 16 and actuator 6, which includes isolation check valve 18. This may be accomplished in many ways, such as through the addition of an orifice (not shown) or another isolation check valve (not shown) between 16 and actuator 4.

[00207] The hydraulic circuit includes lowering control valve 22 which is closed except when the superstructures are being lowered.

[00208] Lift 2 includes position sensors 24 and 26. Each position sensor 24 and 26 is operable to sense the vertical position of the respective superstructure. This may be done by directly sensing the moving component of the actuator, such as in the depicted embodiment a cylinder piston rod, sensing vertical position of the superstructure, or sensing any lift component whose position is related to the position of the superstructure. Recognizing that the position and movement of the superstructures may be determined without direct reference to the superstructures, as used herein, references to the position or movement of a superstructure are also references to the position or movement of any lift component whose position or movement is indicative of the position or movement of a superstructure, including for example the actuators.

[00209] Position sensors 24 and 26 are illustrated as string potentiometers, which generate analog signals that are converted to digital signals for processing. Any position measuring sensor having adequate resolution may be used in the teachings of the invention of S/N 10/123,083 , including by way of non-limiting examples, optical encoders, LVDT, displacement laser, photo sensor, sonar displacement, radar, etc. Additionally, position may be sensed by other methods, such as by

integrating velocity over time. As used herein, position sensor includes any structure or algorithm capable of generating a signal indicative of position.

[00210] Lift 2 includes controller 28 which includes an interface configured to receive position signals from position sensors 24 and 26, and to generate movement control signals to control the movement of the superstructures. Movement control signals control the movement of the superstructures by controlling or directing the operation, directly or indirectly, of the lift components (in the depicted embodiment, the actuators) which effect the movement of the superstructure. Controller 28 is connected to first and second flow control valves 12 and 14, isolation check valve 18, lowering valve 22 and pump motor 30, and includes the appropriate drivers on driver board 32 to actuate them. Controller 28 is illustrated as receiving input from other lift sensors (as detailed in copending application serial no. 10/055,800), controlling the entire lift operation. It is noted that controller 28 may be a stand alone controller (separate from the lift controller which controls the other lift functions) dedicated only to controlling the movement of the superstructures in response to a command from a lift controller.

[00211] In the depicted embodiment, controller 28 includes a computer processor which is configured to execute the software implemented control algorithms every 10 milliseconds. Controller 28 generates movement control signals which control the operation of first and second flow control valves 12 and 14 to allow the required flow volume to the respective actuators 4 and 6 to synchronize the vertical actuation of the pair of superstructures.

[00212] FIG. 202 is a control diagram showing the complete raise control, generally indicated at 34, including raise circuit 36 and position synchronization circuit 38 for the pair of superstructures. When the lift is instructed to raise the superstructures, complete raise control 34

effects the controlled, synchronized movement of the superstructures based on input from position sensors 24, 26. Raise circuit 36 is a feed back control loop which is configured to command the pair of superstructures to an upward vertical trajectory. Raise circuit 36 compares the desired position of the superstructures indicated by vertical trajectory signal 40 (xd) to the actual positions indicated respectively by position signals 42 and 44 (x1 and x2) generated by position sensors 24, 26. The respective differences between each set of two signals, representing the error between the desired position and the actual position, is multiplied by a raise gain factor Kp, to generate first raise signal 46 for the first superstructure and second raise signal 48 for the second superstructure, respectively. Although in the depicted embodiment, Kp was the same for each superstructure, alternatively Kp could be unique for each.

[00213] In the embodiment depicted, vertical trajectory signal 40 is a linear function of time, wherein the desired position xd is incremented a predetermined distance for each predetermined time interval. It is noted that the vertical trajectory may be any suitable trajectory establishing the desired position of the superstructures (directly or indirectly) based on any relevant criteria. By way of non-limiting example, it may be linear or non-linear, it may be based on prior movement or position, or the passage of time. Alternatively, first and second raise signals 46 and 48 could be fixed signals, independent of the positions of the superstructures.

[00214] The vertical trajectory signal resets when the lift is stopped and restarted. Thus, if the upward motion of the lift is stopped at a time when the actual position of the lift lags behind the desired position as defined by the vertical trajectory signal 40, upon restarting the upward motion, the vertical trajectory signal 40 starts from the actual position of the superstructures.

[00215] There are various ways to establish the starting position from which the vertical trajectory signal is initiated. In the depicted embodiment, one of the posts is considered a master and the other is considered slave. When the lift is instructed to raise, the actual position of the superstructures of the master post is used as the starting position from which the vertical trajectory signal starts. Of course, there are other ways in which to establish the starting position of the vertical trajectory signal, such as the average of the actual positions of the two posts.

[00216] In the embodiment depicted, vertical trajectory signal 40 is generated by controller 28. Alternatively vertical trajectory signal 40 could be received as an input to controller 28, being generated elsewhere.

[00217] Position synchronization circuit 38, a differential feedback control loop, is configured to synchronize the vertical actuation/movement of the pair of superstructures during raising. In the depicted embodiment, position synchronization circuit 38 is a cross coupled proportional-integral controller which generates a single proportional-integral error signal relative to the respective vertical positions of the superstructures. As shown, position synchronization circuit 38 includes proportional control 38a and integral control 38b, both of which start with the error between the two positions, x1 and x2, indicated by 50. Output 52 of proportional control 38a is the error 50 multiplied by a raise gain factor Kpc1. Output 54 of integral control 38b is the error 50 multiplied by a raise gain factor Kic1, summed with the integral output 54a of integral control 38b from the preceding execution of integral control 38b. Output 52 and output 54 are summed to generate proportional-integral error signal 56.

[00218] Controller 28, in response to first raise signal 46 and proportional-integral error signal 56, generates a first movement control signal 58 for the first superstructure. In the depicted

embodiment, first movement control signal 58 is generated by subtracting proportional-integral error signal 56 from first raise signal 46. First movement control signal 58 controls, in this embodiment, first flow control valve 12 so as to effect the volume of fluid flowing to and therefore the operation of first actuator 4 and, concomitantly, the first superstructure.

[00219] Controller 28, in response to second raise signal 48 and proportional-integral error signal 56, generates a second movement control signal 60 for the second superstructure. In the depicted embodiment, second movement control signal 60 is generated by adding proportional-integral error signal 56 to second raise signal 48. Second movement control signal 60 controls, in this embodiment, second flow control valve 14 so as to effect the volume of fluid flowing to and therefore the operation of second actuator 6 and, concomitantly, the second superstructure.

[00220] FIG. 203 is a control diagram showing the complete lower control, generally indicated at 62, including lowering circuit 64, and position synchronization circuit 66, a differential feedback control loop, for the pair of superstructures. When the lift is instructed to lower the superstructures, complete lower control 62 effects the controlled movement of the superstructures.

[00221] Lowering circuit 64 is configured to generate first lowering signal 68 for the first superstructure and to generate second lowering signal 70 for the second superstructure. In the depicted embodiment, lowering signals are constant, not varying in dependence with the positions of the superstructures or time. Although in the depicted embodiment, lowering signals 68 and 70 are equal, they could be unique for each superstructure. Lowering signals 68 and 70 may alternatively be respectively generated in response to the positions of the

superstructures, such as based on the differences between a vertical trajectory and the actual positions.

[00222] Position synchronization circuit 66 is similar to position synchronization circuit 38. Position synchronization circuit 66 is configured to synchronize the vertical actuation/movement of the pair of superstructures during lowering. In the depicted embodiment, position synchronization circuit 66 is a cross coupled proportional-integral controller which generates a single proportional-integral error signal relative to the respective vertical positions of the superstructures. As shown, position synchronization circuit 66 includes proportional control 66a and integral control 66b, both of which start with the error between the two positions, x1 and x2, indicated by 72. Output 74 of proportional control 66a is the error 72 multiplied by a lowering gain factor Kpc2. Output 76 of integral control 66b is the error 72 multiplied by a lowering gain factor Kic2, summed with the integral output 76a of integral control 66b from the preceding execution of integral control 66b. Output 74 and output 76 are summed to generate proportional-integral error signal 78.

[00223] Controller 28, in response to first lowering signal 68 and proportional-integral error signal 78, generates a first movement control signal 80 for the first superstructure. In the depicted embodiment, first movement control signal 80 is generated by adding proportional-integral error signal 78 to first lowering signal 68. First movement control signal 80 controls, in this embodiment, first flow control valve 12 so as to effect the volume of fluid flowing from and therefore the operation of first actuator 4 and, concomitantly, the first superstructure.

[00224] Controller 28, in response to second lowering signal 70 and proportional-integral error signal 78, generates a second movement control signal 82 for the second superstructure. In the depicted

embodiment, second movement control signal 82 is generated by subtracting proportional-integral error signal 78 from second lowering signal 70. Second movement control signal 82 controls, in this embodiment, second flow control valve 14 so as to effect the volume of fluid flowing from and therefore the operation of second actuator 6 and, concomitantly, the second superstructure.

[00225] The invention of S/N 10/123,083 is also applicable to lifts having more than one pair of superstructures. For example, the invention of S/N 10/123,083 may be used on a four post lift which has two pairs of superstructures, each pair comprising a left and right side of a respective end of the lift or each pair comprising the left side and the right side of the lift. The invention of S/N 10/123,083 may used with an odd number of superstructures, such as by treating one of the superstructures as being a pair "locked" together. More than two pairs may be used, with one of the pairs being the control or target pair.

[00226] For a four post lift, the controller includes an interface configured to receive first and second position signals of the first pair, and to receive third and fourth positions signals of the second pair. The complete up control and complete down control as described above are used for each pair (first and second superstructures; third and fourth superstructures). The respective gain factors between the pairs, or between any superstructures, may be different. Differences in the hydraulic circuits (such as due to different hydraulic hose lengths) can result in the need or use of different gain factors.

[00227] The controller is further configured to synchronize the first and second pairs relative to each other through a lift position synchronization control which in the depicted embodiment reduces the difference between the average of the positions of the first pair and the mean of the positions of the second pair.

[00228] FIG. 204 is a control diagram showing the lift position synchronization circuit, a differential feedback control loop, generally indicated at 84, for synchronizing the two pairs during raising. As shown, lift position synchronization circuit 84 includes proportional control 84a and integral control 84b, both of which start with the error, indicated by 86, between the first pair and the second pair by subtracting the positions of the second pair, x3 and x4, from the positions of the first pair, x1 and x2. Output 88 of proportional control 84a is the error 86 multiplied by a raise gain factor Kpcc. Output 90 of integral control 84b is the error 86 multiplied by a raise gain factor Kicc, summed with the integral output 90a integral control 84b from the preceding execution of integral control 84b. Output 88 and output 90 are summed to generate lift proportional-integral error signal 92.

[00229] FIG. 205 is a control diagram illustrating the generation of movement control signals for raising each superstructure of each of the two pairs. The controller, in response to first raise signal 94, first pair proportional-integral error signal 96 and lift proportional-integral error signal 92, generates a first movement control signal 98 for the first superstructure. In the depicted embodiment, first movement control signal 98 is generated by subtracting lift proportional-integral error signal 92 and first pair proportional-integral error signal 96 from first raise signal 94. First movement control signal 98 controls, in this embodiment, first flow control valve 12 so as to effect the volume of fluid flowing to and therefore the operation of first actuator 4 and, concomitantly, the first superstructure.

[00230] The controller, in response to second raise signal 100, first pair proportional-integral error signal 96 and lift proportional-integral error signal 92, generates a second movement control signal 102 for the second superstructure. In the depicted embodiment, second movement control signal 102 is generated by adding subtracting lift

proportional-integral error signal 92 from the sum of first pair proportional-integral error signal 96 and first raise signal 100. Second movement control signal 102 controls, in this embodiment, second flow control valve 14 so as to effect the volume of fluid flowing to and therefore the operation of second actuator 6 and, concomitantly, the second superstructure.

[00231] Still referring to FIG. 205, the controller, in response to third raise signal 104, second pair proportional-integral error signal 106 and lift proportional-integral error signal 92, generates a third movement control signal 108 for the third superstructure. In the depicted embodiment, third movement control signal 108 is generated by subtracting second pair proportional-integral error signal 106 from the sum of lift proportional-integral error signal 92 and third raise signal 104. Third movement control signal 108 controls, in this embodiment, third flow control valve 110 so as to effect the volume of fluid flowing to and therefore the operation of the third actuator (not shown) and, concomitantly, the third superstructure.

[00232] The controller, in response to fourth raise signal 112, second pair proportional-integral error signal 106 lift proportional-integral error signal 92, generates a fourth movement control signal 114 for the fourth superstructure. In the depicted embodiment, fourth movement control signal 114 is generated by summing fourth raise signal 112, second pair proportional-integral error signal 106 and lift proportional-integral error signal 92. Fourth movement control signal 114 controls, in this embodiment, fourth flow control valve 116 so as to effect the volume of fluid flowing to and therefore the operation of the fourth actuator (not shown) and, concomitantly, the fourth superstructure.

[00233] During lowering, the controller executes the lift position synchronization algorithm as shown in FIG. 204, except that the

lowering gain factors are not necessarily the same as the raise gain factors. In the depicted embodiment, the lowering gain factors were different from the raise gain factors. During lowering, in the depicted embodiment, the arithmetic operations are reversed for the lift proportional-integral error signal: The lift proportional-integral error signal is added to generate the first and second movement signals (instead of subtracted as shown in FIG. 205) and subtracted to generate the third and fourth movement signals (instead of added as shown in FIG. 205).

[00234] The gain factors described above may be set using any appropriate method, such as the well known Zigler-Nichols tuning methods, or empirically. In determining the gain factors empirically, the integral control was disabled and multiple cycles of different loads were raised and lowered to find the optimum gain factor for the proportional control. The integral control was then enabled and those gain factors determined through multiple cycles of different loads.

[00235] The following table sets forth two examples of the gain factors and up rate:

	Example 1	Example 2
Kp	1.0	6.0
Kpc1	0.5	6.0
Kic1	0.15	0.3
Kpc2	1.5	6.0
Kic2	0.25	0.25
Xdown1	65	50
Xdown2	175	175

up rate	2.0 in/sec	1.8 in/sec

It is noted, as seen above, that gain factors may be 1.

[00236] The controller preferably includes a calibration algorithm for the position sensors. In the depicted embodiment, whenever the lift is being commanded to move when it is near either end of its range of travel and the position sensors do not indicate movement for a predetermined period of time, the calibration algorithm is executed. In such a situation, it is assumed that the lift is at the end of its range of travel. The algorithm correlates the position sensor output as corresponding to the maximum or minimum position of the lift, as appropriate. The inclusion of a calibration algorithm allows a range of position sensor locations, reducing the manufacturing cost.

[00237] The invention of S/N 10/123,083 may be used with a variety of actuators and hydraulic circuits. FIG. 206 illustrates an alternate embodiment of the hydraulic circuit. In this vehicle lift, generally indicated at 118, the difference in comparison to FIG. 201 lies in that control of the flow of hydraulic fluid to actuators 4 and 6 is accomplished through the use of individual motors 120 and 128 and pumps 122 and 130 for each superstructure, with each motor/pump being controlled by a respective variable frequency drive (VFD) motor controller 124 and 132 to effect raising the lift and through the use of respective proportioning flow control valves 126 and 134 to effect lowering the lift. Alternatively, individual motors 120, 128 could drive a screw type actuator.

[00238] As illustrated, each motor/pump 120/122 and 128/130 has a respective associated source of hydraulic fluid 136 and 138, although a single source could be associated with both motors and pumps. Each pump

122 and 130 has a respective discharge 122a and 130a which is in fluid communication with its respective actuator 4 and 6.

[0100] Controller 140 includes the appropriate drivers for the VFD motor controllers 124 and 132, and executes the control algorithms as described above to synchronize the vertical actuation of the superstructures. By varying the speed of the respective motors 120 and 132, the hydraulic fluid flow rate to the respective actuators 4 and 6 varies for raising.

[00239] **END OF SECTIONS ON OTHER APPLICATIONS**

[00240] In summary, numerous benefits have been described which result from employing the concepts of the invention. The foregoing description of a preferred embodiment of the invention has been presented for purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed. Obvious modifications or variations are possible in light of the above teachings. The embodiment was chosen and described in order to best illustrate the principles of the invention and its practical application to thereby enable one of ordinary skill in the art to best utilize the invention in various embodiments and with various modifications as are suited to the particular use contemplated. It is intended that the scope of the invention be defined by the claims appended hereto.

What is claimed is:

1. An inground lift for use in a lift bay having a lift bay floor, said lift comprising:

   a. at least one vertically moveable jack having a distal end configured to engage a vehicle; and

   b. structure configured to interact with said lift bay floor to transfer substantially all load placed on said distal end of said jack to said lift bay floor.

2. The lift of claim 1, wherein at least one of said at least one jack is horizontally moveable.

3. The lift of claim 2, comprising a sensor for sensing respective horizontal positions of each of said at least one horizontally moveable jack.

4. The lift of claim 2, comprising a mechanism configured to move said at least one horizontally moveable jack horizontally.

5. The lift of claim 4, wherein said mechanism is supported by said structure.

6. The lift of claim 5, wherein said mechanism comprises a horizontally moveable carriage supported by a track.

7. The lift of claim 1, wherein said structure comprises a plurality of laterally extending members.

8. The lift of claim 7, wherein said laterally extending members are arranged in a pattern configured to provide necessary structural strength for said lift bay floor to support said at least one jack.

9. The lift of claim 7, wherein a plurality of said laterally extending members comprise a "V" shape.

10. The lift of claim 7, wherein a plurality of said laterally extending members comprise a "U" shape.

11. The lift of claim 10, wherein said "U" shape opens laterally outward.

12. The lift of claim 10, wherein said "U" shape opens upwardly.

13. The lift of claim 10, wherein said "U" shape comprises first and second spaced apart members, said first member being shorter than said second member.

14. The lift of claim 1, wherein said at least one vertically moveable jack comprises a telescoping cylinder.

15. The lift of any of the preceding claims, wherein said at least one vertically moveable jack comprises at least two vertically moveable jacks.

16. The lift of claim 15, wherein at least two of said at least two vertically moveable jacks are disposed in a single housing.

17. The lift of claim 16, wherein each of said vertically moveable jacks which are disposed in a single housing are horizontally moveable.

18. The lift of claim 15, wherein at least one of said at least two vertically moveable jacks is disposed in a housing separate from any other of said at least two vertically moveable jacks.

19. A lift bay comprising:

a. a lift bay floor;

b. an inground lift comprising

i. at least one vertically moveable jack, a distal end of said jack configured to engage a vehicle; and

ii. structure configured to interact with said lift bay floor to transfer substantially all load placed on said distal end of said jack to said lift bay floor;

c. a supporting layer underlying said lift bay floor configured to provide support to said lift bay floor sufficient for said lift bay floor carry the load which is transferred to said lift bay floor by said structure; and

d. said lift bay floor configured to have sufficient structural capacity to carry said load when supported by said supporting layer.

20. The lift bay of claim 19, wherein said lift bay floor has a nominal thickness distal from said inground lift, said lift bay floor having an increased thickness proximal said inground lift.

21. The lift bay of claim 20, wherein the thickness of said lift bay floor slopes from said nominal thickness to said increased thickness.

22. The lift bay of claim 29, wherein said supporting layer comprises rigid material adjacent said inground lift.

23. The lift bay of claim 22, wherein said supporting layer comprises pea gravel disposed adjacent said inground lift, underlying said rigid material.

24. A method of constructing a lift bay, said lift bay having a lift bay floor when said lift bay is fully constructed, said method comprising:

a. forming a trench;

b. providing at least one inground lift comprising at least one vertically moveable jack having a distal end, a housing having a lower end and sides, and structure configured to interact with said lift bay floor to transfer substantially all load placed on said distal end of said jack to said lift bay floor;

c. disposing said lower end on top of a first substrate within said trench;

d. disposing discrete material adjacent a lower portion of said sides; and

e. pouring said lift bay floor, said structure being embedded in said lift bay floor.

25. The method of claim 24, wherein said first substrate is pea gravel.

26. The method of claim 24, wherein said discrete material is pea gravel.

27. The method of claim 24, wherein the step of pouring said lift bay floor comprises pouring said lift bay floor as a substantially single pour.

28. The method of claim 24, comprising the step of disposing rigid material adjacent said at least one inground lift.

29. The method of claim 28, wherein said rigid material is disposed overlying said pea gravel.

30. The method of claim 24, wherein said pea gravel adjacent said sides includes an upper surface, and comprising the step of compacting the upper surface.

31. A method of constructing a lift bay, said lift bay having a lift bay floor when said lift bay is fully constructed, said method comprising:

a. forming a trench;

b. providing at least one inground lift comprising at least one vertically moveable jack having a distal end, and structure configured to interact with said lift bay floor to transfer substantially all load placed on said distal end of said jack to said lift bay floor;

c. disposing said inground lift within said trench; and

d. pouring said lift bay floor as a substantially single pour, said structure being embedded in said lift bay floor.

32. The method of claim 31, comprising the step of providing a supporting layer underlying said lift bay floor.

33. The method of claim 32, wherein the step of providing a supporting layer includes disposing rigid material adjacent said at least one inground lift, underlying said lift bay floor.

34. The method of claim 33, wherein the step of providing a supporting layer includes disposing pea gravel underlying said rigid material.

35. A method of supporting an inground lift in a lift bay, comprising the steps of:

a. providing

i. at least one vertically moveable jack having a distal end configured to engage a vehicle and having structure configured to interact with a lift bay floor to transfer substantially all load placed on said distal end of said jack to said lift bay floor; and

ii. a lift bay floor; and

b. interacting said structure with said lift bay floor such that substantially all load placed on said distal end of said jack is transferred to said lift bay floor.

