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(54) Asbestos removal system.

(57) A method and apparatus is disclosed for the safe removal of asbestos-containing materials present in buildings in the form of ceiling or wall panels and the like. The apparatus includes a panel-sized containment bin which includes rotary saws that extend outward therefrom to cut loose the asbestos-containing materials. A protective surfactant is first applied to the material to be removed, and the material is then sawed into conveniently sized panels using slow-speed cutting heads and both primary and secondary negative air pressure systems so as to capture within the containment bin any asbestos fibers that become airborne. An encapsulant is also applied to the materials being removed immediately after cutting. The invention may be used for both vertical or horizontal panel installations. The apparatus is mobile and self-propelled, and may be remotely operated to give additional operator safety. The invention when in use has limited the production of residual airborne asbestos fibers to an average of 0.0032 fibers/cc, of fibers over 5 microns long and having an aspect ratio of 3:1, the range of such fiber counts over 15 measurements being 0.0024-0.0047 fibers/cc with a standard deviation of 0.00096.

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ASBESTOS REMOVAL SYSTEM

Field of the Invention

This invention relates to a method for the safe removal of dangerous building materials such as asbestos, and to mobile or portable apparatus for effecting such removal, including apparatus for isolating and containing asbestos fibers.

BACKGROUND OF THE INVENTION

After decades of having asbestos materials employed for insulating purposes in public, commercial, industrial and residential buildings in the United States and elsewhere, it has been discovered that such materials may act as a source of inhalable fibers which pose a significant health risk and can cause permanent damage to the lungs, specifically to cause lung cancer. Asbestos materials that have been installed for many years, even if painted over, can produce an airborne effluent of ultra-small asbestos particulates of sufficient concentration to be quite dangerous. As a result of these discoveries, efforts have been made to remove all such installed asbestos in order that the buildings in which it is present may again be safely inhabited.

However, the process of removing the asbestos has itself been found to a significant source of danger. In particular, the operation of removing the asbestos can create an intensified hazard in that any mechanical manipulation of the asbestos, as by sawing, e.g., of asbestos containing panels, will create an immediate, local increase in the concentration of airborne asbestos fibers that will endanger the person seeking to remove the asbestos. The smallest fibers, which are those having diameters of 0.1 micron or less and lengths of less than 5 microns, are believed to be the most hazardous to human health, and also the most likely to remain airborne and thus subject to inhalation for extended periods of time. Various statutory and regulatory provisions or policies have thus been established requiring not only that such asbestos materials be removed, but also that any such removal be carried out in a manner that will minimize the danger to the health of the person doing the removal.

A number of attempts have thus been made to develop methods and apparatus for protection against or for the safe removal of asbestos materials that have been installed in the walls and ceilings, etc., of every kind of building. With regard to protection, U. S. Patent No. 4,632,847 to Lomasney et al. describes a process of using a polymeric membrane that is applied as a liquid to surfaces that are in the vicinity of an asbestos removal operation so as to protect them from asbestos contamination. The protection of other persons is addressed in U. S. Patent No. 4,604,111 issued to Natale, which seeks to minimize asbestos contamination in regions surrounding the area in which asbestos removal is taking place by surrounding the area with an enclosure on the order of room size which also has decontamination chamber spaces, preferably including three separate "rooms" thereof, at its entrances and exits. A vacuum filtration system generates a negative air pressure throughout the enclosure. However, the persons who are actually doing the asbestos removal remain exposed to the asbestos, and are protected only by protective clothing and breathing masks.

As to the removal of such materials, U. S. Patent No. 4,626,291 to Natale describes a containment bag system for the removal of asbestos insulation from asbestos covered pipes and valves which provides a tool pouch internal to the bag, armholes for worker access, and means for wetting the material removed and for evacuating the bag with a suitable vacuum device. Other devices of the kind are described in Canadian Patent No. 1,188,191 to Atkinson, U. K. Patent No. 1,567,270 to Atkinson, and in PCT Application No. WO86/05431 of Hamlet et al. Such devices, however, require the immediate presence of the worker, and are not suitable for the removal, e.g., of large wall and ceiling panels that cannot be enclosed in a containment bag.