36. An inground lift for use in a lift bay having a lift bay floor, said lift comprising first and second self contained lift modules, each lift module comprising at least one respective vertically moveable jack, means for vertically moving said jack, and a housing.

37. The lift of claim 36, further comprising a control panel configured to receive operator inputs to selectively control movement of said jacks, said control panel being separate from said modules.

38. The lift of claim 36, wherein at least one of said at least one jack of said first lift module is horizontally moveable, said first lift module comprising means for moving said jack horizontally.

39. An inground lift comprising:

   a. at least one vertically and horizontally moveable jack having a distal end configured to engage a vehicle;

   b. an electronic control configured to selectively control vertically and horizontal movement of said at least one vertically and horizontally moveable jack based upon user input, said control being selectable between a positioning mode in which user input directs the horizontal movement of said at least one vertically and horizontally moveable jack and a lifting mode in which user input directs the vertical movement of said at least one vertically and horizontally moveable jack.

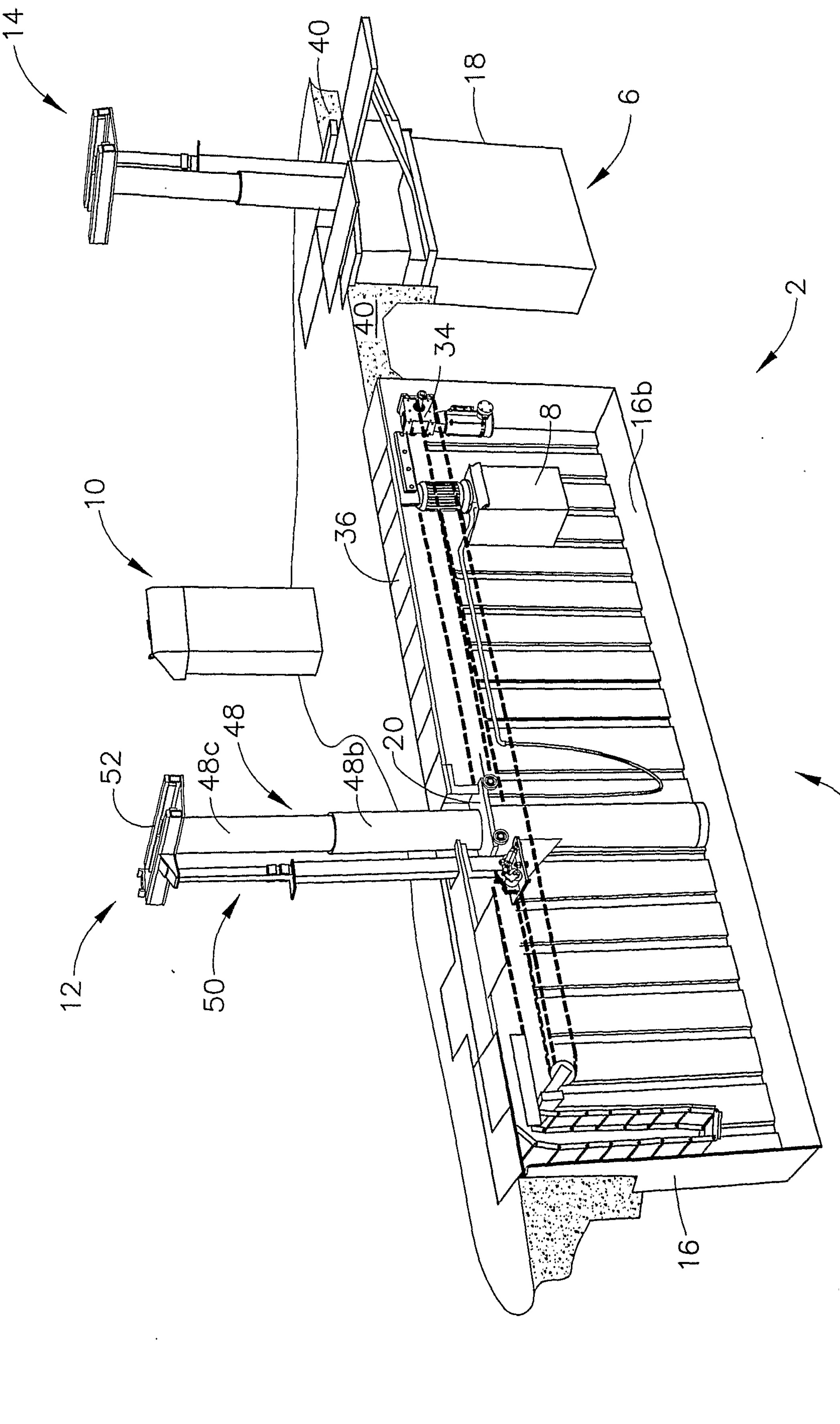


FIG. 1

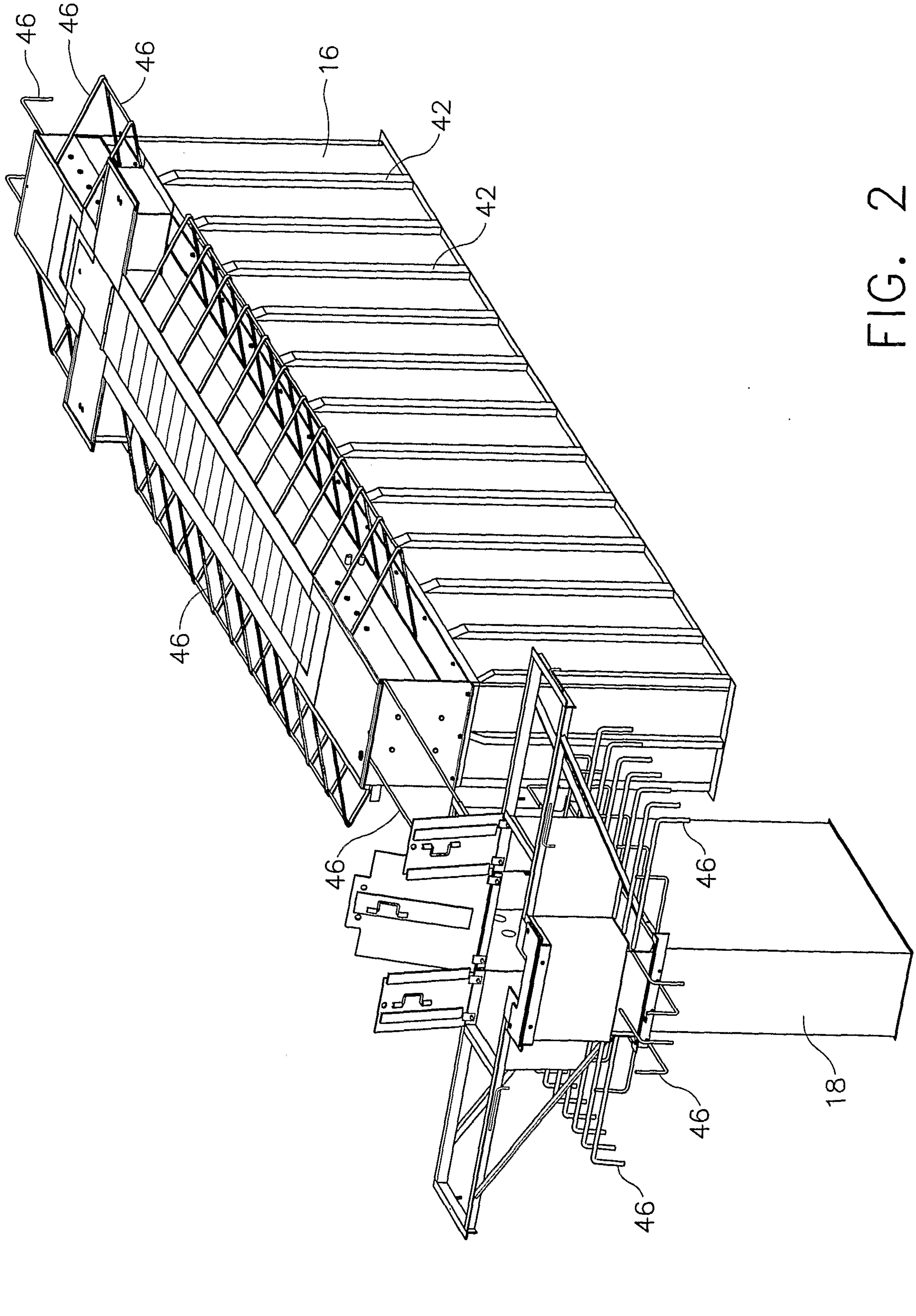


FIG. 2

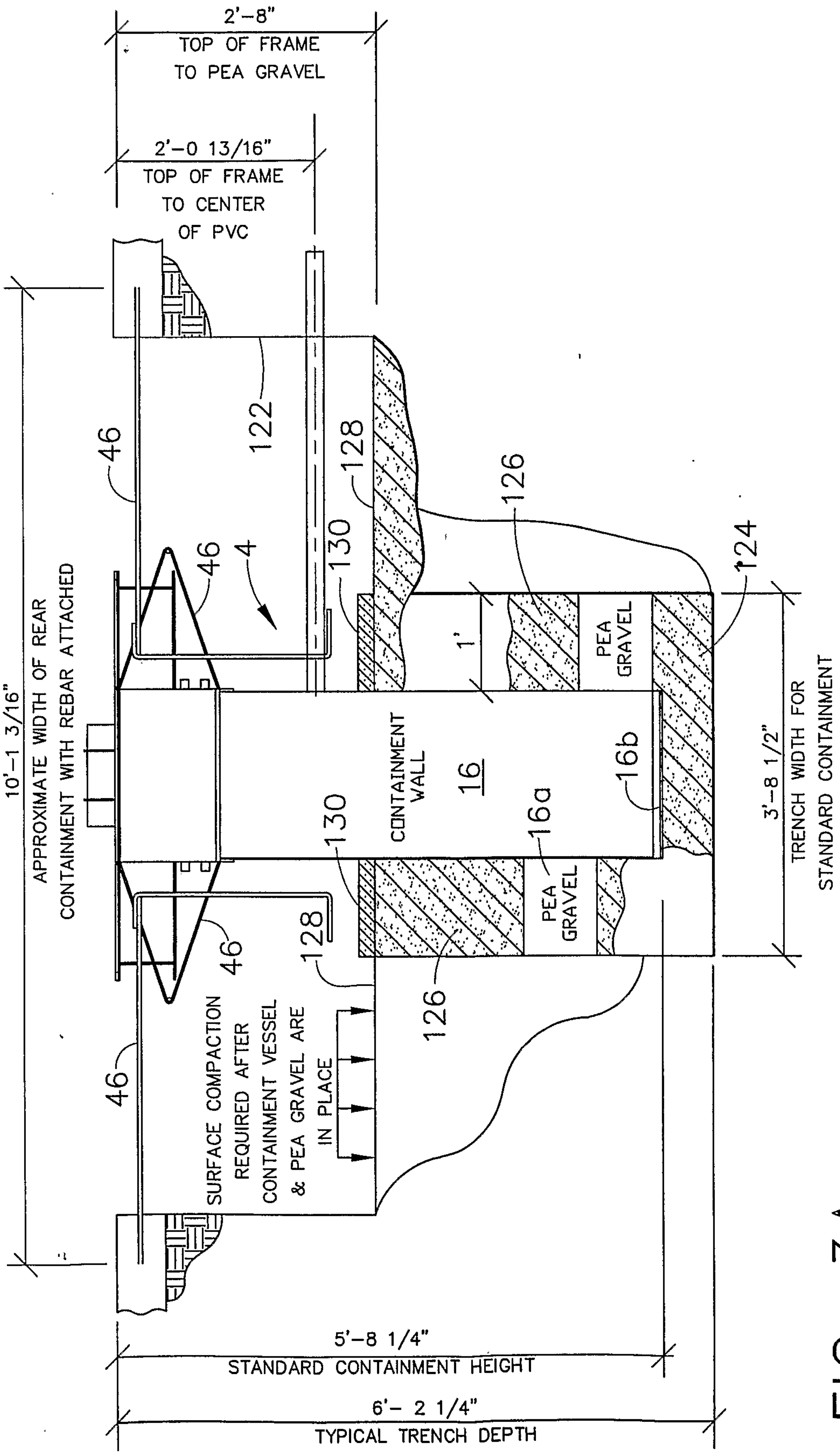

2'-8"
TOP OF FRAME
TO PEA GRAVEL
2'-0 13/16"
TOP OF FRAME
TO CENTER
OF PVC
10'-1 3/16"
APPROXIMATE WIDTH OF REAR
CONTAINMENT WITH REBAR ATTACHED
46
122
128
126
130
4
124
1'
PEA
GRAVEL
CONTAINMENT
WALL
16
16a
16b
3'-8 1/2"
TRENCH WIDTH FOR
STANDARD CONTAINMENT
SURFACE COMPACTION
REQUIRED AFTER
CONTAINMENT VESSEL
& PEA GRAVEL ARE
IN PLACE
5'-8 1/4"
STANDARD CONTAINMENT HEIGHT
6'- 2 1/4"
TYPICAL TRENCH DEPTH

FIG. 3A

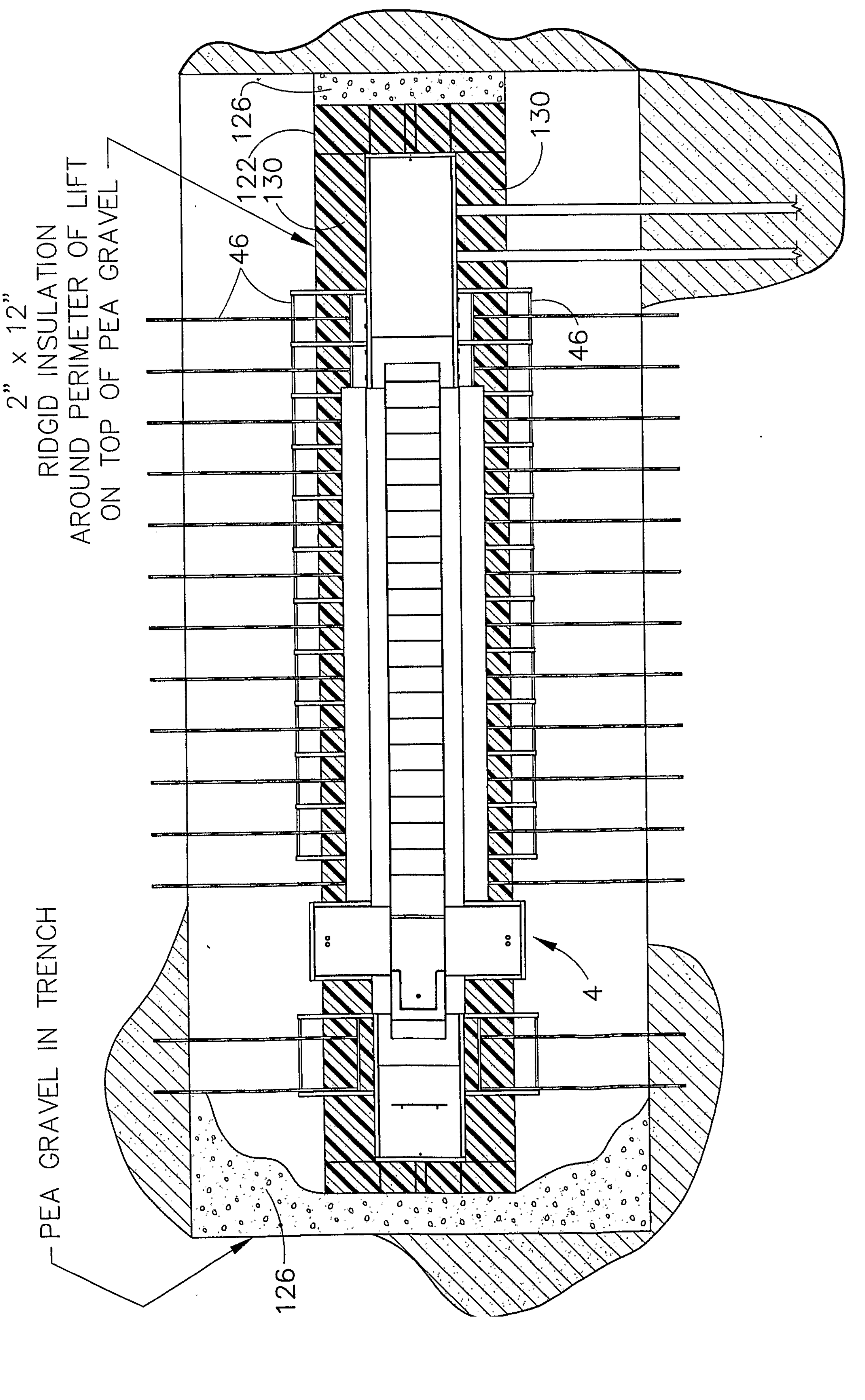

2" x 12"
RIDGID INSULATION
AROUND PERIMETER OF LIFT
ON TOP OF PEA GRAVEL
126
122
130
126
130
46
46
4
PEA GRAVEL IN TRENCH
126

FIG. 3B

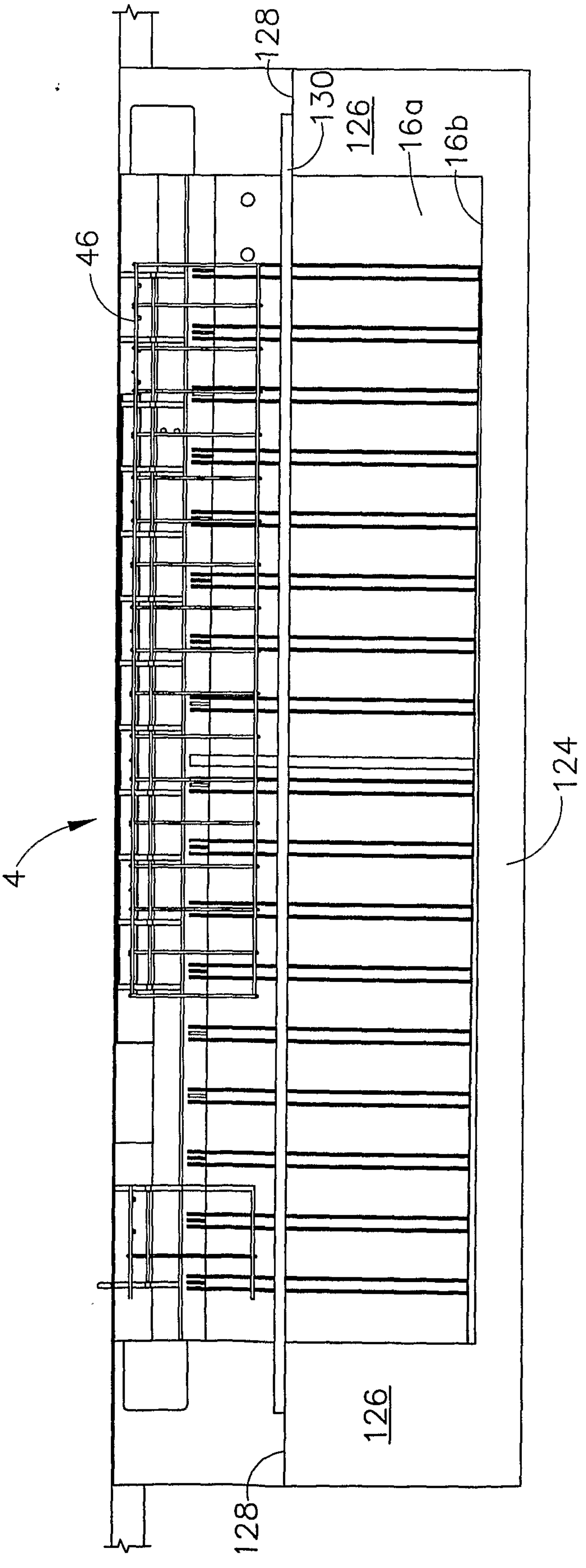


FIG. 3C

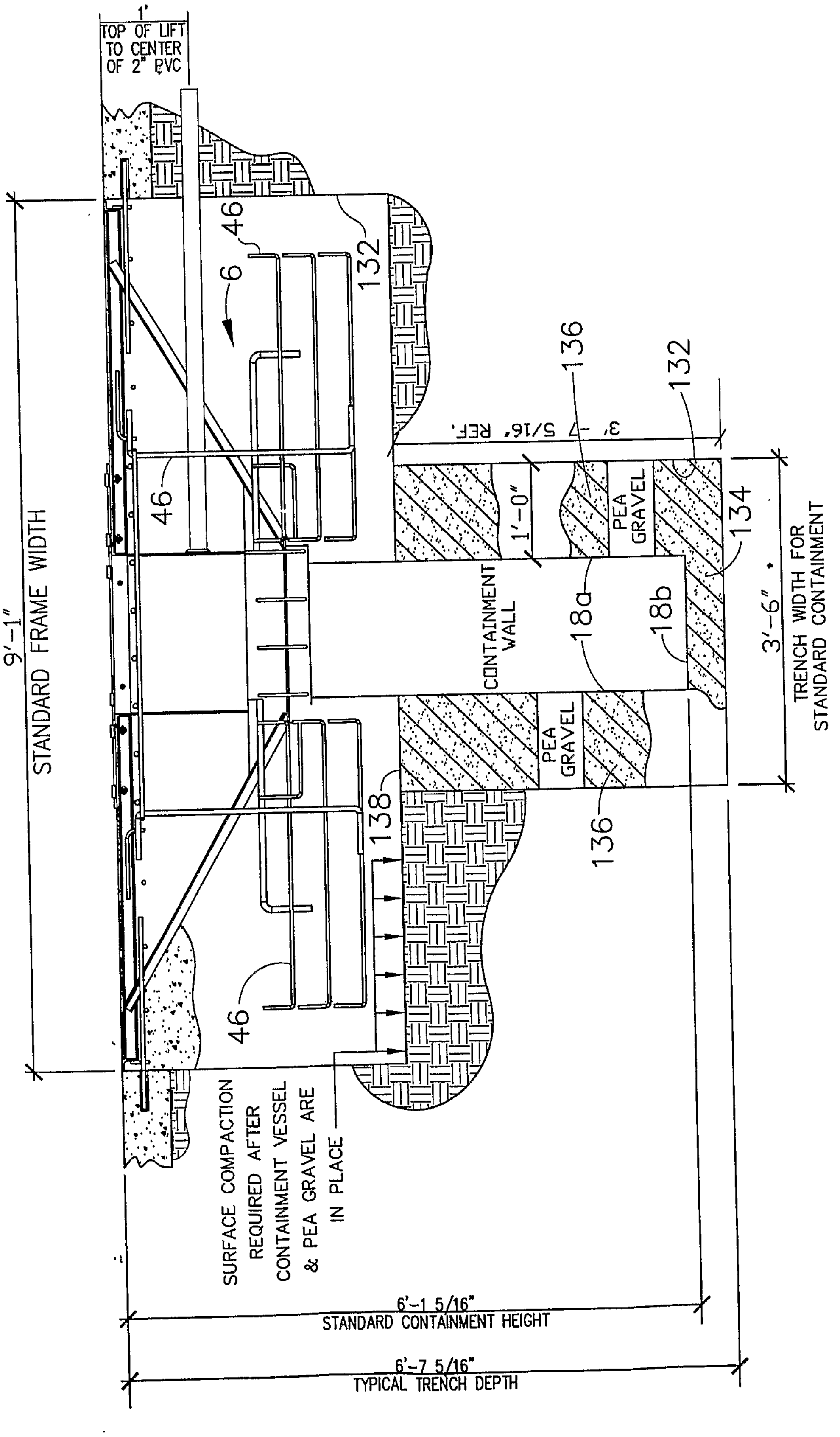

1'
TOP OF LIFT TO CENTER OF 2" PVC
9'-1"
STANDARD FRAME WIDTH
46
6
132
136
132
3'-7 5/16" REF.
46
1'-0"
PEA GRAVEL
134
CONTAINMENT WALL
18a
18b
3'-6"
TRENCH WIDTH FOR STANDARD CONTAINMENT
PEA GRAVEL
138
136
46
SURFACE COMPACTION REQUIRED AFTER CONTAINMENT VESSEL & PEA GRAVEL ARE IN PLACE
6'-1 5/16"
STANDARD CONTAINMENT HEIGHT
6'-7 5/16"
TYPICAL TRENCH DEPTH

FIG. 4A

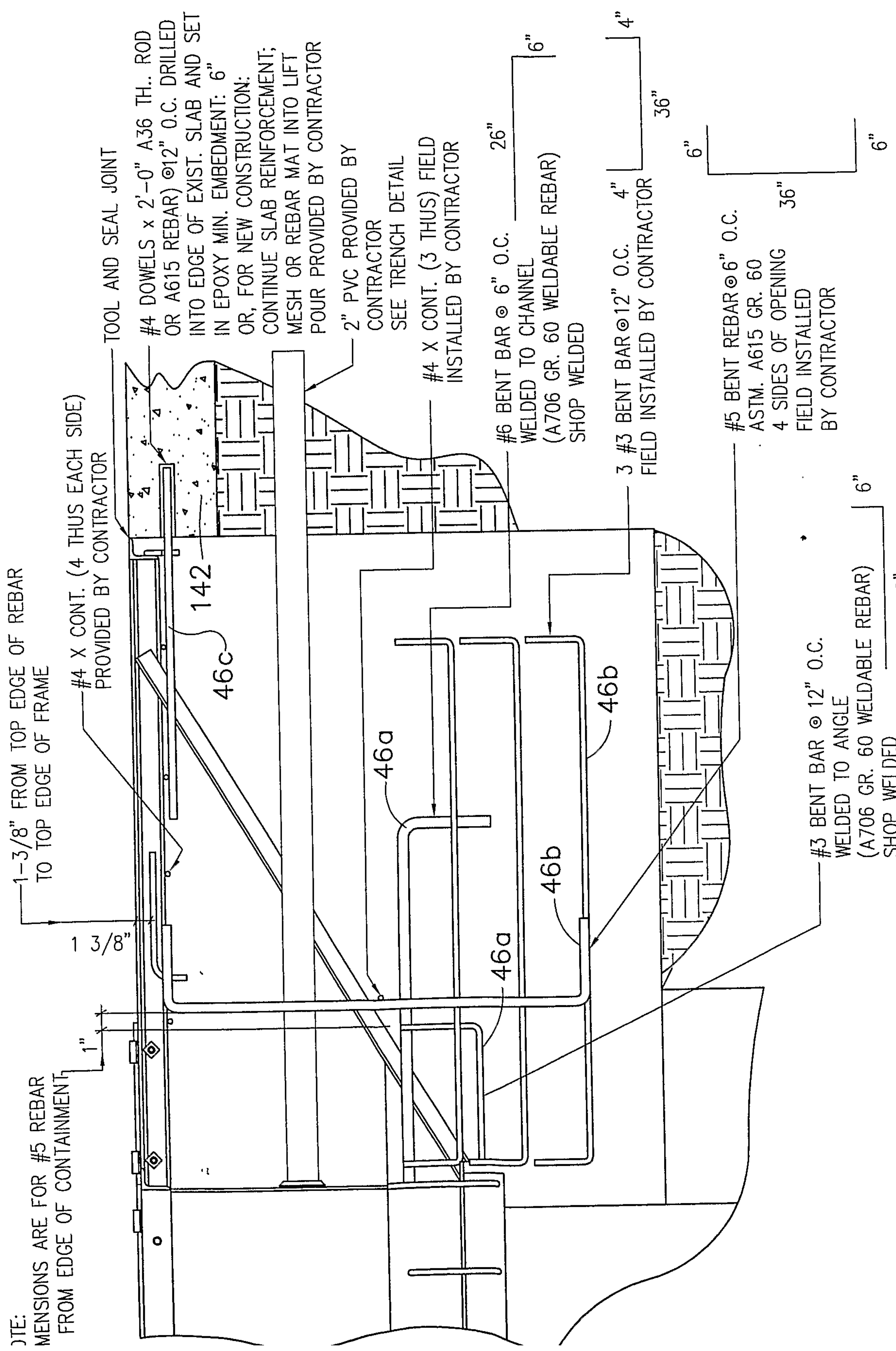

TOOL AND SEAL JOINT
#4 DOWELS x 2'-0" A36 TH.. ROD OR A615 REBAR) ⊙12" O.C. DRILLED INTO EDGE OF EXIST. SLAB AND SET IN EPOXY MIN. EMBEDMENT: 6" OR, FOR NEW CONSTRUCTION: CONTINUE SLAB REINFORCEMENT; MESH OR REBAR MAT INTO LIFT POUR PROVIDED BY CONTRACTOR
2" PVC PROVIDED BY CONTRACTOR SEE TRENCH DETAIL
#4 X CONT. (3 THUS) FIELD INSTALLED BY CONTRACTOR
#6 BENT BAR ⊙ 6" O.C. WELDED TO CHANNEL (A706 GR. 60 WELDABLE REBAR) SHOP WELDED
26"
6"
3 #3 BENT BAR ⊙12" O.C. FIELD INSTALLED BY CONTRACTOR
4"
36"
4"
#5 BENT REBAR ⊙6" O.C. ASTM. A615 GR. 60 4 SIDES OF OPENING FIELD INSTALLED BY CONTRACTOR
6"
36"
6"
#3 BENT BAR ⊙ 12" O.C. WELDED TO ANGLE (A706 GR. 60 WELDABLE REBAR) SHOP WELDED
12"
6"
1-3/8" FROM TOP EDGE OF REBAR TO TOP EDGE OF FRAME
#4 X CONT. (4 THUS EACH SIDE) PROVIDED BY CONTRACTOR
1 3/8"
1"
)TE: MENSIONS ARE FOR #5 REBAR FROM EDGE OF CONTAINMENT
142
46c
46a
46b
46a
46b
46a

FIG. 4B

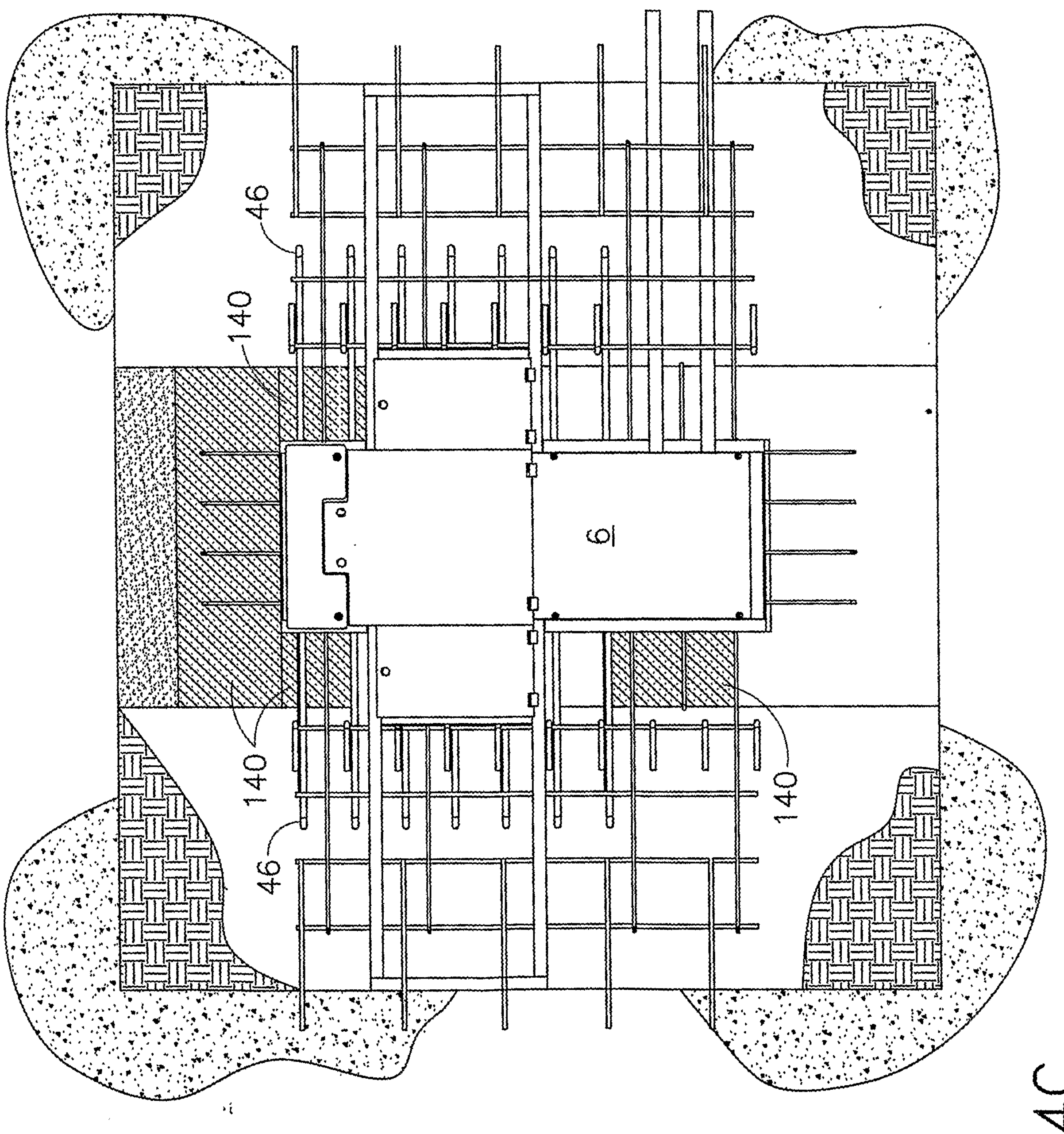
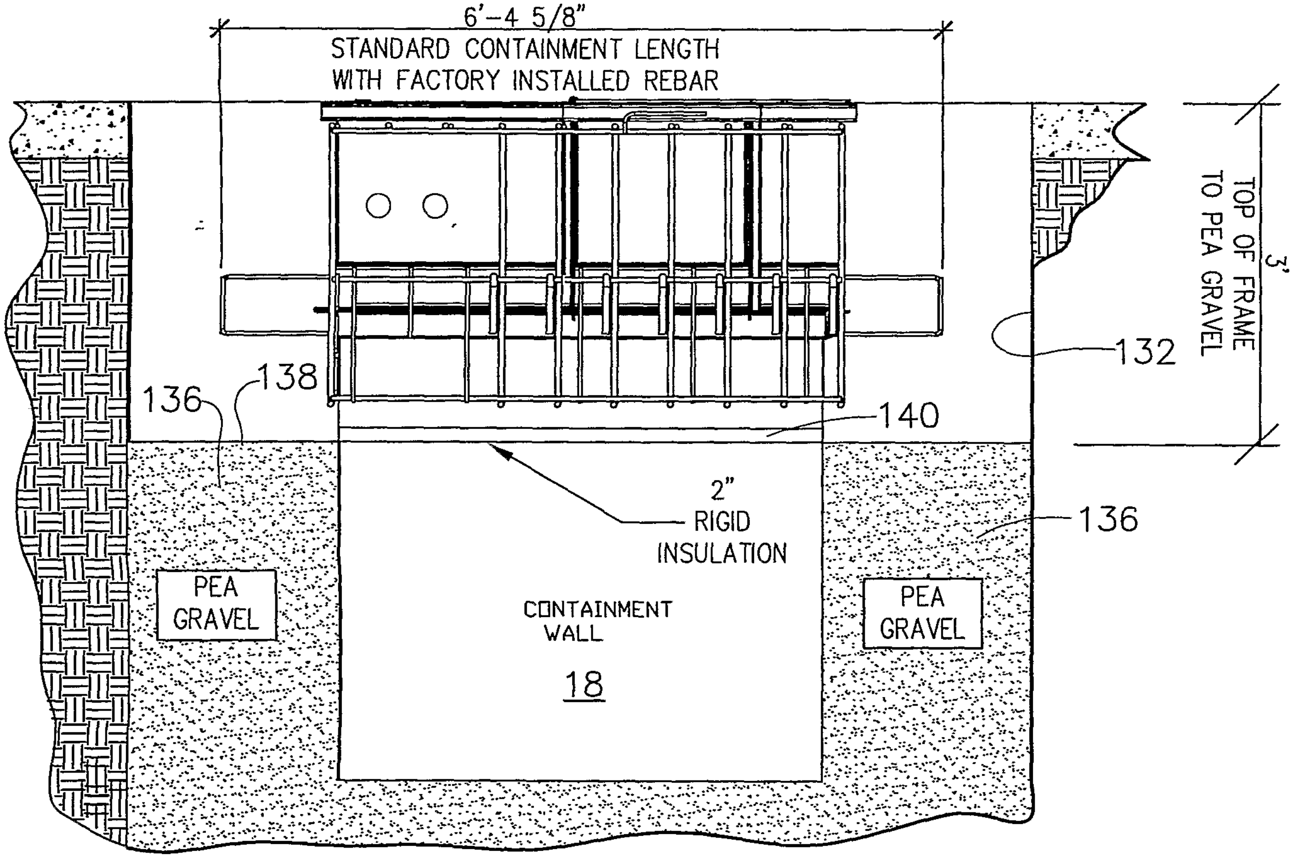


FIG. 4C



NOTES:
1. LOCAL SOILS ENGINEER MUST OBSERVE AND/OR TEST SOIL AT EACH INDIVIDUAL JOB AND CERTIFY SOIL IS GOOD FOR AT LEAST 3000 PSF BRG. CAPACITY

2. CONCRETE MIX DESIGN SPECIFICATIONS:
MIN. 28 DAY COMPRESSIVE STRENGTH, f'c=4000psi
SLUMP=4" (MAY BE 6" WITH SUPERPLASTICZER)
MAX. WATER/CEMENT RATIO 0.50
MAX AGG. SIZE= 3/4"

FIG. 4D

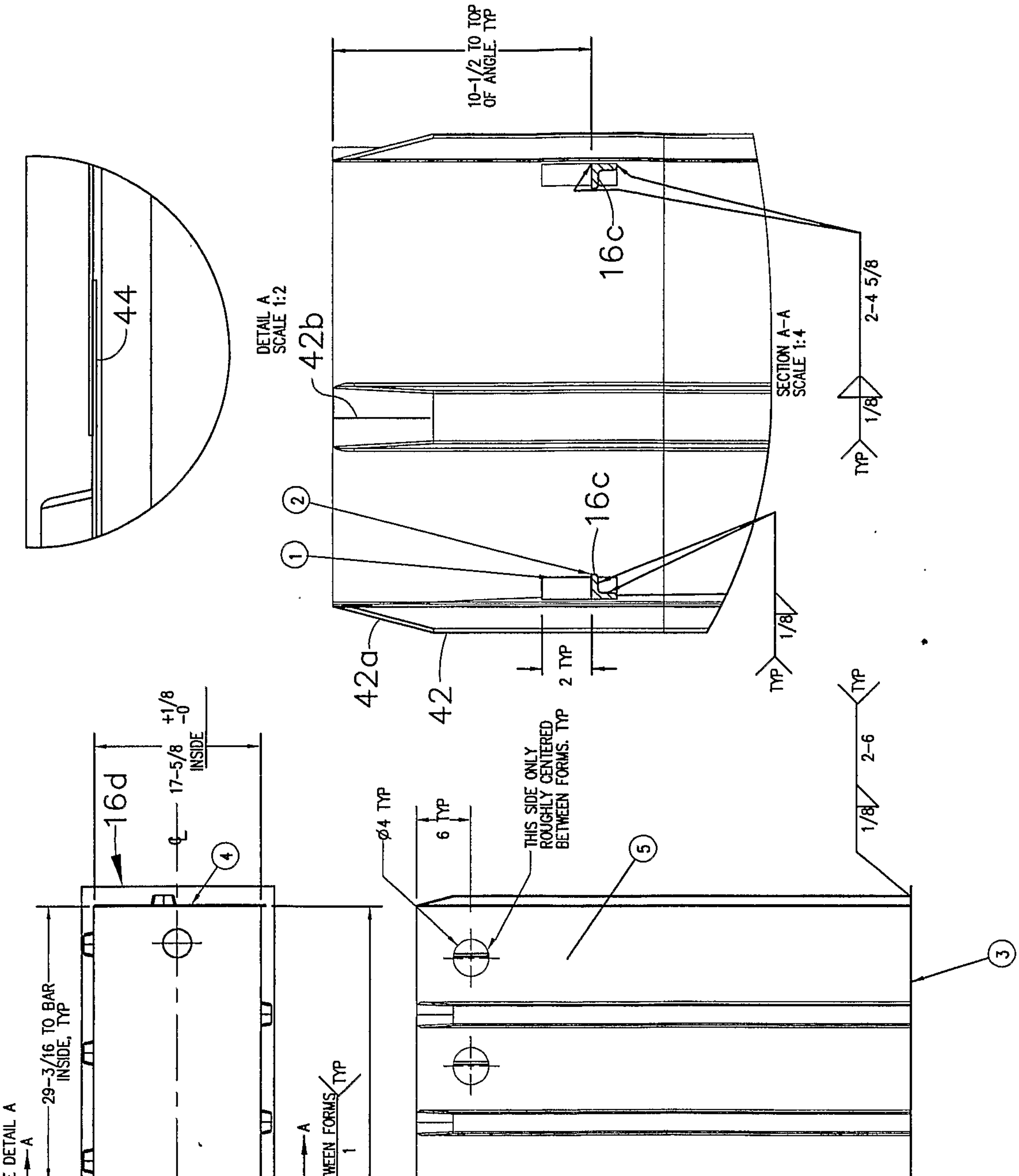

10-1/2 TO TOP OF ANGLE TYP
16c
2-4 5/8
DETAIL A SCALE 1:2
42b
44
SECTION A-A SCALE 1:4
1/8
TYP
16c
42a
42
2 TYP
16d
17-5/8 +1/8 -0 INSIDE
ø4 TYP
6 TYP
THIS SIDE ONLY ROUGHLY CENTERED BETWEEN FORMS. TYP
2-6
SEE DETAIL A
29-3/16 TO BAR INSIDE, TYP
CTR'D BETWEEN FORMS
144-7/16 +1/4 -0 INSIDE
AT SHEET JOINT
1-6 1/2
CTR'D ON FORMS
16b