For the latter type removal activities, it has become the practice to isolate the area of asbestos removal by sheets of polyethylene film that are duct-taped into place so as to form an enclosure within which a negative pressure is created that will inhibit the escape of asbestos particles therefrom. British patent application No. 2,168,475A describes means for connecting a conduit pipe from the interior of a protective tent to the exterior thereof, so that vacuum may be used to remove asbestos dust from within the tent for external disposal. While not being suited to asbestos removal operations, British application No. 2,131,160A discloses a machine tool cutter that provides for removing cuttings by vacuum suction. Russian patent application No. 1,168,780A discloses a dust protective housing including an air purification system and having a working table and an air extraction box under the table. When using these systems, however, the persons doing the removal work are again protected from dust contamination only by using

protective clothing and breathing masks.

Also, devices for the removal of building materials and the like from within a building have sometimes not taken account of the hazardous nature of such materials. For example, U. S. Patent No. 4,682,448 to Healey is intended to aid in doing above-ceiling work and provides a shelter that extends from floor to ceiling within which the materials to be removed may be collected without being spread into the surrounding space, together with a vacuum system for creating a negative pressure within the shelter. However, this device also requires the worker to be within the shelter and thus to be exposed to the materials being removed.

It would be desireable, therefore, to provide an apparatus and method whereby the debris produced in sawing loose a wall, ceiling or floor panel could be encapsulated or isolated as soon as possible, particularly any such debris that is of a small enough size to become airborne and thus to produce asbestos particles of the smallest sizes that are especially hazardous to human health. Additionally, it would be desireable to provide means by which a worker who is removing pieces or panels of asbestos materials from building structures may be isolated as much as is practicable from the actual cutting operations. Such a method and apparatus are provided by the present invention, as hereinafter described.

SUMMARY OF THE INVENTION

The present invention comprises a method and apparatus for removing hazardous building materials such as wall, ceiling or floor panels that may include asbestos. The apparatus includes a portable or mobile containment bin that may be moved to an area of a wall, ceiling or floor from within which the materials that may contain asbestos are to be removed. The apparatus is moved to a selected area of a wall, ceiling or floor and the containment bin is placed in close proximity thereto. An effective amount of surfactant is sprayed onto the selected area at which sawing is to occur so as to minimize dust creation. A vacuum system which will provide a negative air pressure within the containment bin and in the immediate vicinity of the saw is also actuated so as to capture the debris created by the sawing operation. One or more saws located within the containment bin are then actuated so as to loosen conveniently sized panels of the material to be removed. In the case that there are two or more saws, at least one of them is laterally moveable with respect to another such saw, in order to permit adjustment of the size of the panels to be removed. Surfactant is also sprayed onto the area of the cut in the course of sawing, and the cutting debris may either be allowed to fall to the bottom of the containment bin within which there exists a negative pressure, or such debris may be actively removed by the vacuum system that creates that negative air pressure. Upon sufficient loosening of a panel that it is nearly ready for removal, e.g., so as to require only the cutting of bonding wires to effect complete removal, the containment bin is removed from near the panel and, in the case that the panels are to be removed from a ceiling, may be replaced by any convenient lift device for accepting the loosened panel. The final removal step is then carried out, and a ealant or encapsulant is sprayed onto each panel as it is removed onto the lift device. The panels so removed are then stacked to a convenient height and sealed in plastic for disposal, and the cutting debris from the sawing operation is also encapsulated or enclosed in plastic for disposal.

Spraying operations are pressure actuated, the horizontal motion of the apparatus is either manual or motor driven, and the vertical lift of the containment bin is by an electrically controlled hydraulic system. When removing ceiling or floor panels, the motor which moves the apparatus about the floor also provides the driving force for the sawing operation, while the vertical lift maintains the saws in contact with the surface to be sawed. When carrying out a vertical cut in removing panels from a vertical wall, the motor that moves the apparatus about the floor holds the saws against the surface to be cut, and it is the vertical lift that provides the driving force for the saws. When carrying out a horizontal cut on a vertical wall, the vertical lift positions the saws for cutting, and it is the driving force for the apparatus which both holds the saws against the wall for cutting and provides the driving force for the sawing operation. All of such operations except for the final removal of each panel or any manual movement of the apparatus may be carried out from a remote location using a cabled remote operator interface. A more detailed description of the invention now proceeds with reference to the following drawings, in which like elements are designated by the same number in the different figures.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic drawing which depicts the principal mechanical features of one embodiment of the present invention that may be used for removing panels from horizontal ceilings.