FIG. 5

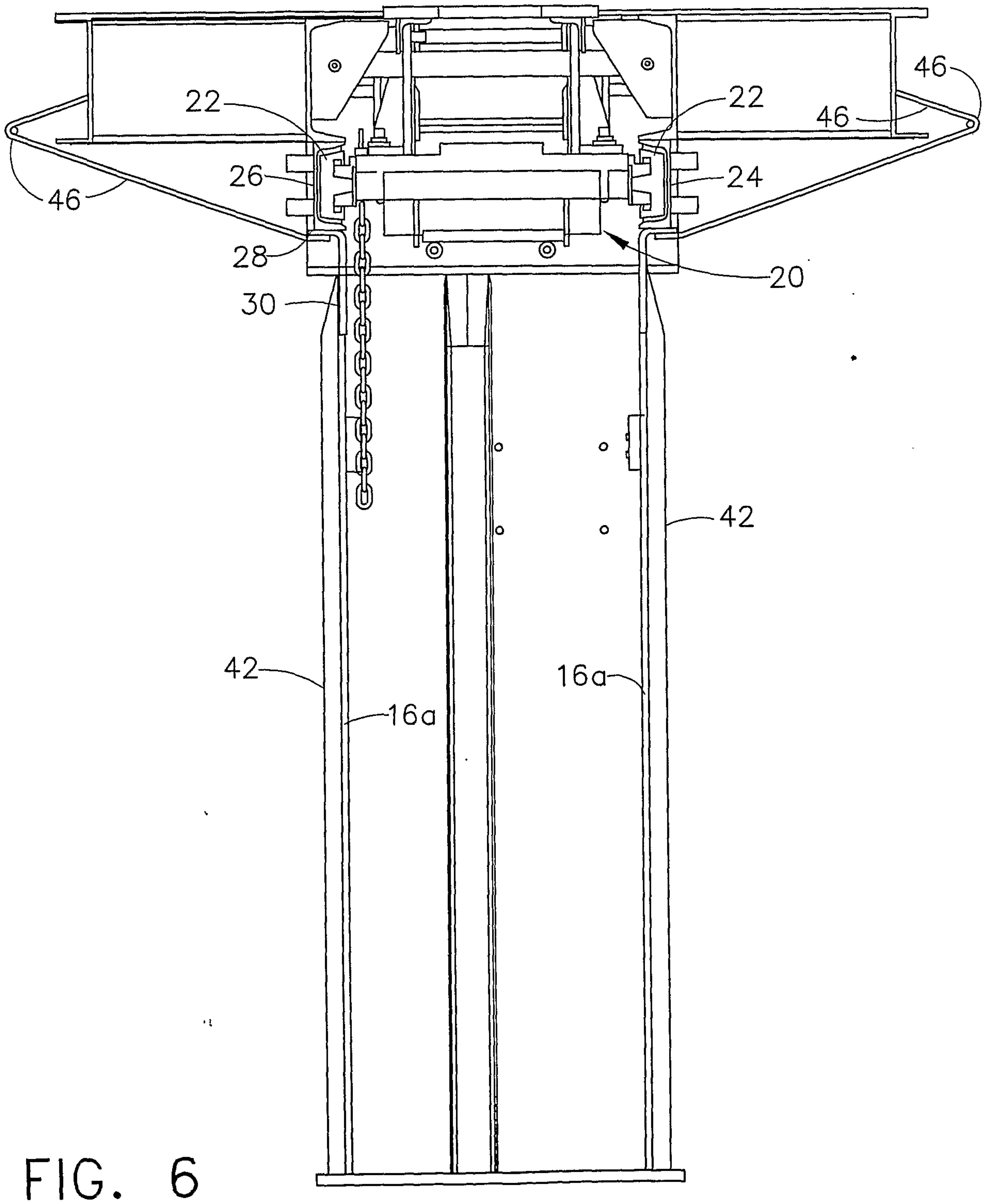


FIG. 6

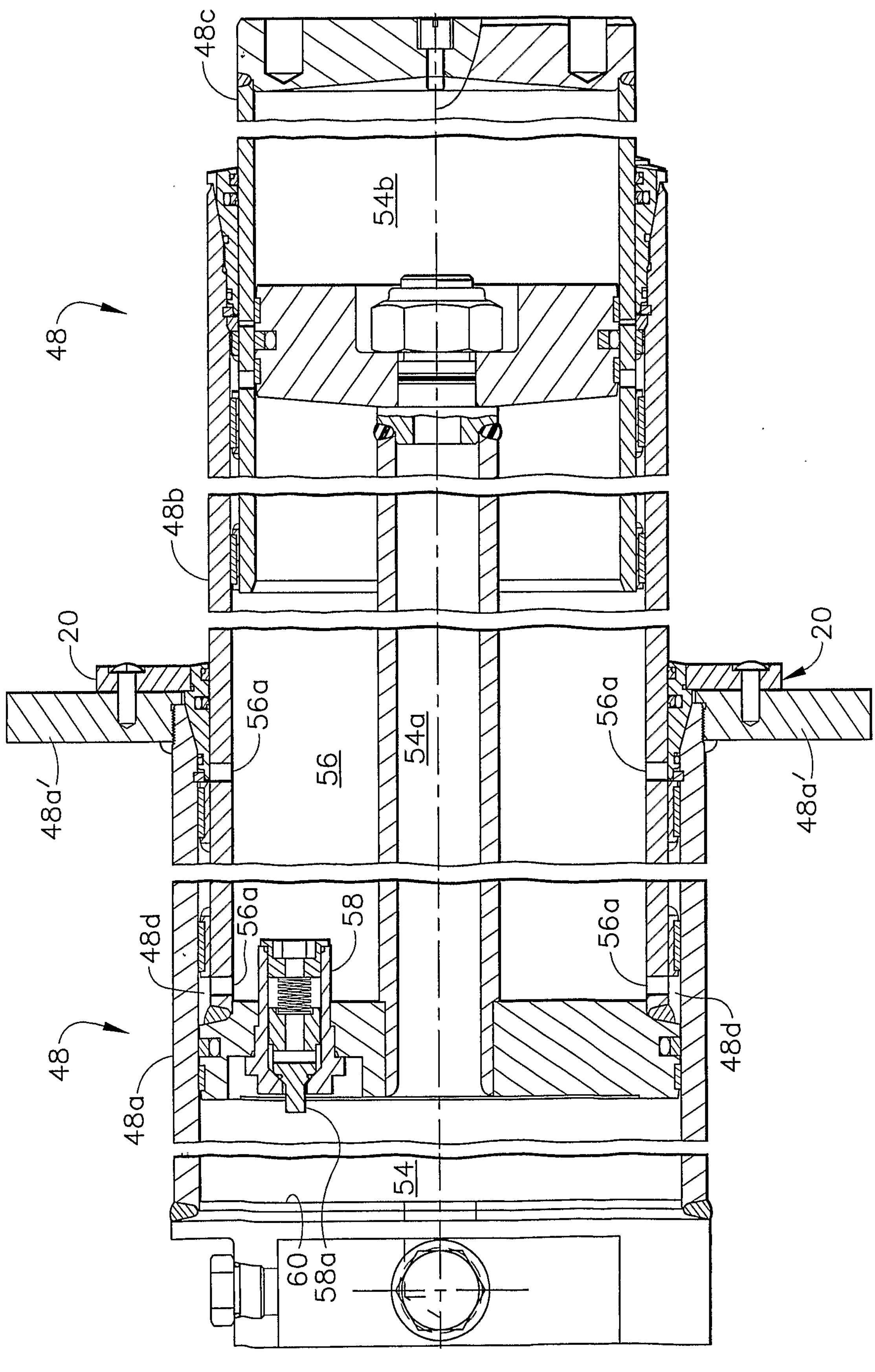

48c
54b
48
48b
20
56a
56
54a
56a
20
48a′
48a′
48d
56a
58
56a
48
48a
48d
54
60
58a

FIG. 7

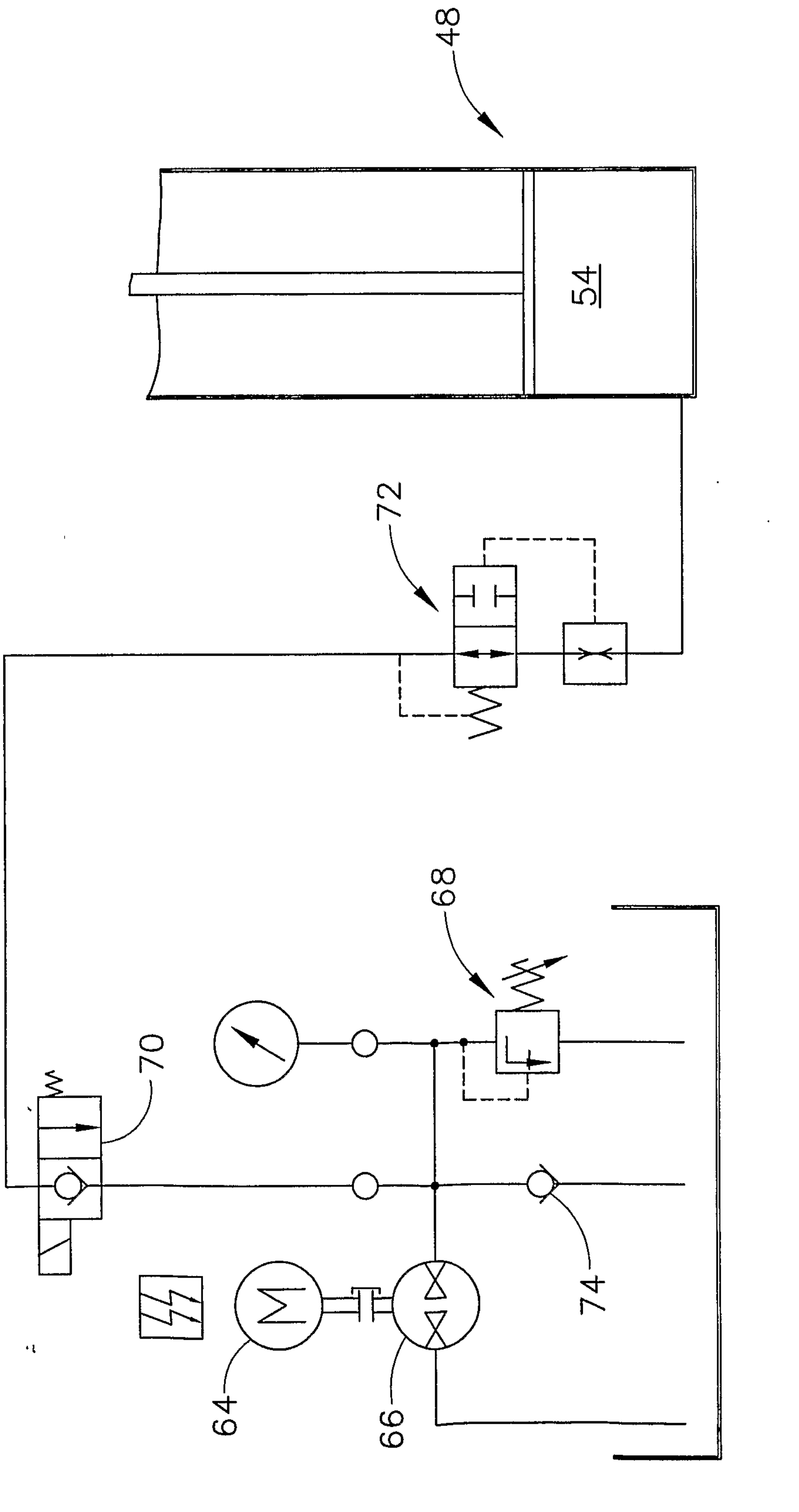


FIG. 8

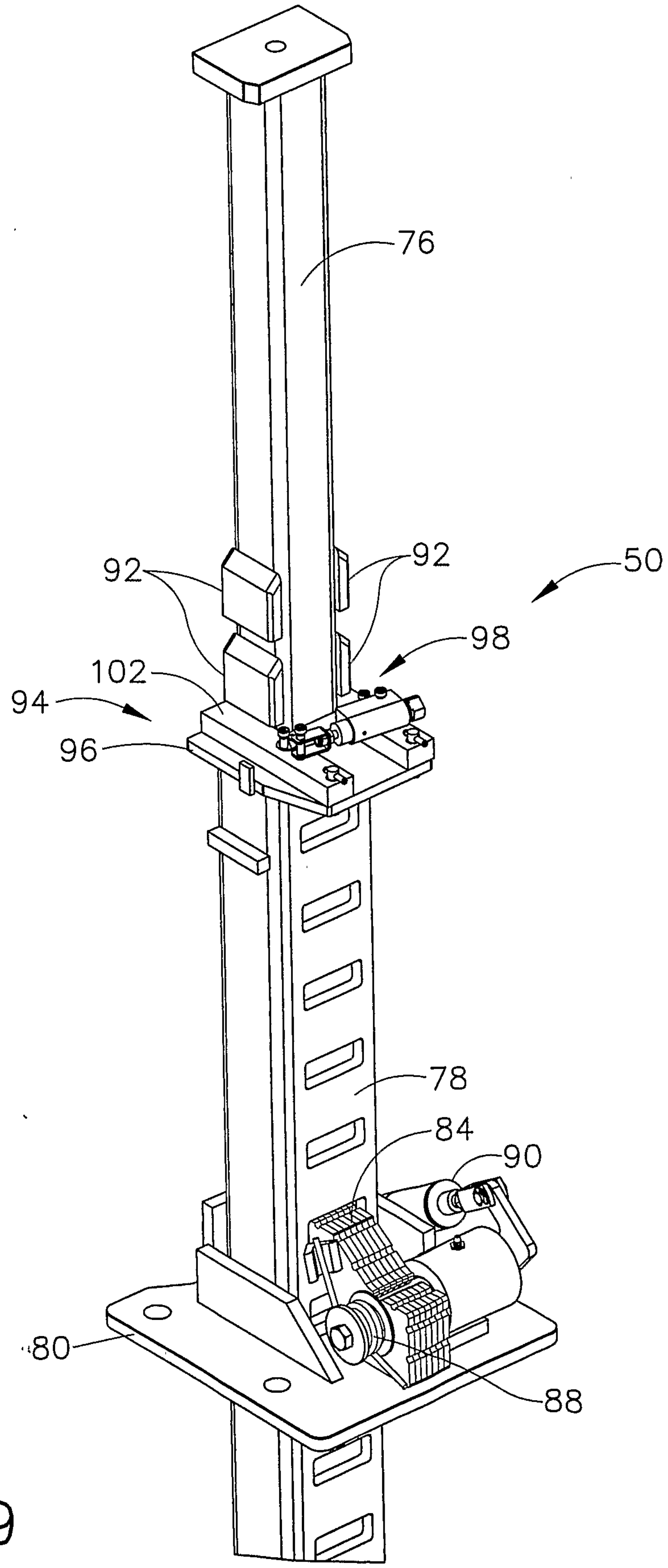


FIG. 9

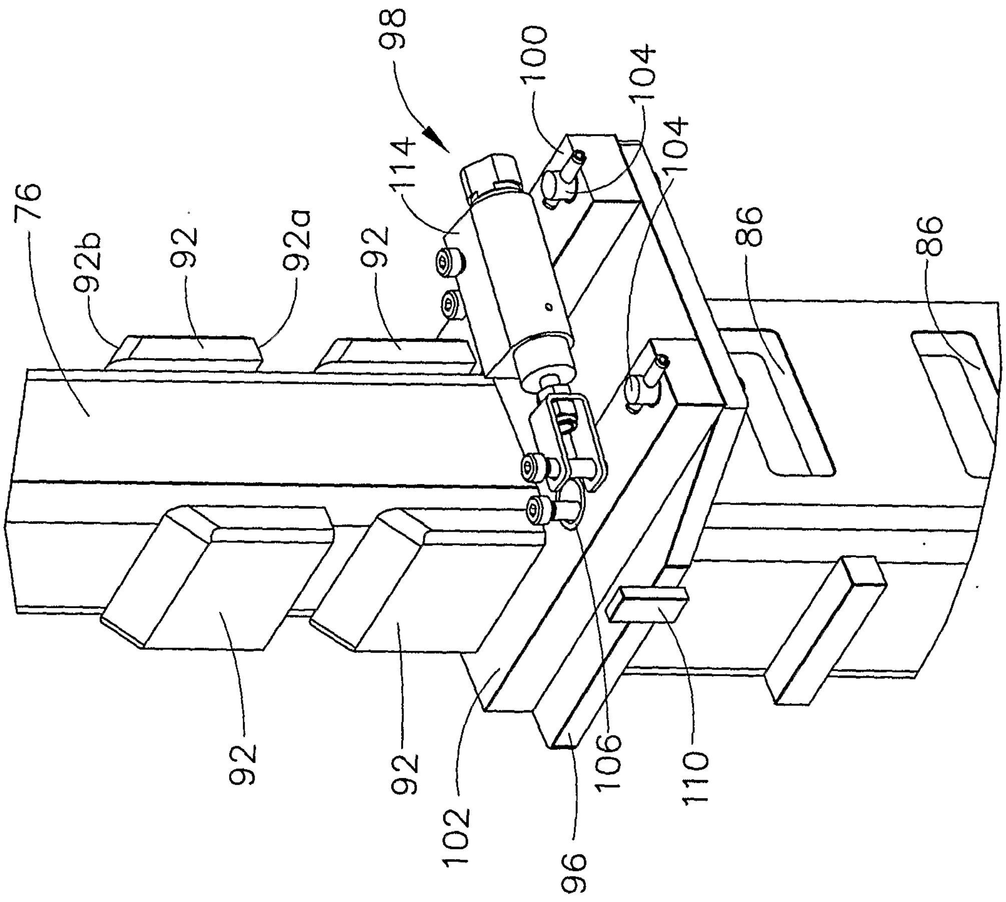

98
100
104
104
114
76
92b
92
92a
92
86
86
92
92
102
96
106
110

FIG. 11

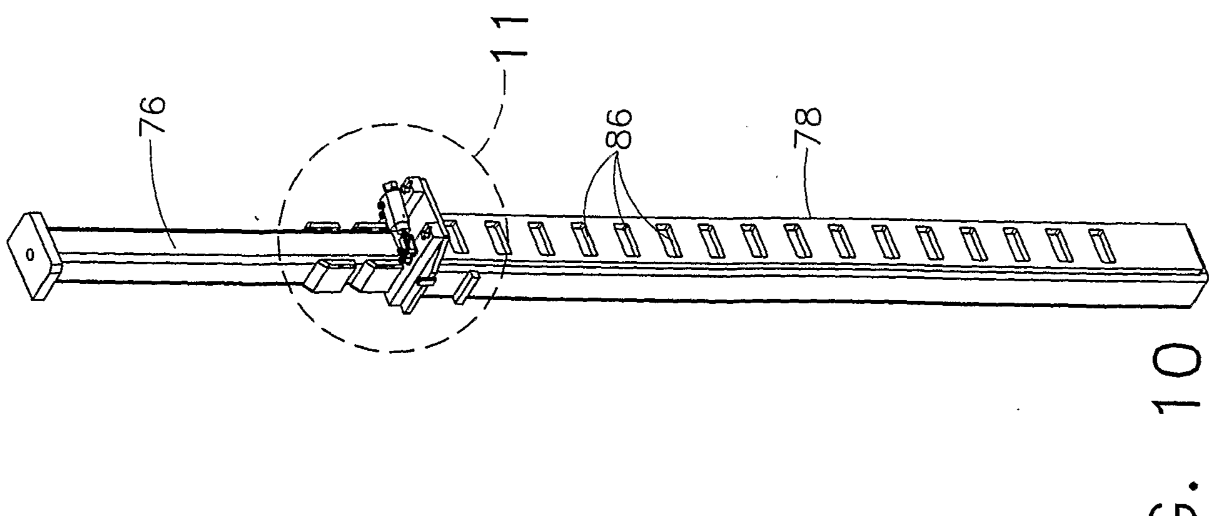

76
11
86
78

FIG. 10

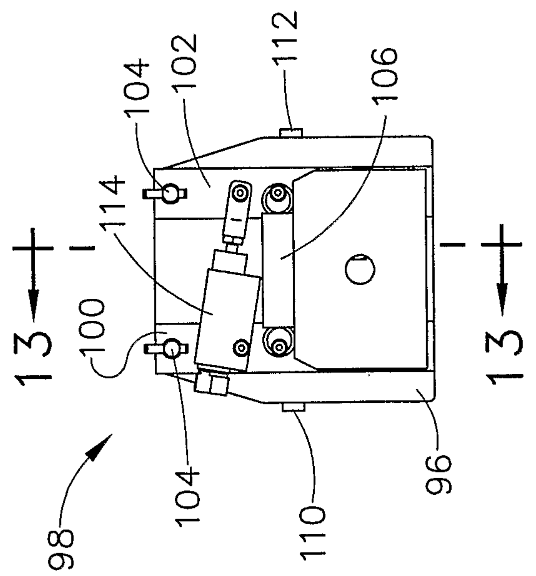

13
13
98
104
100
114
104
102
112
106
110
96

FIG. 12

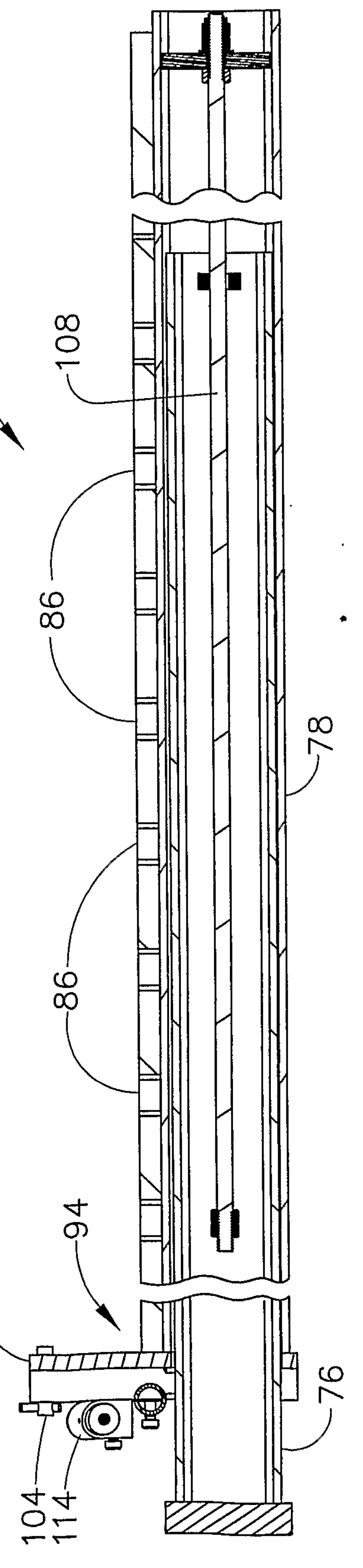

50
108
86
86
78
94
96
104
114
76

FIG. 13

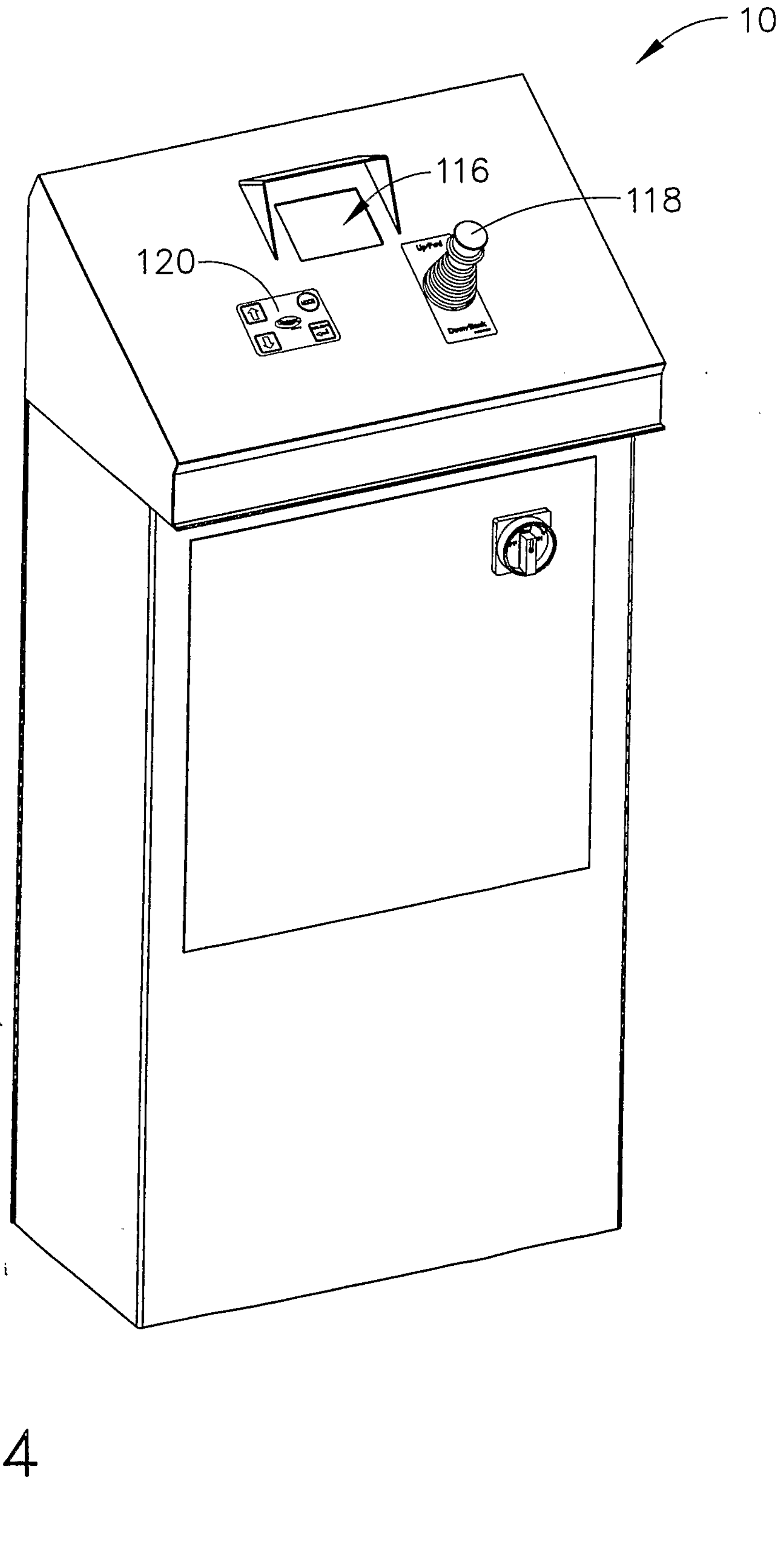


FIG. 14

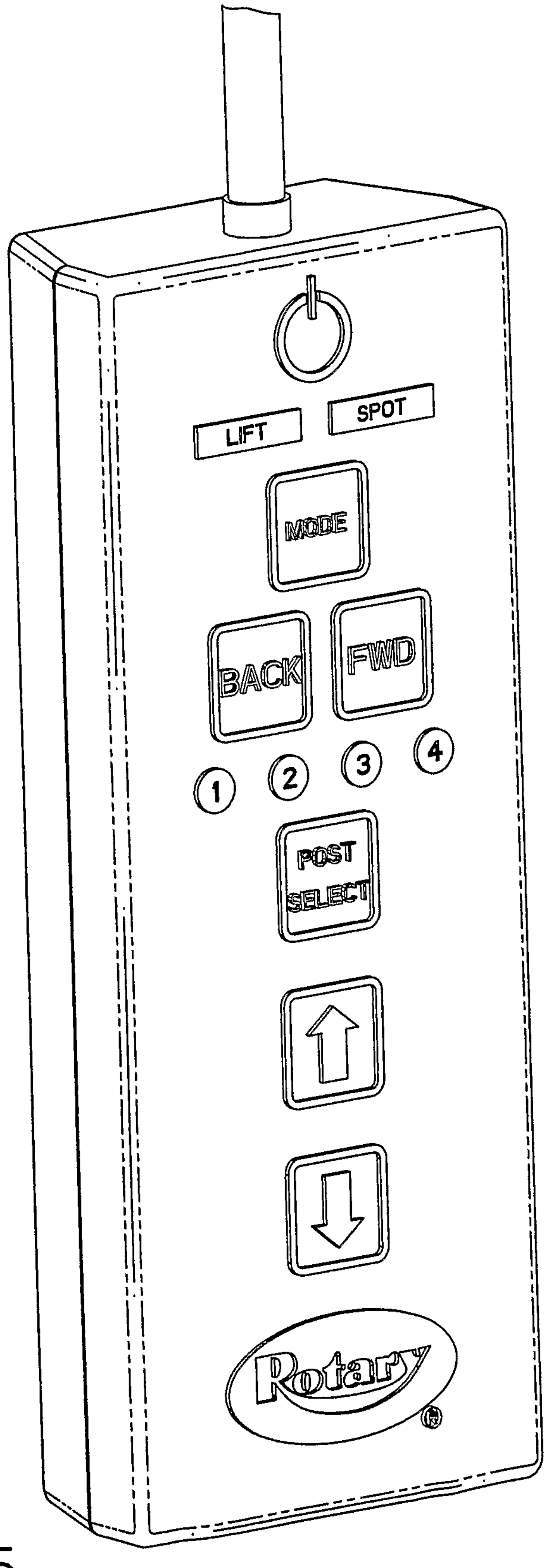


FIG. 15

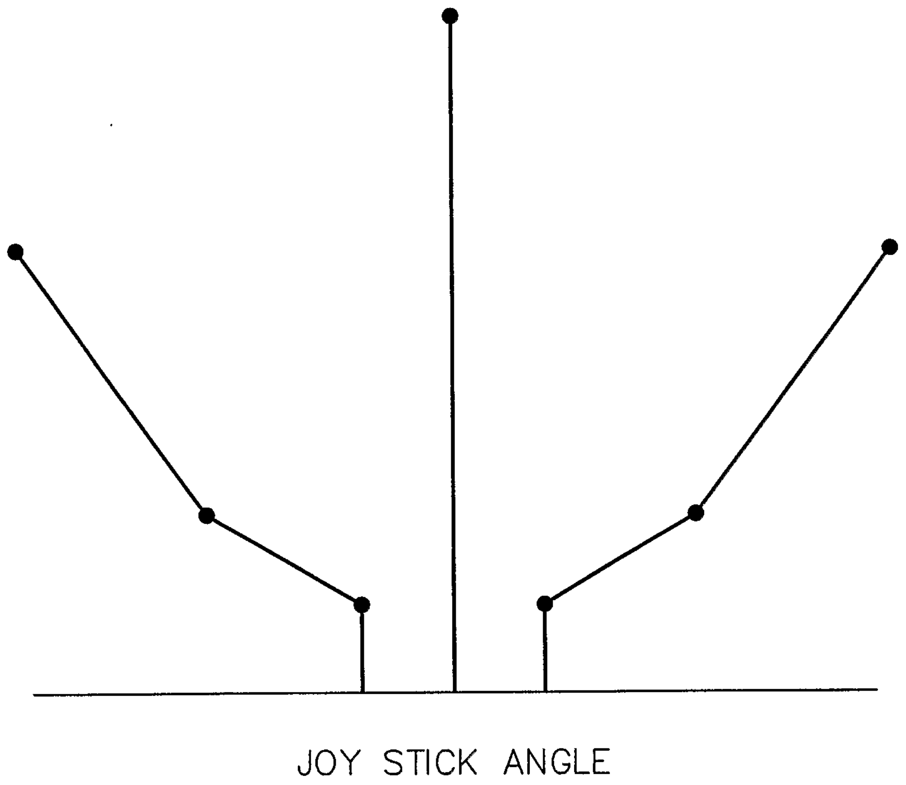


FIG. 16

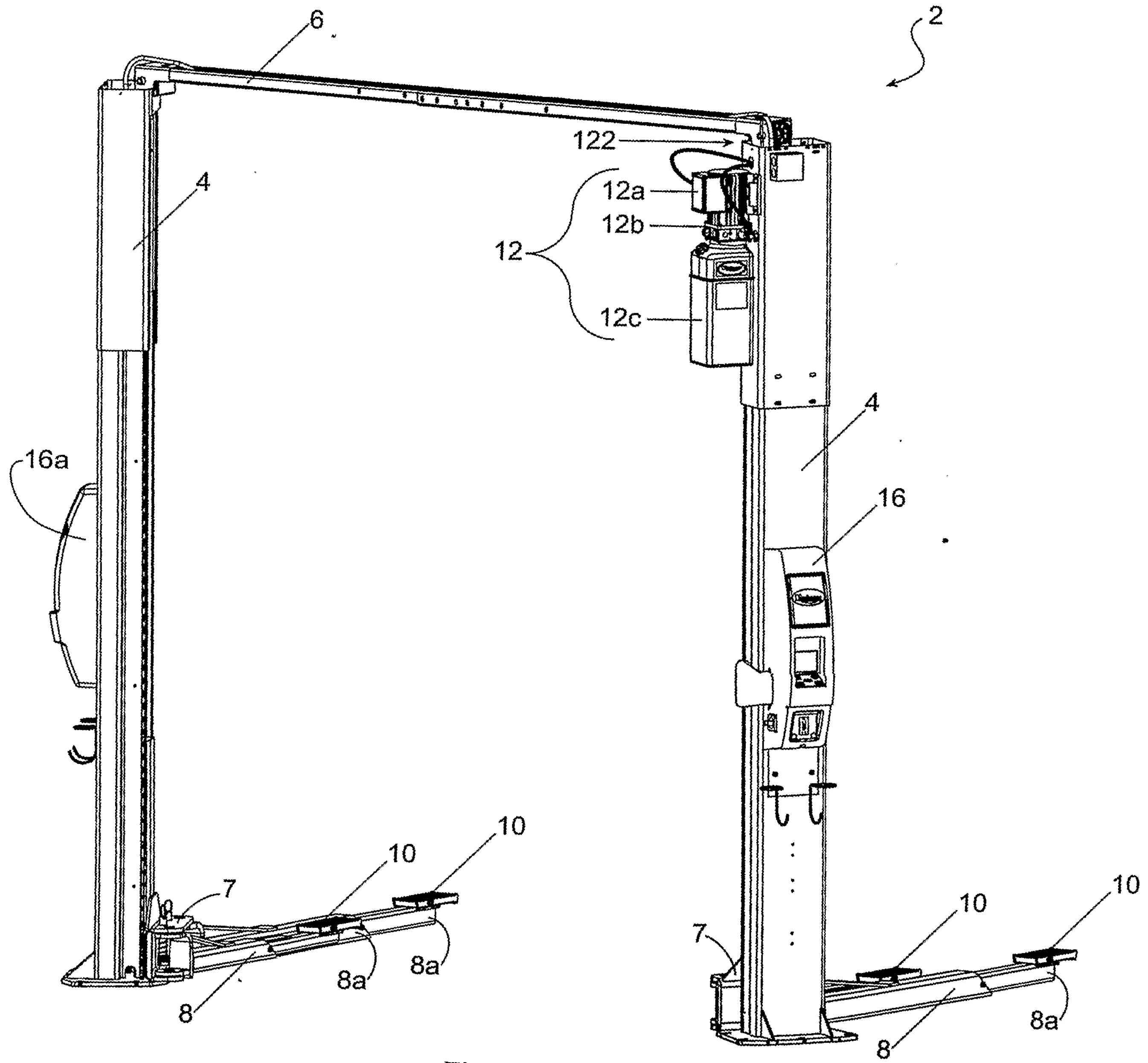


Fig. 101

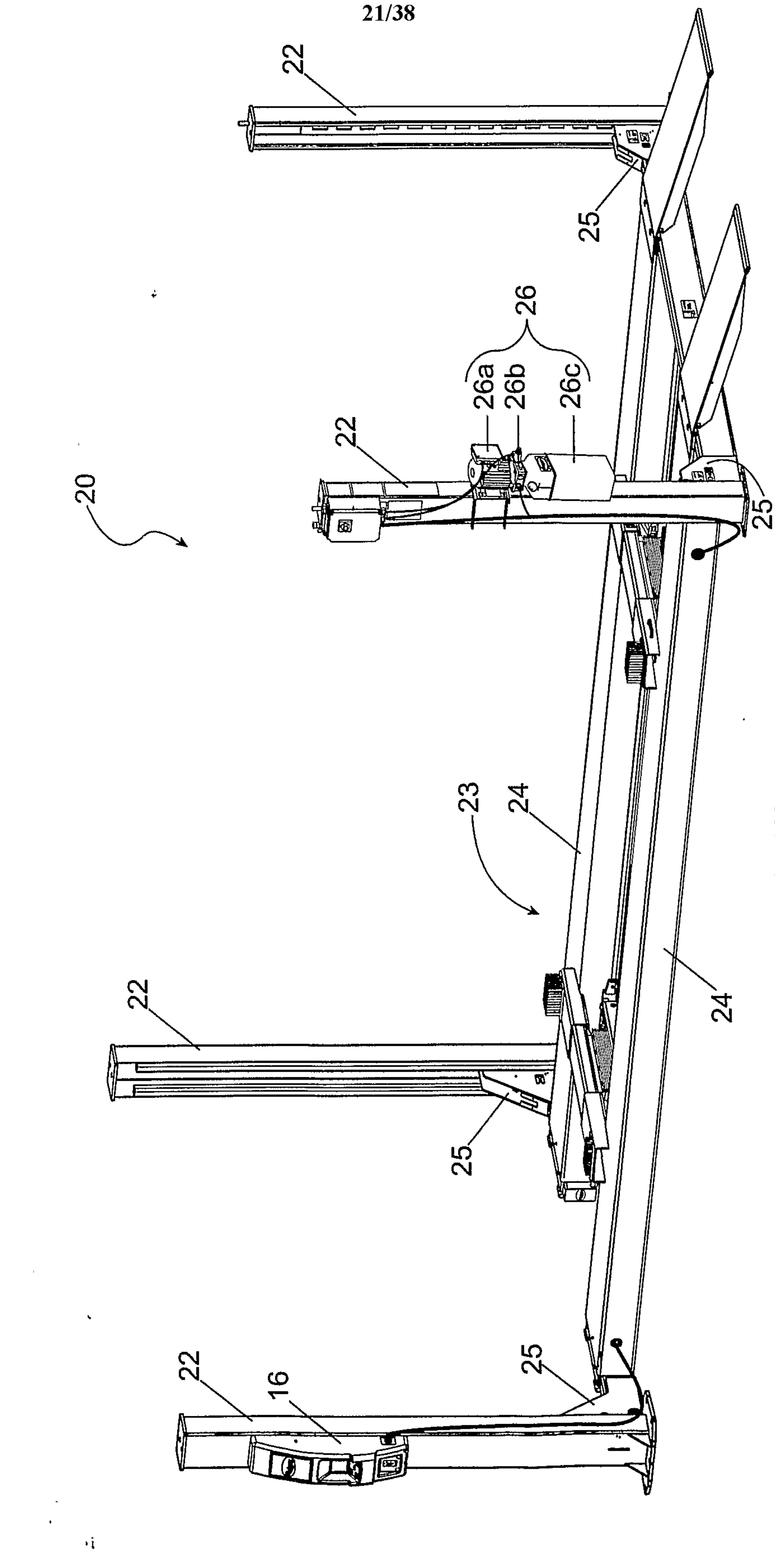


Fig. 102

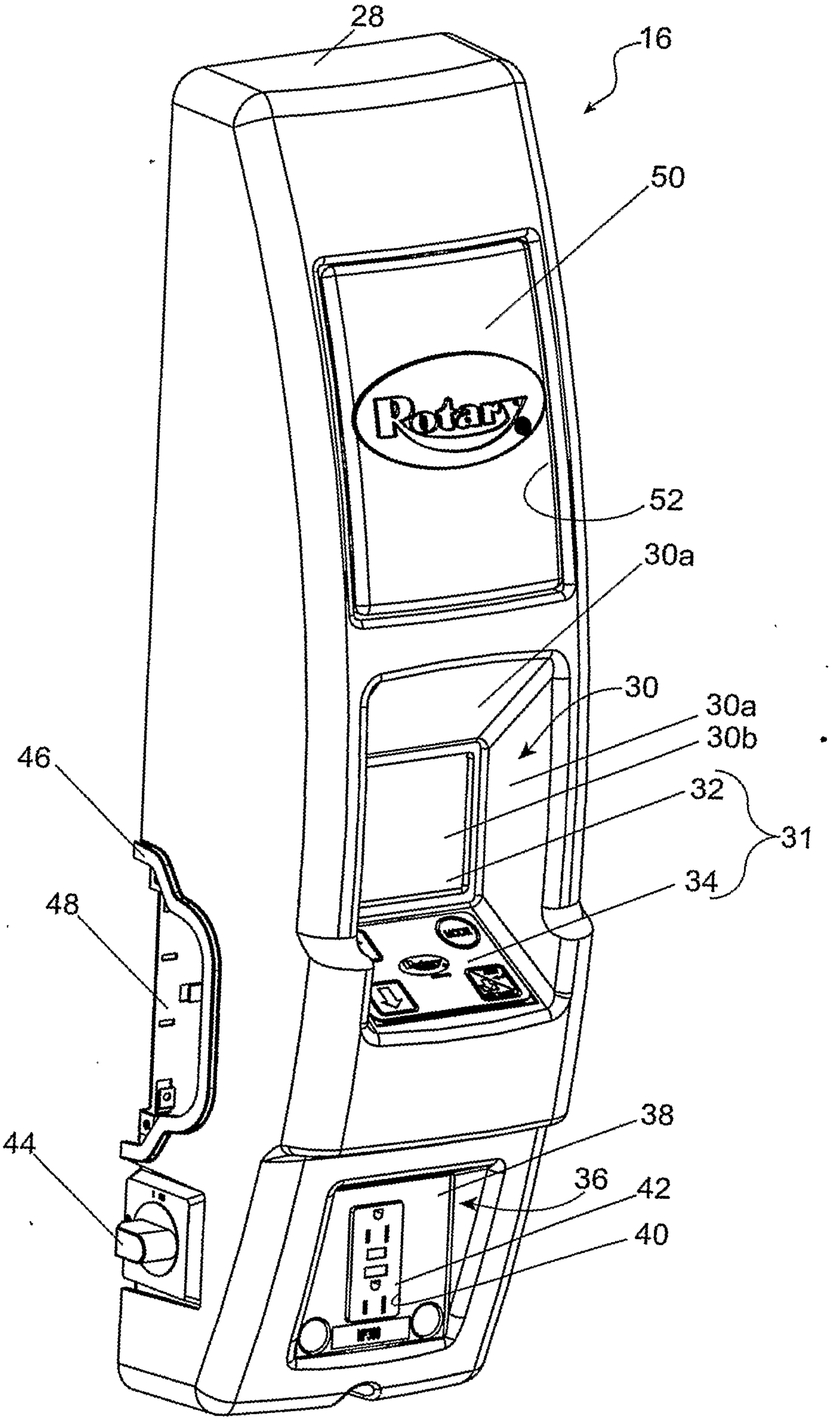