Fig. 2 is a top view of an alternative embodiment of the apparatus of Fig. 1.

Figs. 3a and 3b (3b being partially cut away) are alternate perspective views of one preferred embodiment of the present invention for removing panels from horizontal ceilings, said embodiment including mobile transport and lift features.

Fig. 4 is a more detailed, exploded view of the manner of construction of the containment bin and blower bin of Fig. 3.

Fig. 5 is a more detailed view of the primary vacuum system shown in Fig. 3.

Fig. 6 is a more detailed view of the saw and saw motor assembly which shows the attachment of the cutting support shoe.

Fig. 7 is a partially disassembled view of the saw and saw motor assembly and its attachment within the containment bin.

Fig. 8 is a cross-sectional drawing of the containment bin and saw assembly that illustrates the operation of the primary and secondary negative air pressure systems and the placement of the cutting saws into rest and cutting positions.

Fig. 9 is a detailed schematic drawing of equipment for providing surfactant and encapsulant to the materials being removed.

Fig. 10 is a detailed schematic drawing of the pneumatic distribution manifold.

Fig. 11 is a schematic drawing of the control pendent which permits remote operation of the apparatus.

Figs. 12a and 12b illustrate alternative embodiments of the apparatus of Figs. 3a-3b that are useable for removing panels respectively from a wall and from a floor.

DETAILED DESCRIPTION

As shown schematically in Fig. 1, the principle components of one simple embodiment of the present invention include a containment bin 10, a hydraulic lift 20, a hollow flexible duct 30, and an exhaust blower 40. Contained within containment bin 10 are one or more saws 12 that are operated by saw motors 14, said saw motors 14 being designed to operate at slow speeds so as to minimize throwing off the sawing debris ("sawdust") that will be produced when saws 12 are applied to a wall, ceiling or floor. (The detailed nature of these respective saws and motors will be set forth below in connection with the description of additional embodiments.)

In more detail, containment bin 10 is mounted on hydraulic lift 20 which in turn is mounted on horizontal stand 22 having three or more wheels 24 (only two of which are shown in Fig. 1) that are distributed in a spaced-apart relationship so as to allow horizontal movement of stand 22 over a surface such as a floor. The volume of bin 10 is defined by opposite walls 16a and 16b, to the respective opposite ends of which opposite walls 16c and 16d (not shown in Fig. 1) are attached in an airtight manner. Bin floor 18 is attached in an airtight manner at the lower edges of walls 16a-16d. Lift 20 may be actuated either hydraulically or electrically and of any appropriate commercial variety. In this embodiment, lift 20 consists, e.g., of a Marklift Model No. S3315, and serves to lift bin 10 into close proximity to a ceiling area 26 within which a panel of material that may contain asbestos is to be cut free.

Proximal end 32 of flexible duct 30 is attached to bin 10 through exhaust outlet 34 consisting of a hollow tube that passes through bin floor 18 and provides access to the interior of bin 10. Duct 30 leads therefrom to distal end 36 thereof which is attached through exhaust inlet 38, likewise consisting of a hollow tube, to exhaust blower 40, said inlet 38 providing access to the interior of blower 40 so as to create a negative air pressure within bin 10 when blower 40 is operated. Blower 40 includes a blower outlet 42 and a high efficiency particulate (HEPA) filter 44, and may be of any variety of appropriate size such as the GE-Phantom III Negative Air Machine. Preferably, blower 40 will be supplied with three or more wheels 46 (only two of which are shown in Fig. 1) in order that it may be moved about on floor 48 as containment bin 10 is moved from area to area along a ceiling, wall or floor.

Figure 2 shows a top plan view of an alternative embodiment of the apparatus of Fig. 1 in which blower 40′ (and accompanying filter 44′) is contained within the apparatus structure. In more detail, this embodiment includes both a containment bin 10′ and an adjacent blower bin 50 within which blower 40′ is mounted so as to be in direct contact with containment bin 10′. In this case, containment bin 10, includes an exhaust window 34′, and exhaust inlet 38′ of blower 40′ is placed into direct contact with containment bin 10′ and is sized so that it can be fitted or at least taped into exhaust window 34′ so as to provide an air-tight seal.