Fig. 103

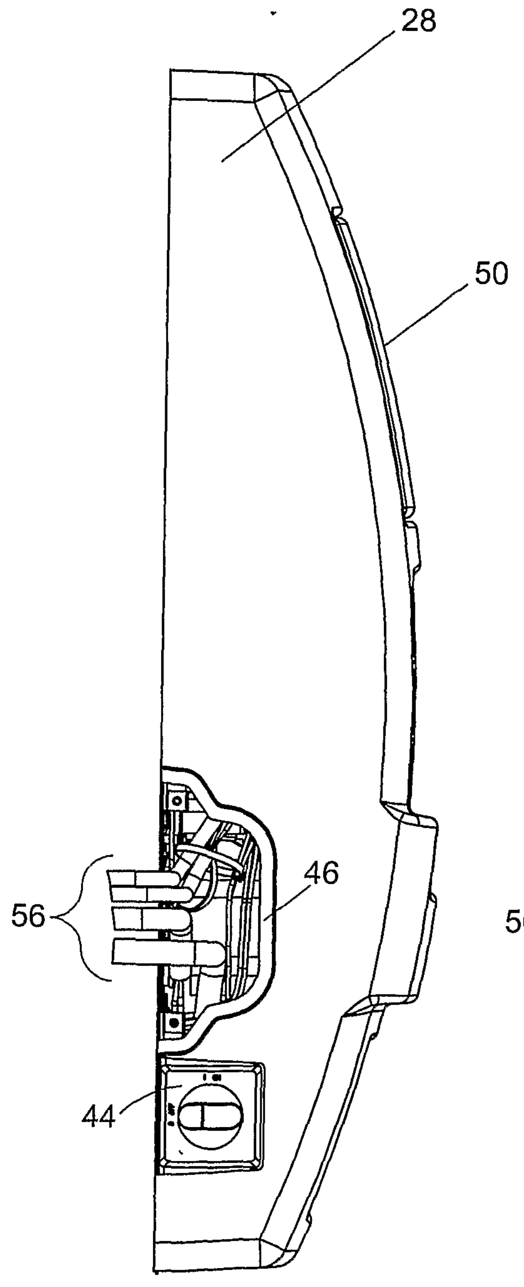


Fig. 105

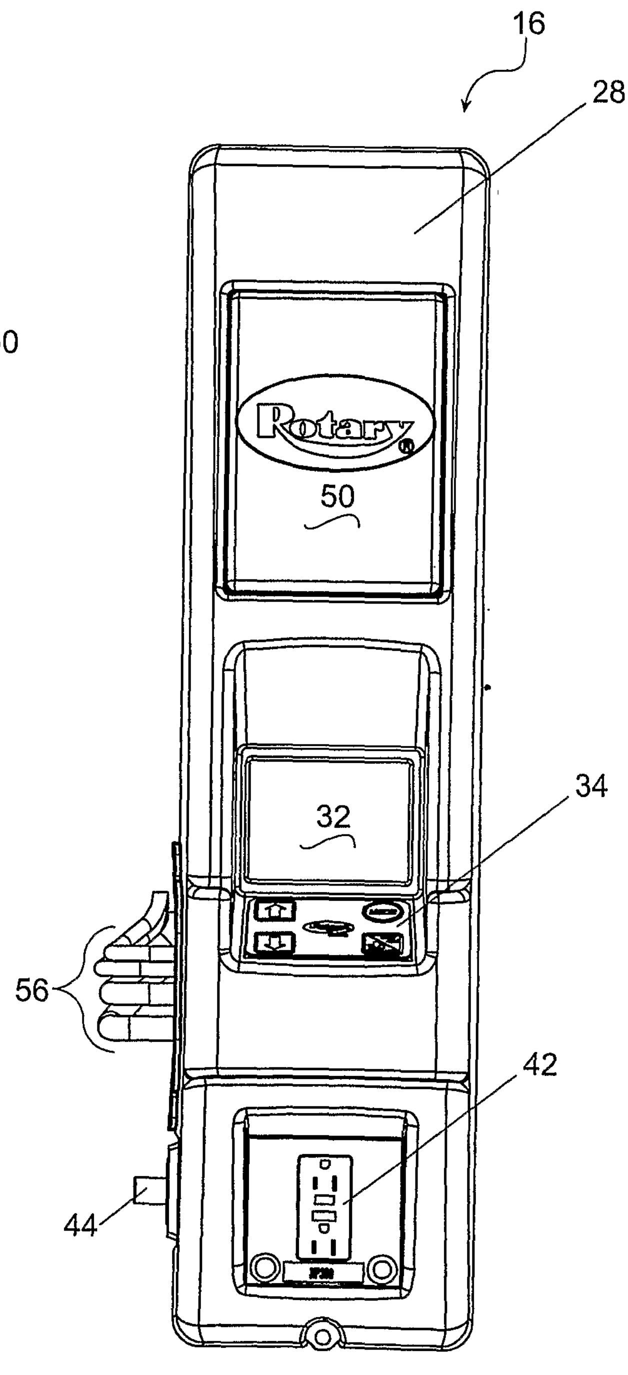


Fig. 104

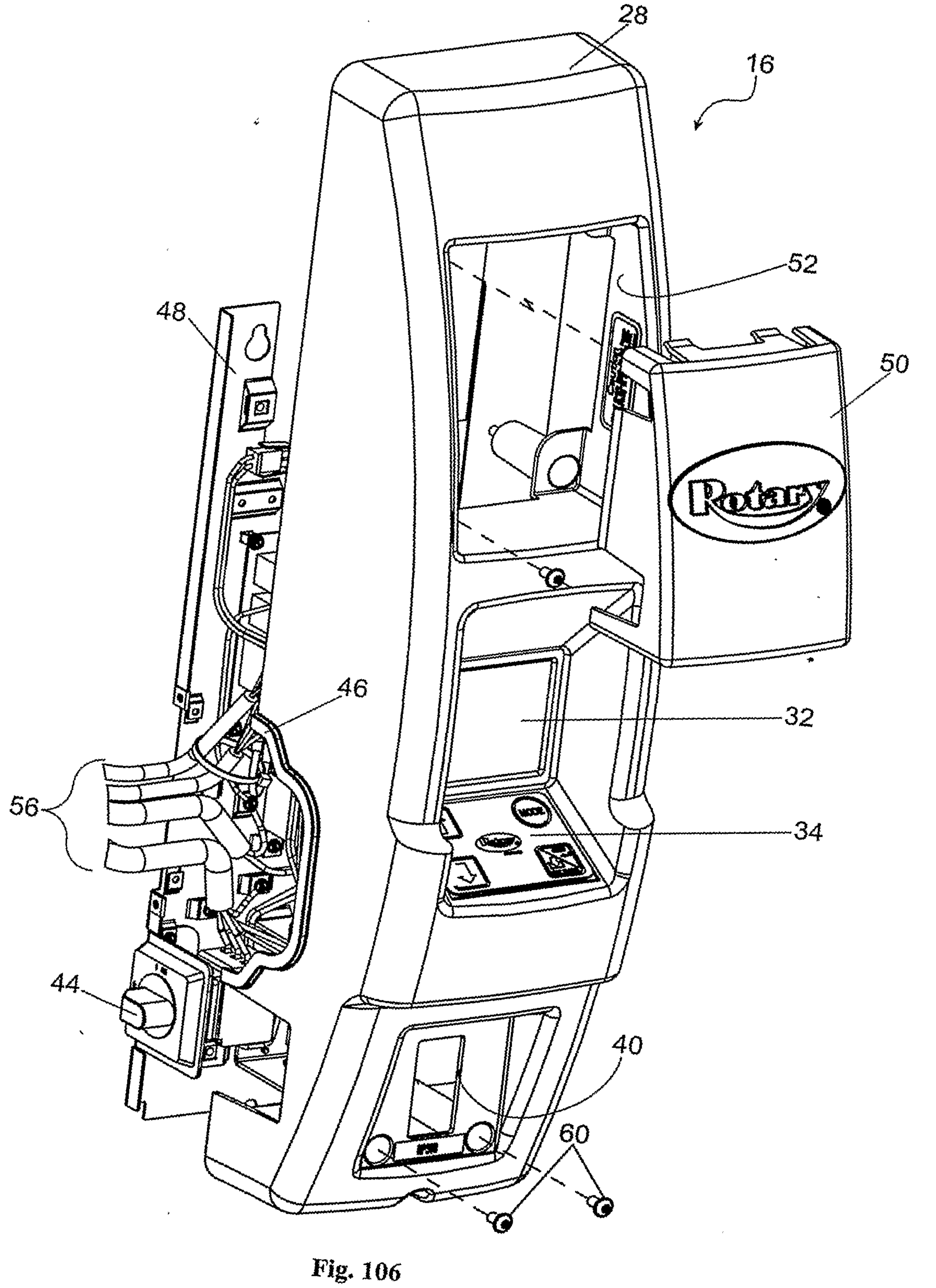


Fig. 106

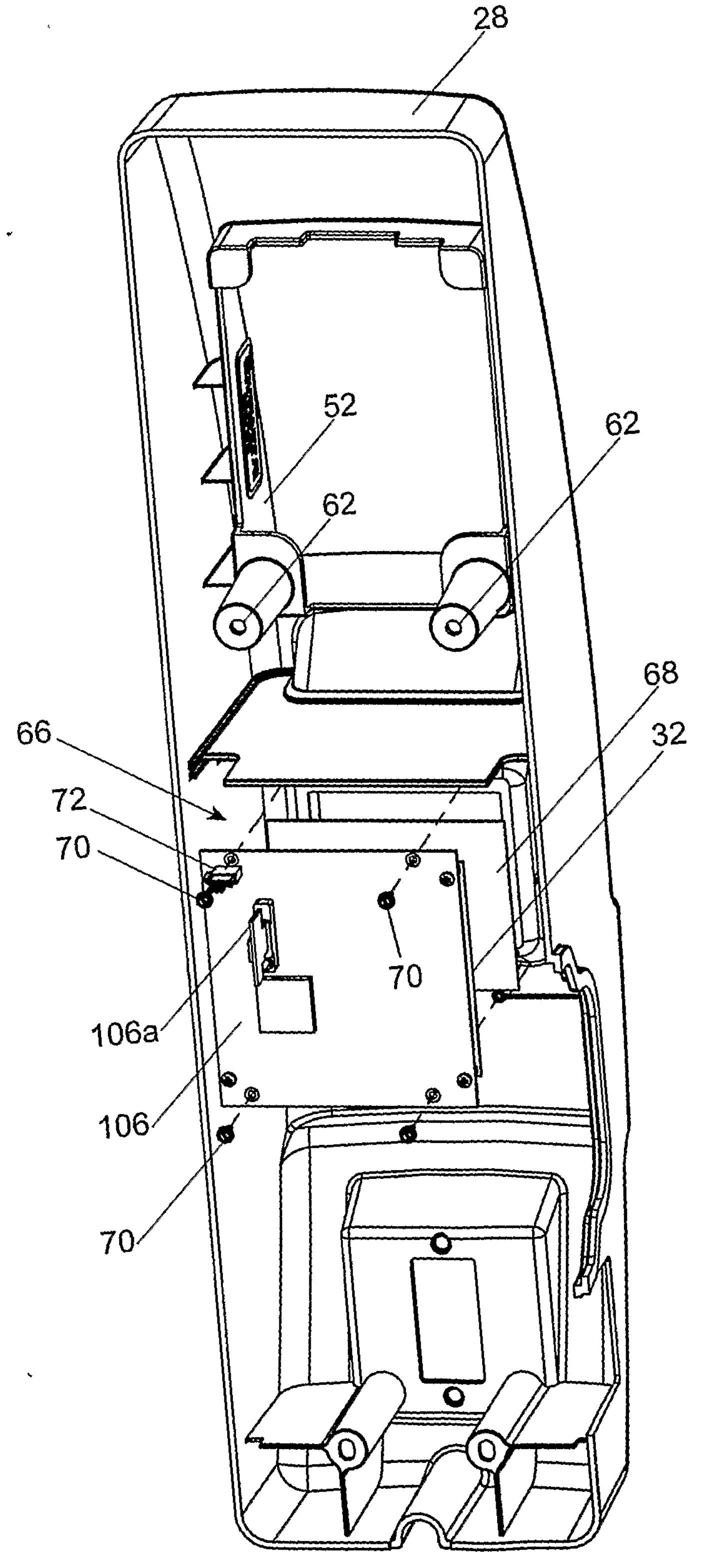


Fig. 107

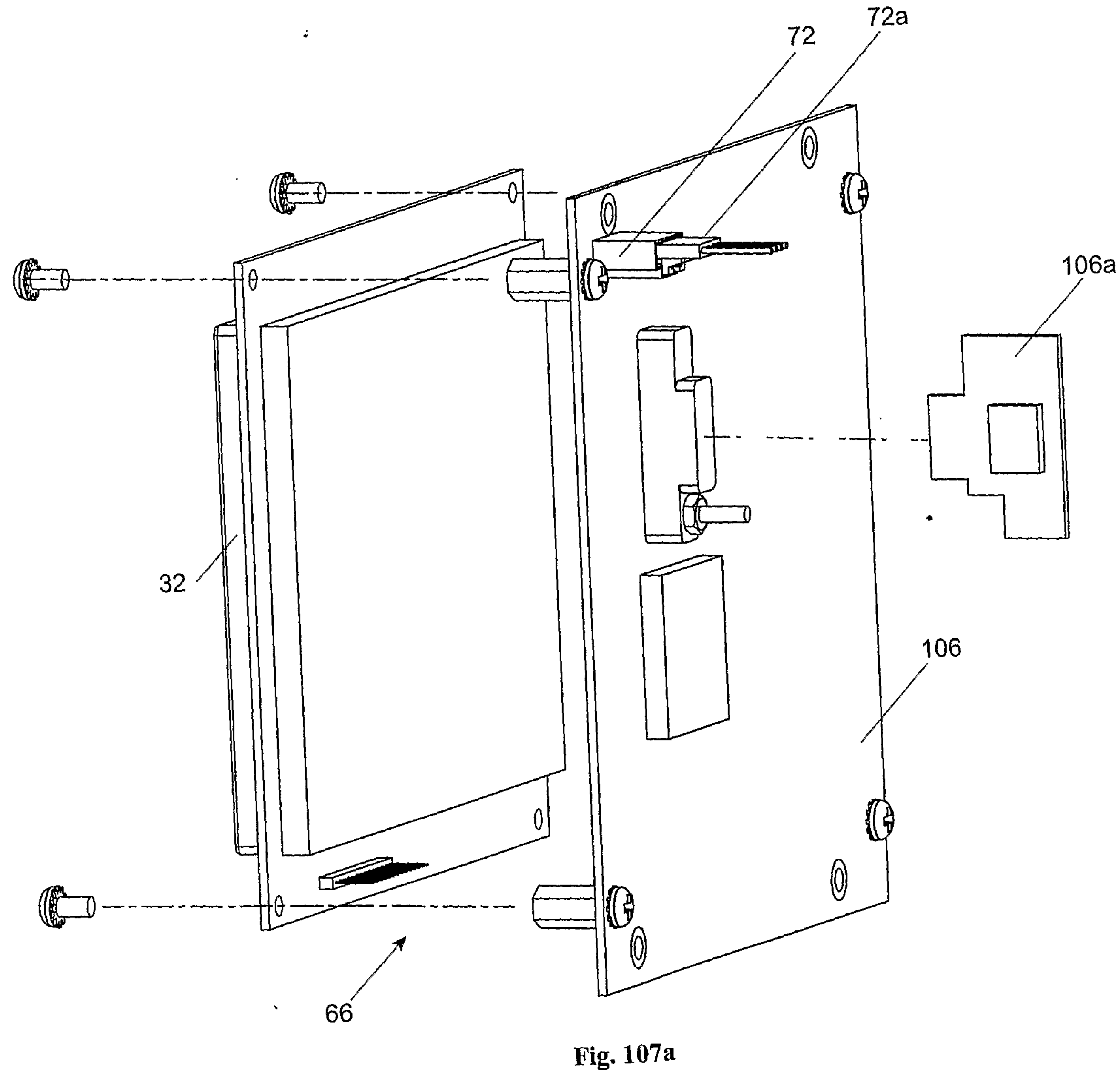


Fig. 107a

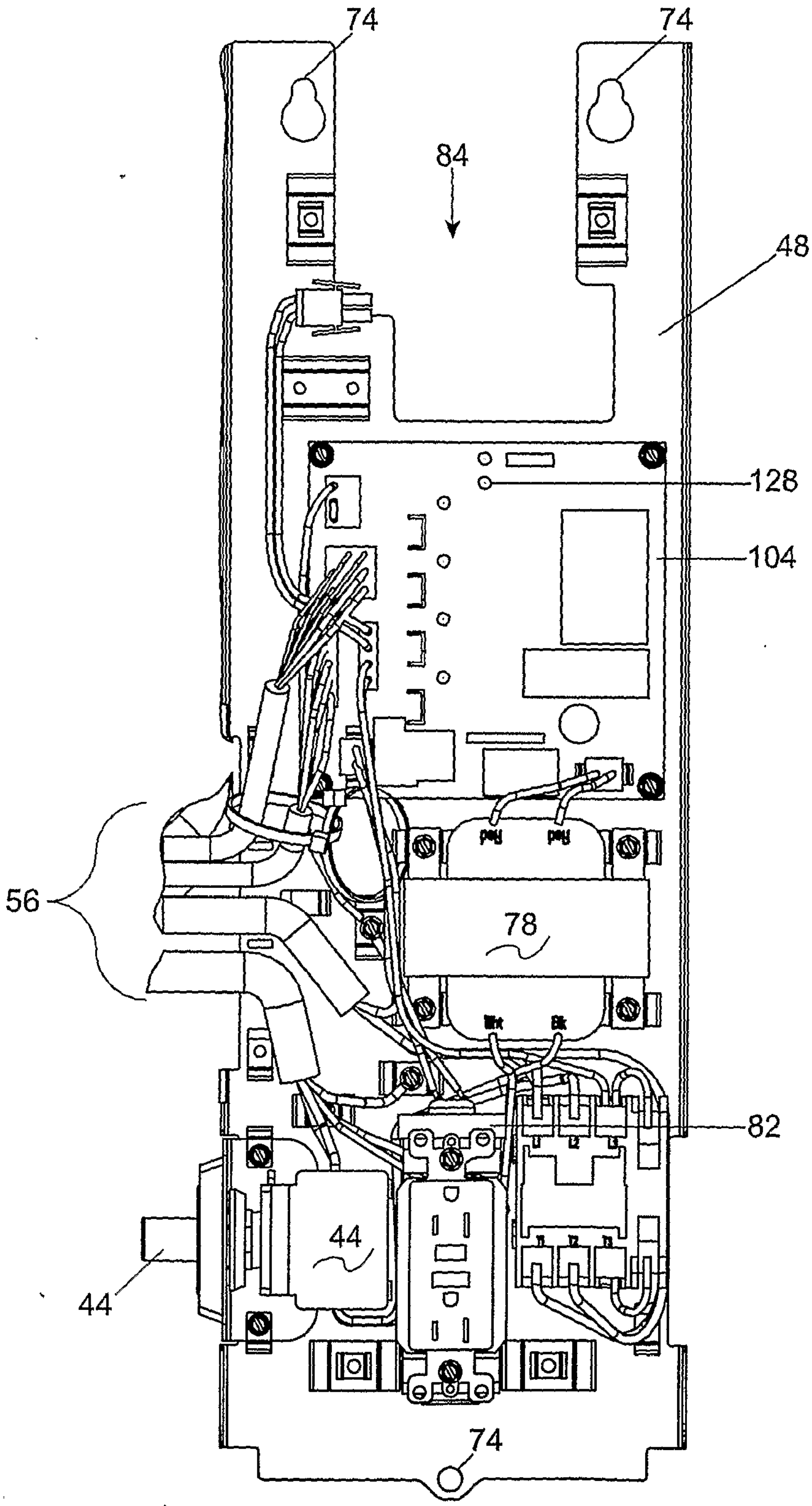


Fig. 108

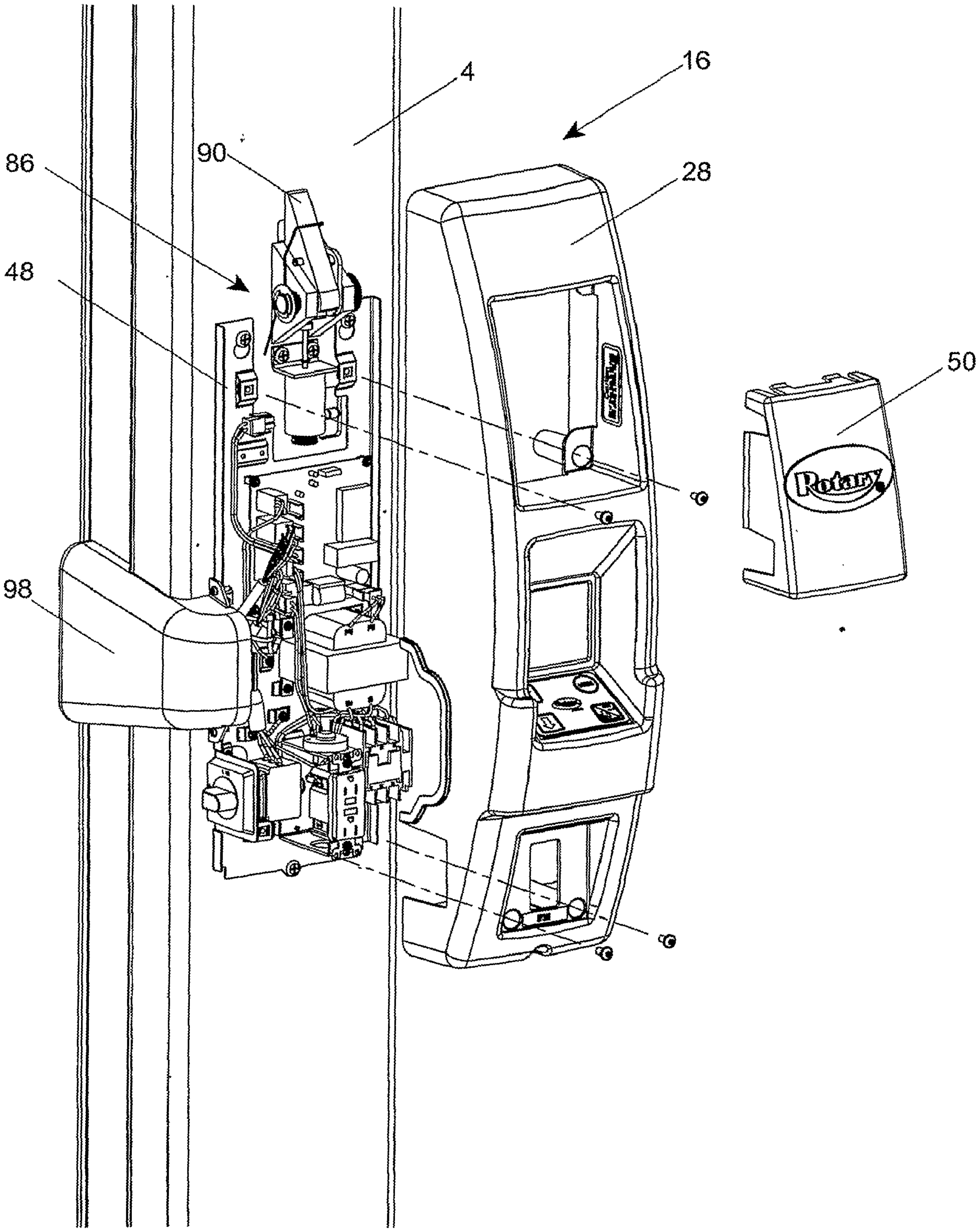


Fig. 109

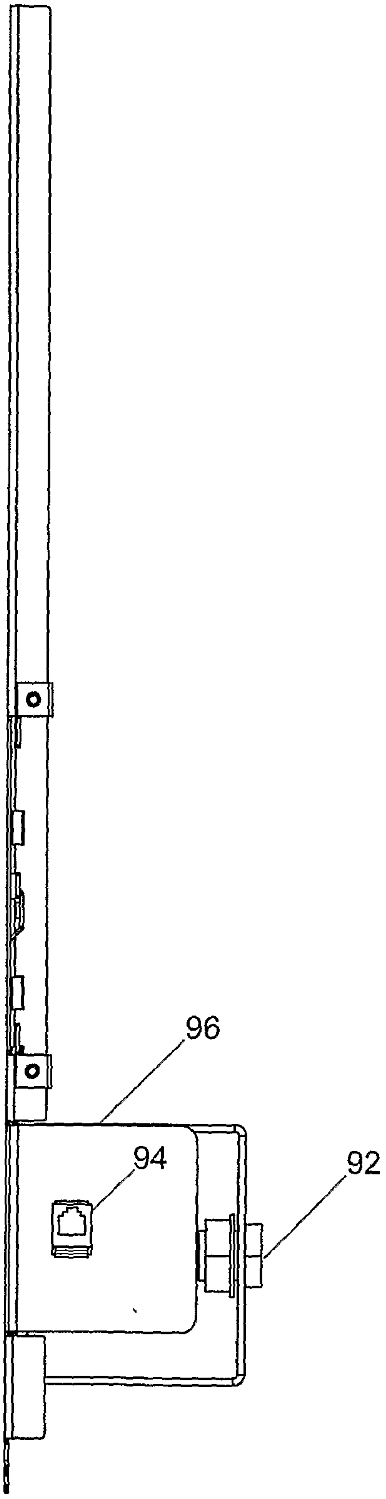


Fig. 110b

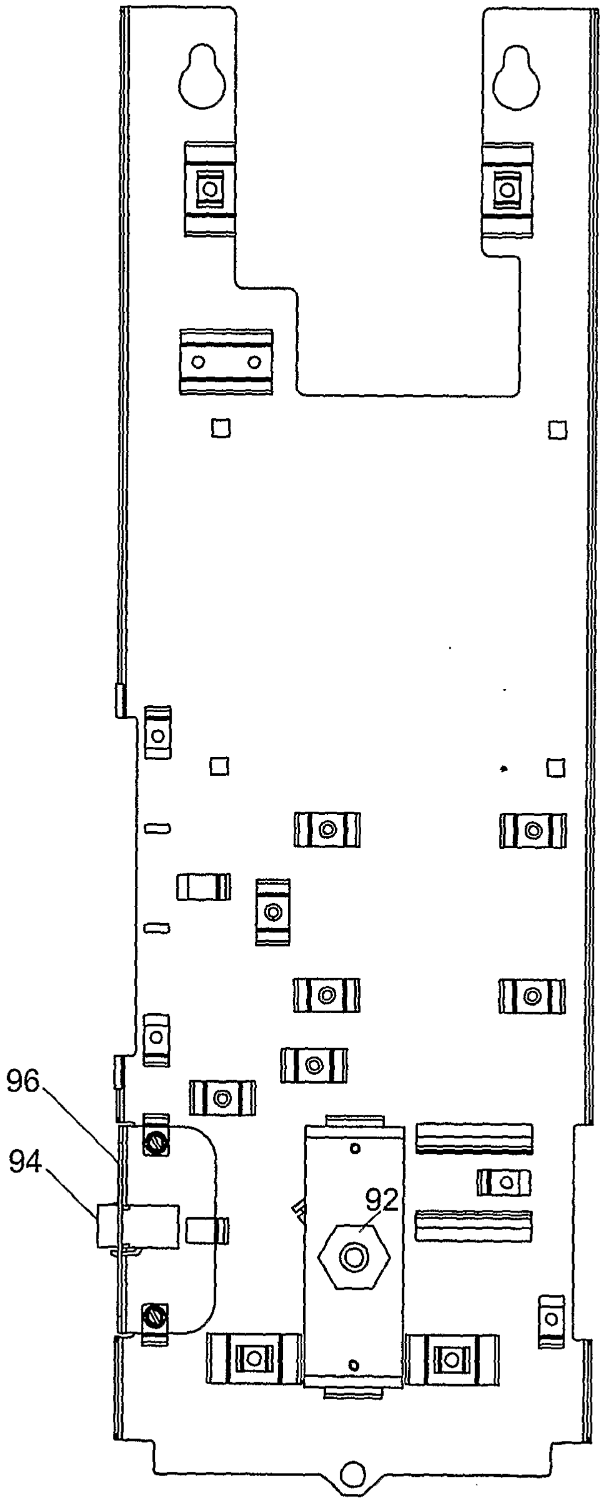


Fig. 110a

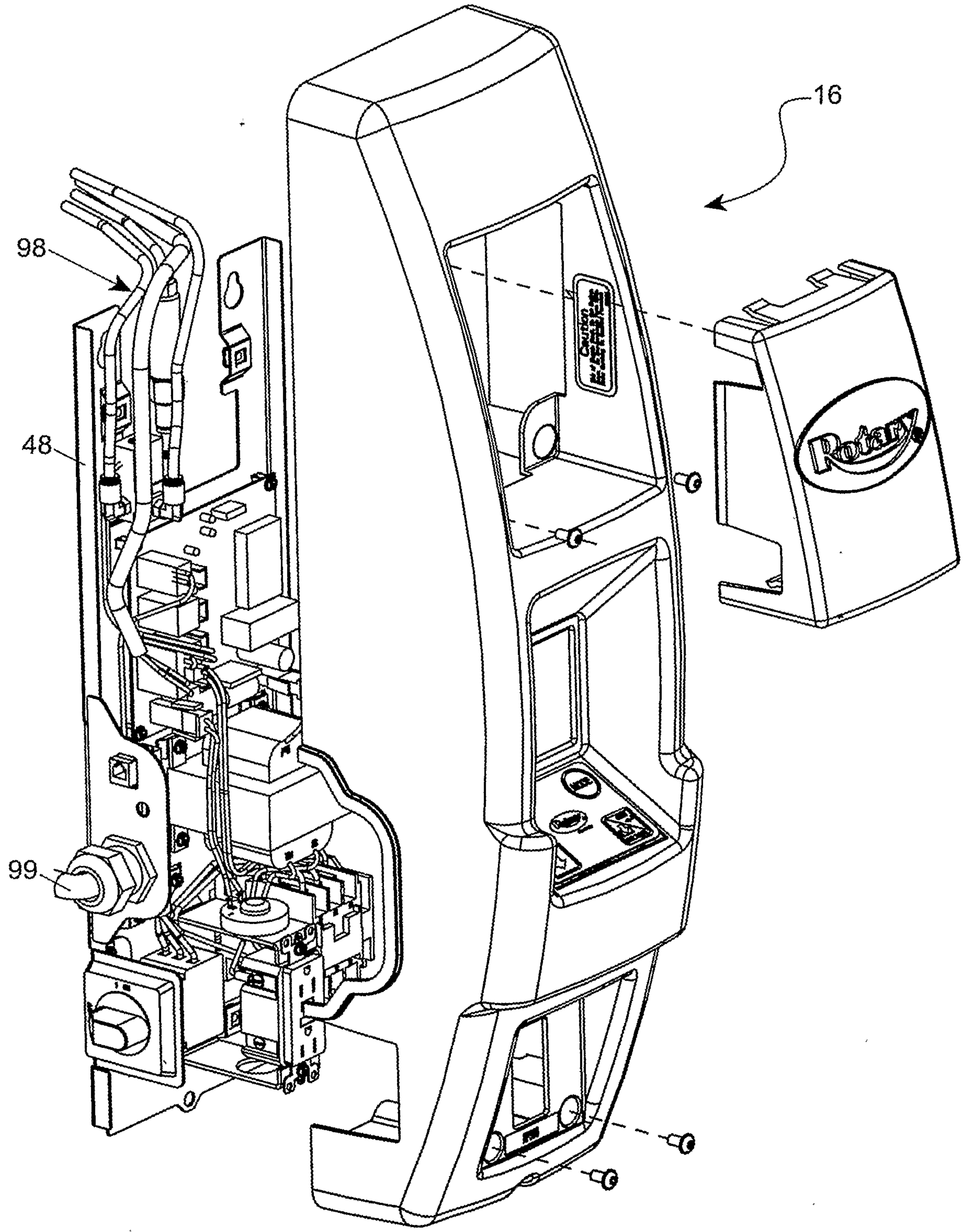


Fig. 111

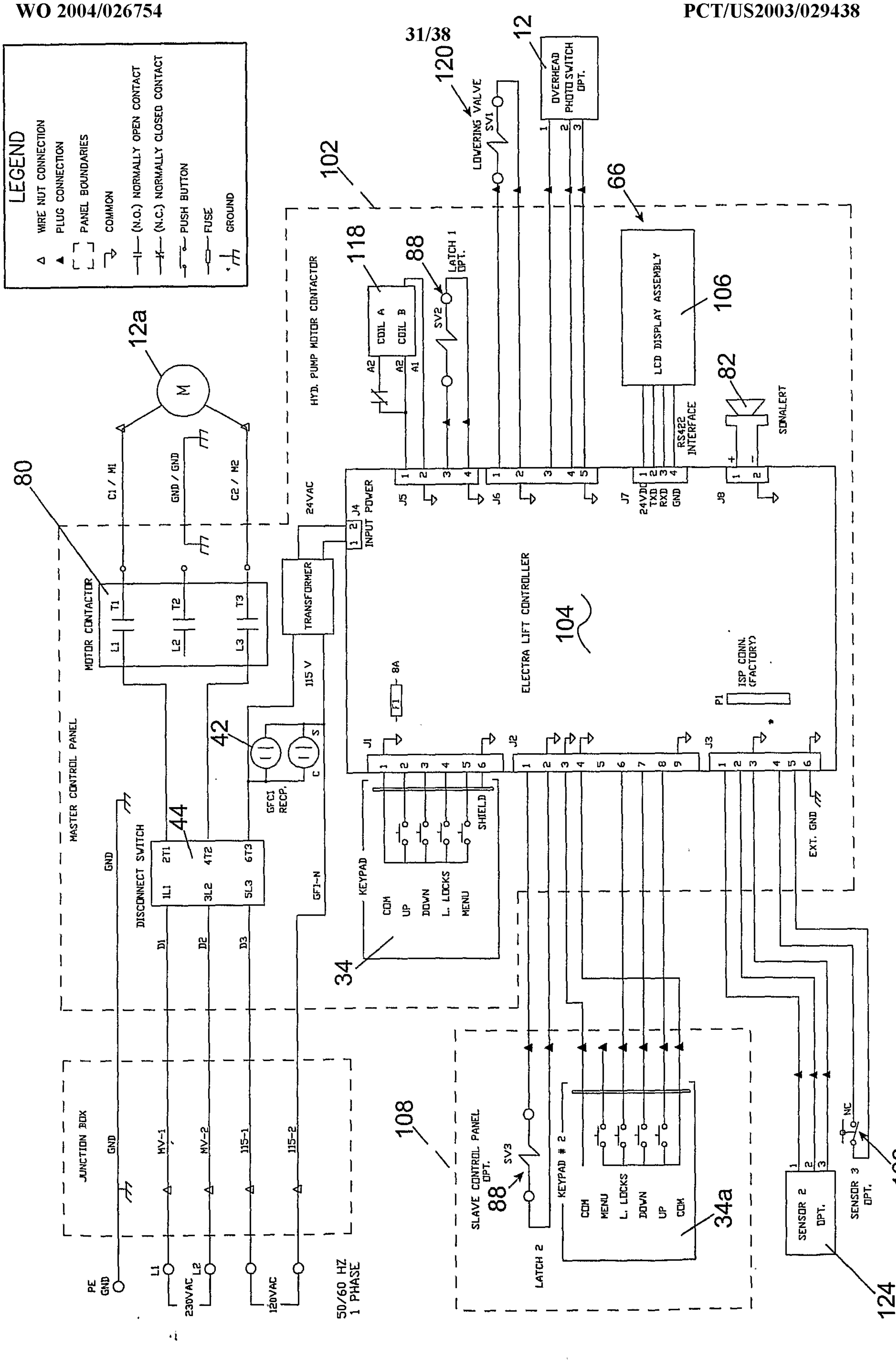

LEGEND
WIRE NUT CONNECTION
PLUG CONNECTION
PANEL BOUNDARIES
COMMON
(N.O.) NORMALLY OPEN CONTACT
(N.C.) NORMALLY CLOSED CONTACT
PUSH BUTTON
FUSE
GROUND
12
OVERHEAD PHOTO SWITCH OPT.
120
LOWERING VALVE
SV1
102
HYD. PUMP MOTOR CONTACTOR
118
COIL A
COIL B
A2
A1
88
LATCH 1 OPT.
SV2
66
LCD DISPLAY ASSEMBLY
106
82
SONALERT
RS422 INTERFACE
24VDC
TXD
RXD
GND
J5
J6
J7
J8
12a
M
80
C1 / M1
GND / GND
C2 / M2
24VAC
J4 INPUT POWER
MOTOR CONTACTOR
T1
T2
T3
L1
L2
L3
TRANSFORMER
115 V
ELECTRA LIFT CONTROLLER
104
8A
F1
ISP CONN. (FACTORY)
P1
J1
J2
J3
42
GFCI RECP.
MASTER CONTROL PANEL
44
DISCONNECT SWITCH
2T1
4T2
6T3
1L1
3L2
5L3
GND
GFI-N
D1
D2
D3
KEYPAD
COM
UP
DOWN
L. LOCKS
MENU
SHIELD
34
EXT. GND
JUNCTION BOX
GND
MV-1
MV-2
115-1
115-2
PE GND
L1
L2
230VAC
120VAC
50/60 HZ 1 PHASE
108
SLAVE CONTROL PANEL OPT.
SV3
88
LATCH 2
KEYPAD # 2
COM
MENU
L. LOCKS
DOWN
UP
COM
34a
SENSOR 2 OPT.
124
NC
SENSOR 3 OPT.
126

Fig. 112

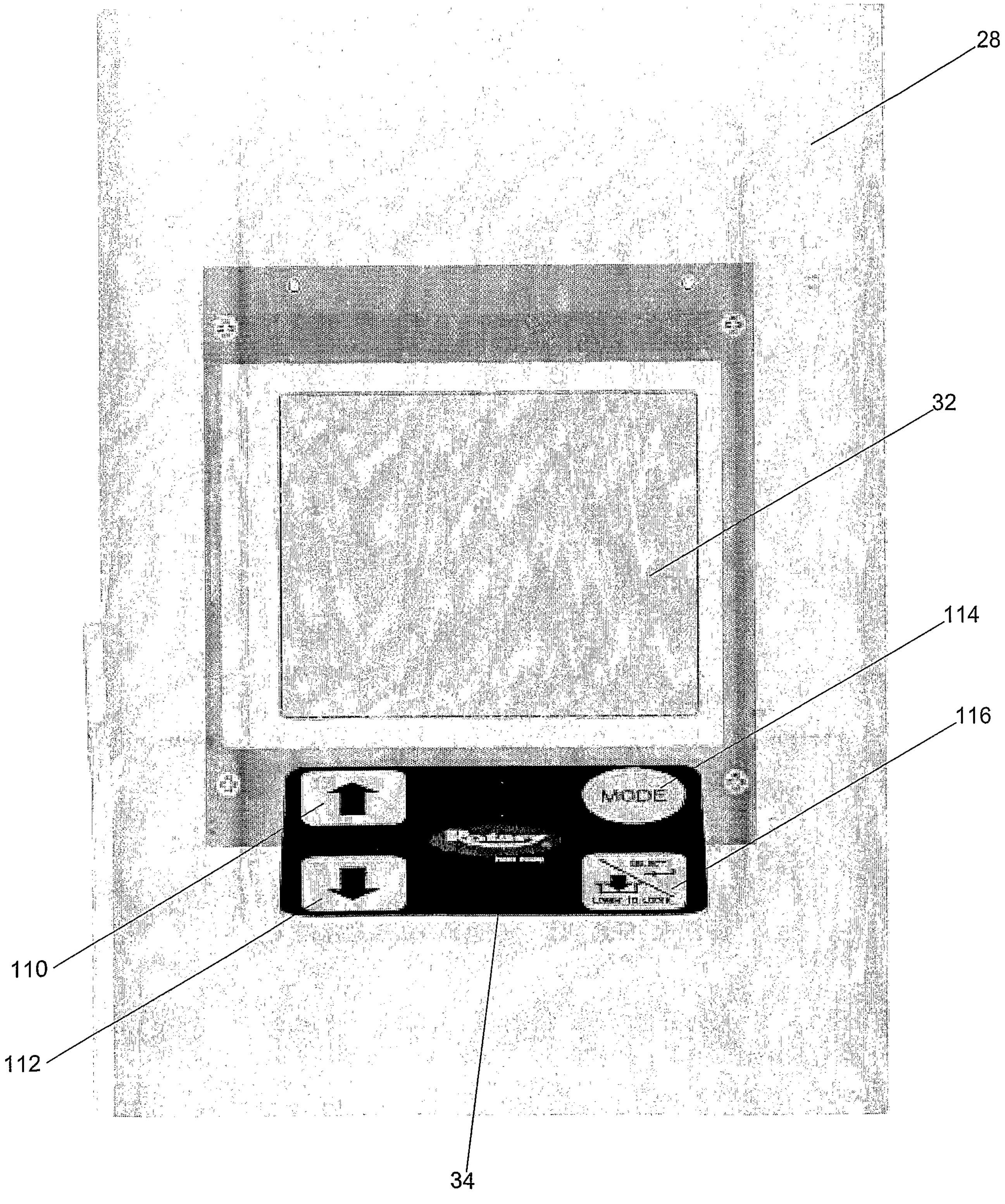


Fig.113

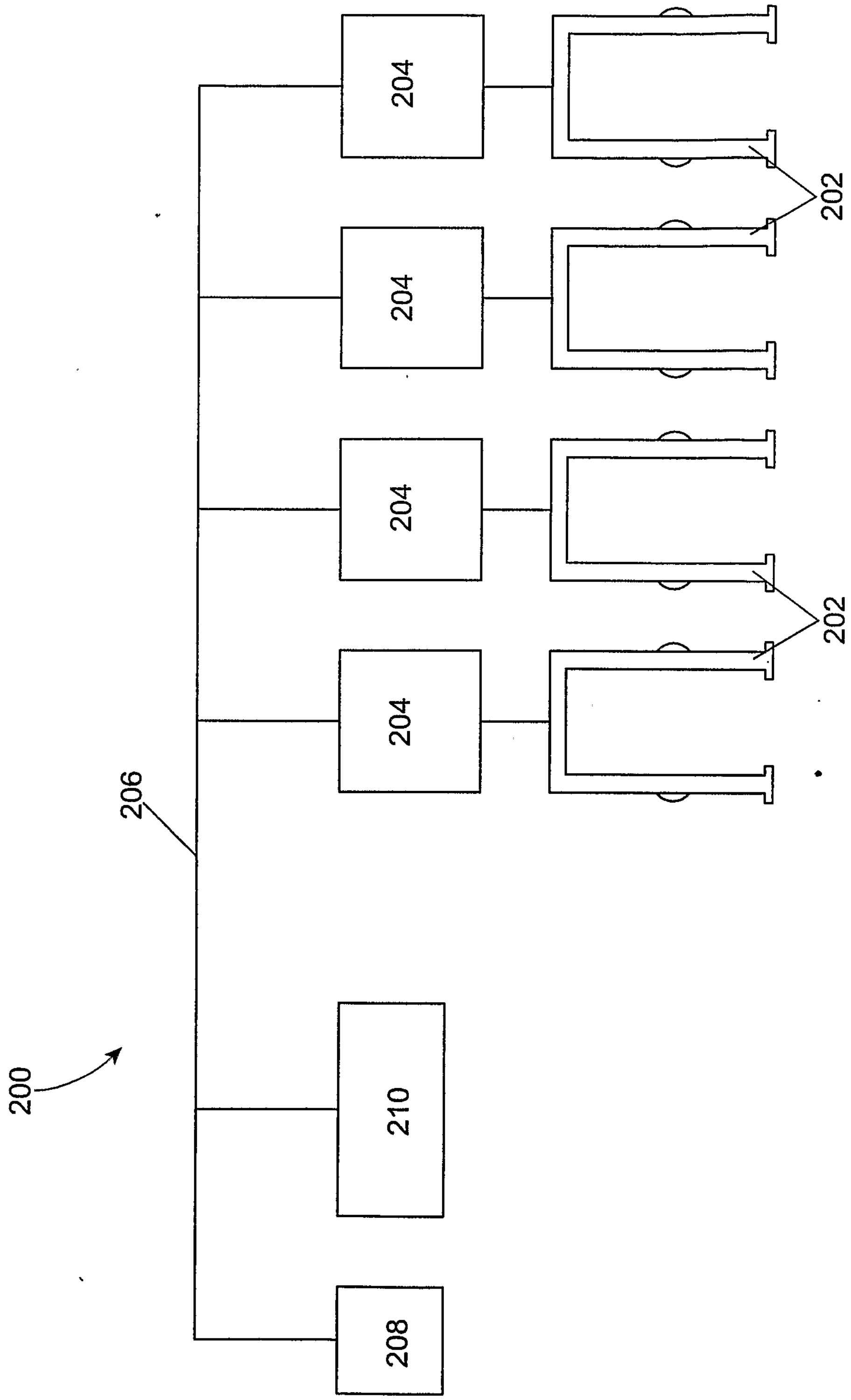


Fig. 114

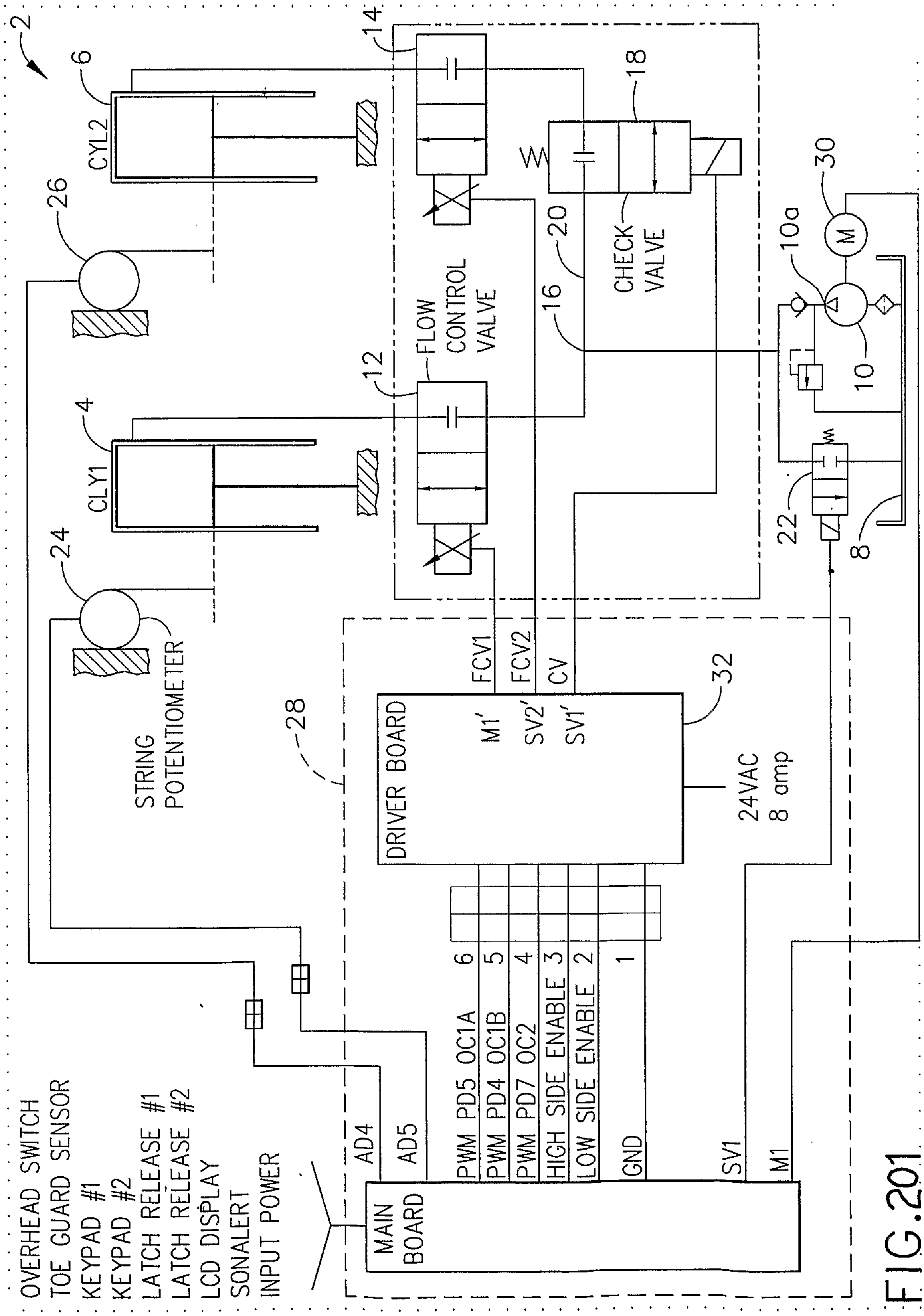

2
6
CYL2
14
18
26
CHECK
VALVE
20
30
M
10a
FLOW
CONTROL
VALVE
16
12
10
4
CLY1
24
22
8
STRING
POTENTIOMETER
28
FCV1
FCV2
CV
32
DRIVER BOARD
M1'
SV2'
SV1'
24VAC
8 amp
6
5
4
3
2
1
OVERHEAD SWITCH
TOE GUARD SENSOR
KEYPAD #1
KEYPAD #2
LATCH RELEASE #1
LATCH RELEASE #2
LCD DISPLAY
SONALERT
INPUT POWER
AD4
AD5
PWM PD5 OC1A
PWM PD4 OC1B
PWM PD7 OC2
HIGH SIDE ENABLE
LOW SIDE ENABLE
GND
SV1
M1
MAIN
BOARD

FIG.201

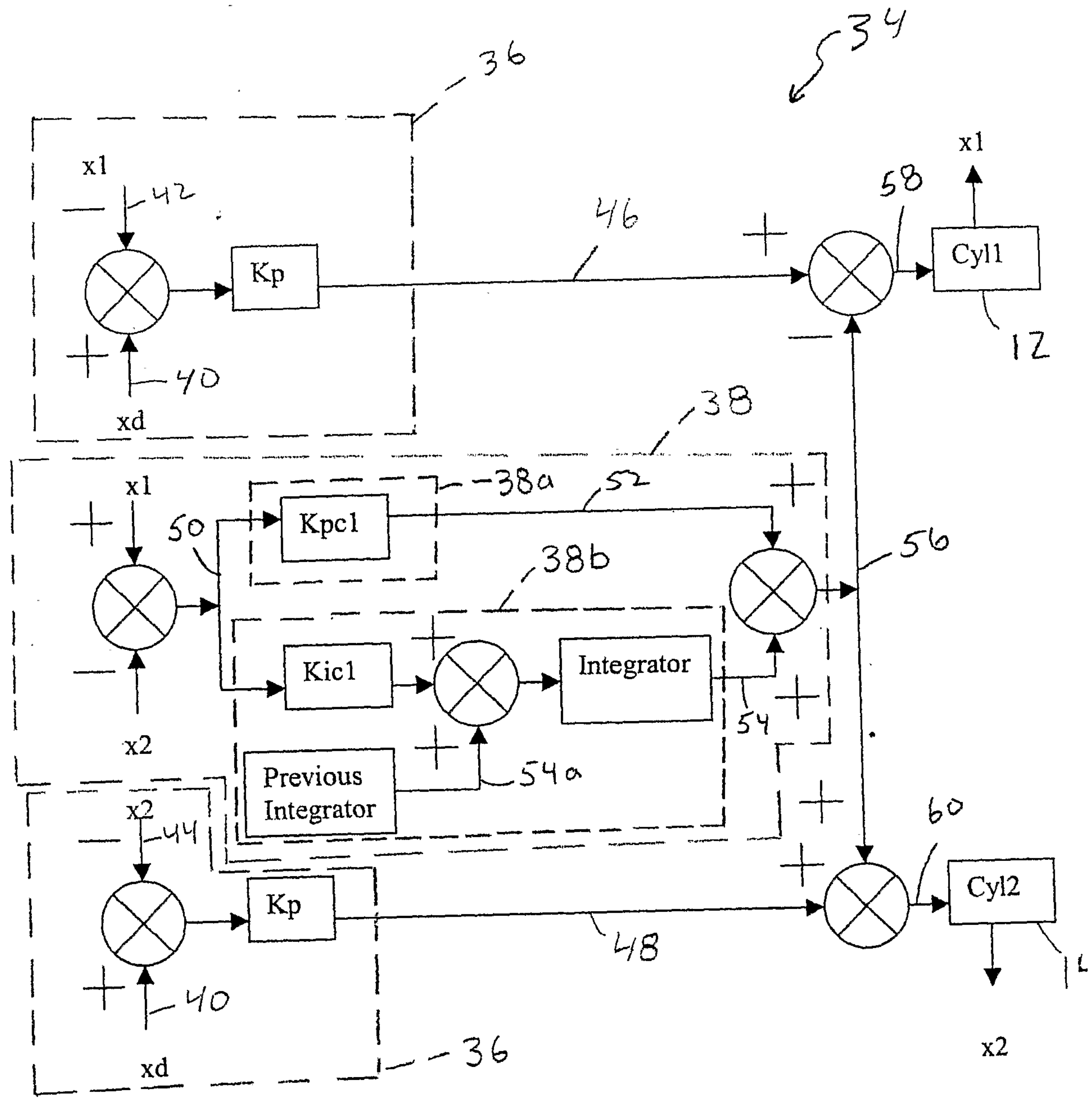

34
36
x1
42
Kp
46
58
x1
Cyl1
12
40
xd
38
x1
38a
52
Kpc1
50
38b
56
Kic1
Integrator
54
x2
Previous Integrator
54a
x2
44
60
Kp
Cyl2
48
40
xd
36
x2

Fig. 202

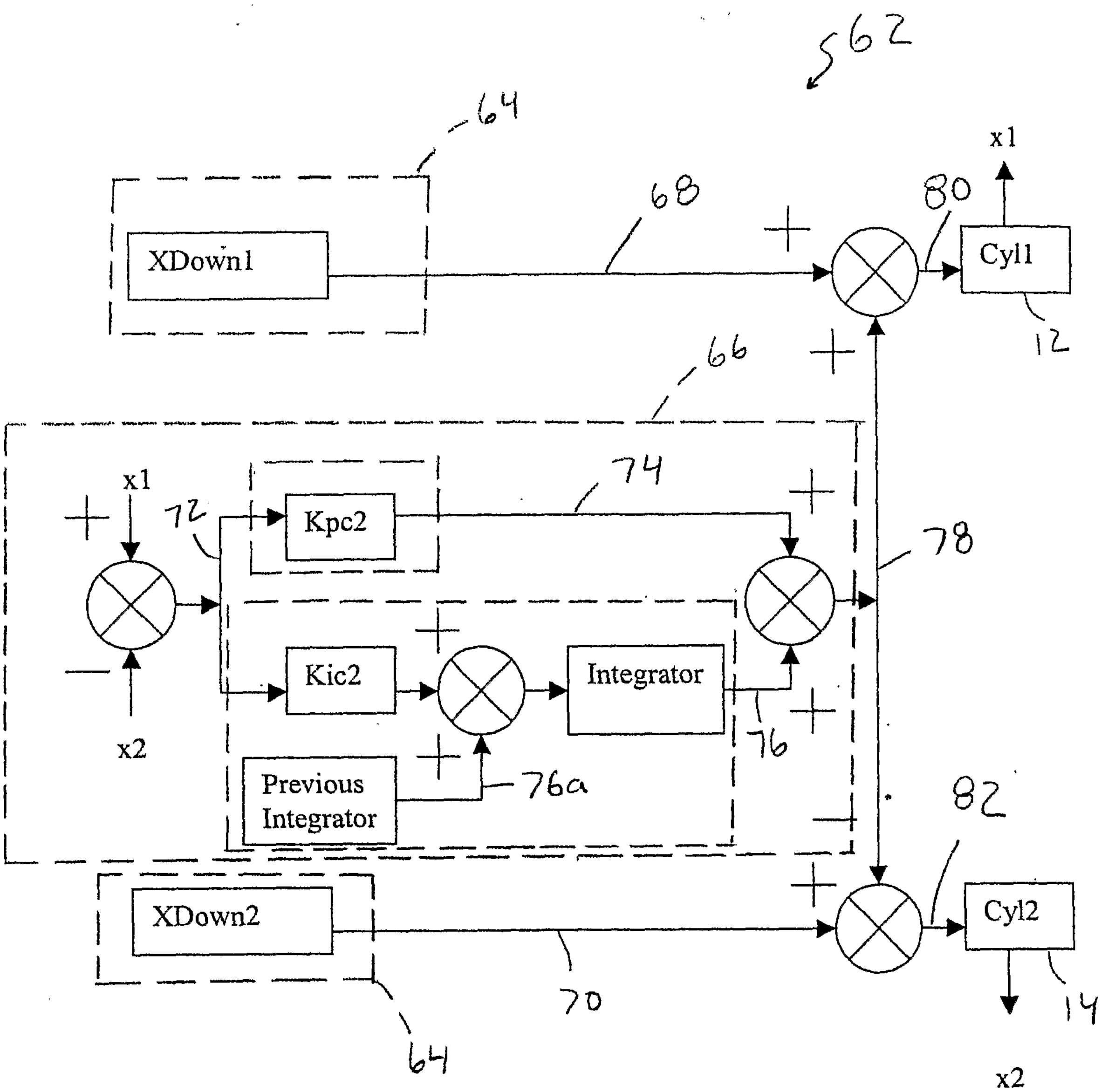

562
64
XDown1
68
+
80
x1
Cyl1
12
+
66
x1
+
72
Kpc2
74
+
78
−
x2
+
Kic2
Integrator
76
+
+
Previous Integrator
76a
82
−
+
XDown2
Cyl2
70
14
64
x2

Fig. 203

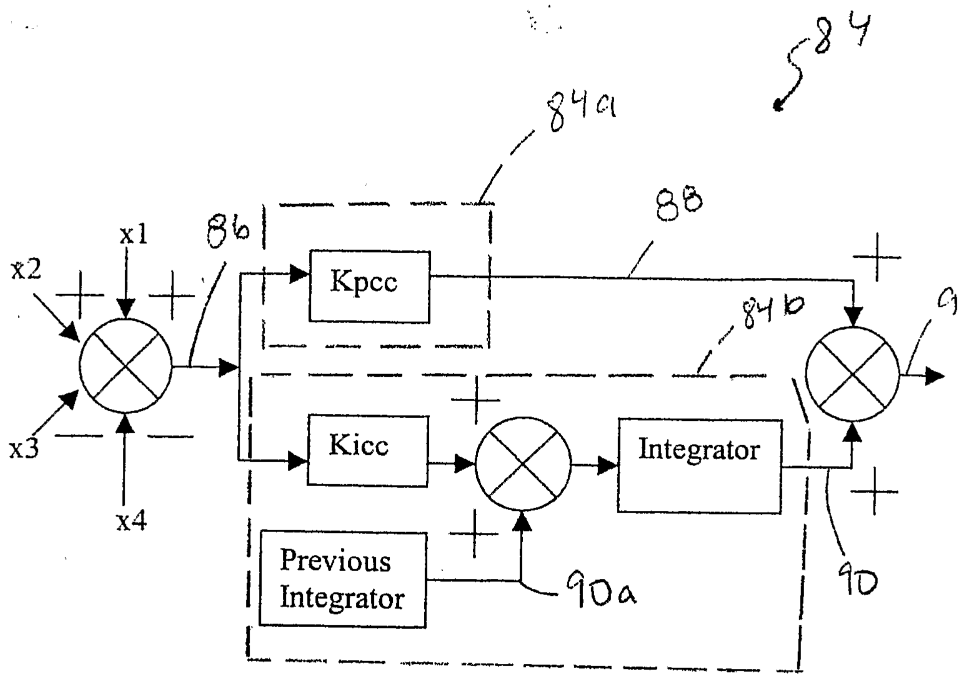


Fig. 204

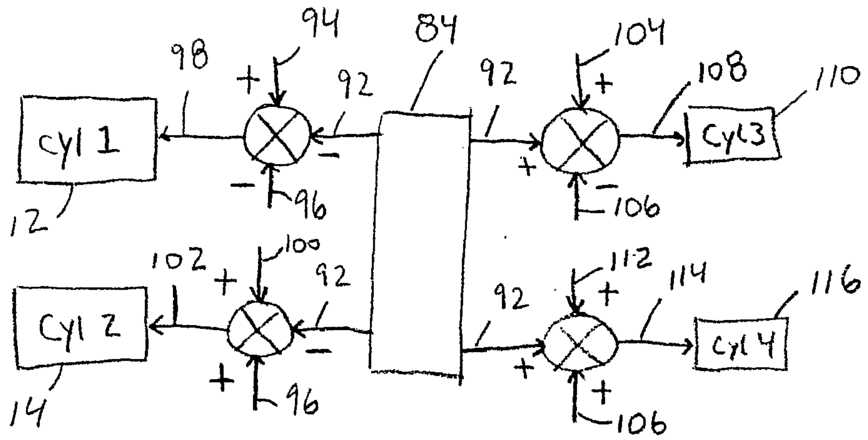


Fig. 205

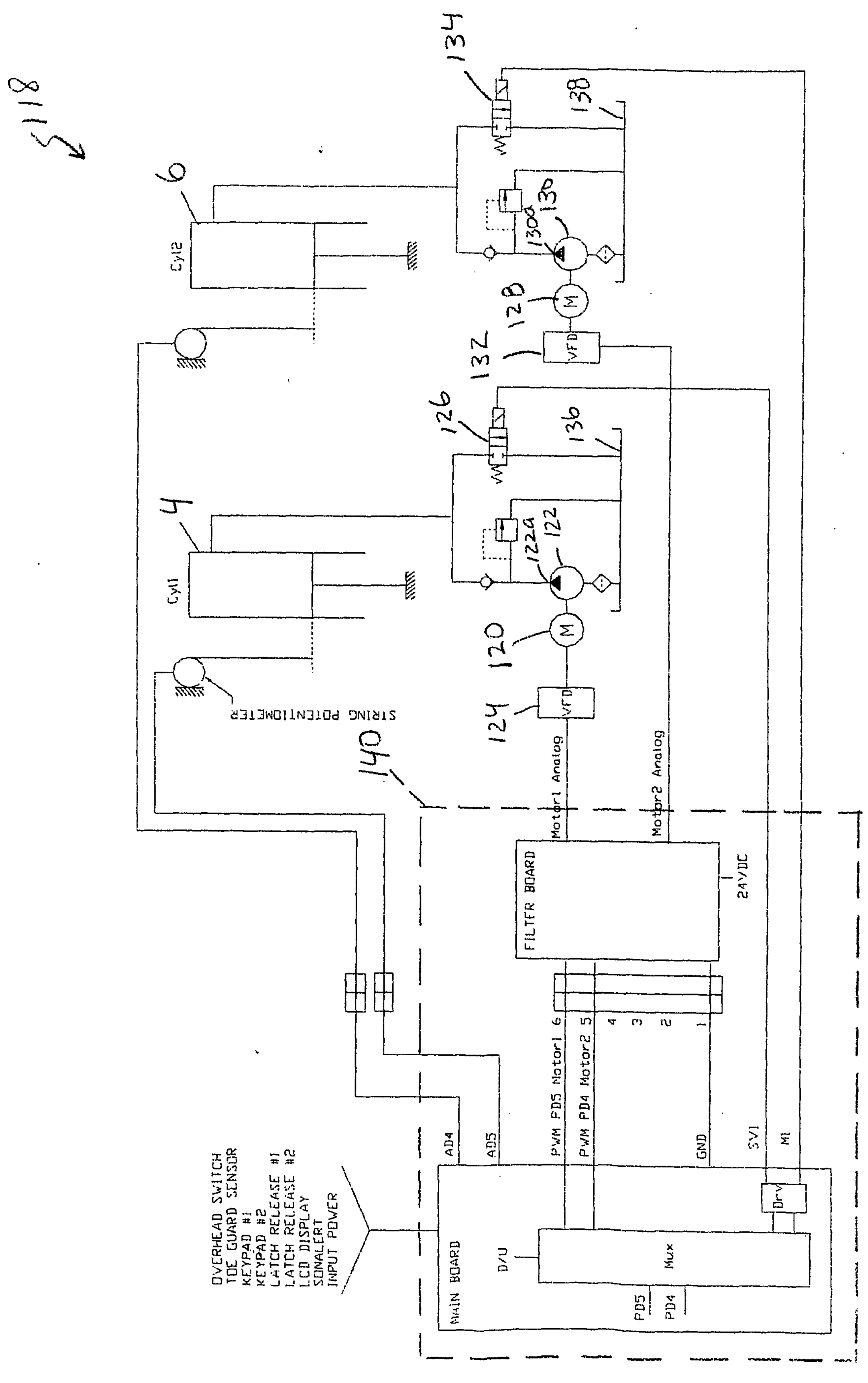

118
6
Cyl2
134
138
130
130a
128
132
VFD
M
126
136
4
Cyl1
122a
122
120
124
STRING POTENTIOMETER
140
Motor1 Analog
Motor2 Analog
FILTER BOARD
24VDC
6
5
4
3
2
1
PWM PD5 Motor1
PWM PD4 Motor2
AD4
AD5
GND
SV1
M1
Drv
Mux
D/U
MAIN BOARD
PD5
PD4
OVERHEAD SWITCH
TOE GUARD SENSOR
KEYPAD #1
KEYPAD #2
LATCH RELEASE #1
LATCH RELEASE #2
LCD DISPLAY
SONALERT
INPUT POWER

Fig. 206