Saws 12a, 12b are positioned at selected locations within containment bin 10′ together with motors 14a, 14b, respectively, which provide power to run saws 12a, 12b. The combination of saw 12a and motor 14a is positioned nearly adjacent to an outer wall 16a of bin 10′, while the combination of saw 12b and motor 14b is mounted at a selectable distance from outer wall 16b of bin 10′, wall 16b oppositely facing wall 16a. Walls 16a and 16b extend so as to encompass the areas of both containment bin 10′ and blower bin 50, and walls 16c and 16d are attached in an airtight manner at

respective opposite ends thereof so as to enclose the complete area of containment bin 10′ and blower bin 50. The distance from outer wall 16b to saw 12b and motor 14b is not predetermined, in order that saw 12b and motor 14b may be positioned so as to define a selected distance therefrom to saw 12a and motor 14a, thereby to define the distance between saws 12a and 12b and hence the desired size of a panel of asbestos-containing material to be cut free. Typically, saw 12b and motor 14b are positioned so as to yield panels that are 40 inches on a side, although one form of the apparatus has been constructed in which that position is adjustable so as to yield such a dimension ranging from 39 to 44 inches.

The foregoing embodiment of the invention provides certain advantages in the removal of asbestos panels from a ceiling or wall, in that the portable containment bin 10 (or 10′) reduces the volume within which a negative pressure must be created in order to minimize asbestos contamination of other spaces, as compared to the methods of the prior art that have sought to create a negative pressure throughout an entire room. However, containment bin 10 (and particularly 10′) gives to the device a dangerously high center of gravity, and the device must be moved about manually by rolling stand 22 over floor 48, both to select an area on which to work and also to force saws 12 through the selected area. Consequently, the operator of this embodiment of the invention is obliged te remain in the vicinity of the sawing operation that loosens the asbestos panels, and may therefore be exposed to at least some amount of loose asbestos fibers. A more preferred embodiment that is of a physically safer design and that may be remotely operated is shown in Fig. 3.

Specifically, Fig. 3 shows an improved apparatus 60 in which a modified containment bin 62 and a negative air pressure unit or blower bin 64 and filters 66 are mounted on a table 68 that is itself mounted on an equipment platform 70, the height of which is adjustable by hydraulically operated scissors jack 72 that is of a size much larger than bins 62, 64. Scissors jack 72, which may be of any appropriately sized commercial variety but which in the preferred embodiment is that incorporated into the Mark Industries Model 25E Marklift, is mounted on a drive platform 74. In this embodiment, jack 72 has a height when lowered of 47.5 inches and an extended height of 25 feet, thus providing ample extension for reaching the ceiling of almost any building structure. Of course, in extreme cases it may be necessary to substitute an alternative scissors jack with greater extension, and that may be done without departing from the scope of the present invention. The Marklift Model 25E has a lifting capacity of 1500 lbs., which is sufficient to lift the weight of containment bin 62, blower bin 64, and their included equipment in the present embodiment, though that factor may also need to be adjusted to accommodate alternative embodiments of different size. Similarly, the Marklift Model 25E provides a lift/lower speed of approximately 1 foot per second, which is convenient for most working purposes.

In order to impart mobility to the present apparatus, drive platform 74 has attached thereto in the conventional manner a pair of steering wheels 76a, 76b and a pair of drive wheels 78a, 78b that are operated by a drive motor 80 through a drive shaft in the conventional manner. The drive mechanism provided by drive motor 80, drive wheels 78a, 78b and steering wheels 76a, 76b permits apparatus 70 to be mobile or self-moving, i.e., it does not need to be moved manually from place to place along a wall, ceiling or floor. That mechanism also provides the necessary motion in the direction of arrow 81 in Fig. 3 so as to force the cutting saws along the surfaces to be cut, as will be described hereinafter.

As shown in more detail in Fig. 4, containment bin 62 has at the top thereof a surface 82 within which are incorporated a pair of apertures 84a, 84b that are each sized to accommodate a saw shroud (shown hereinafter). The volume of containment bin 62 is defined by walls 86a, 86b, 86c and 86d in the same manner as was described with respect to containment bin 10′. The bottom surface of containment bin 62 is defined by the top surface 88 of table 68 upon which containment bin 62 is placed. (In the alternative, containment bin 62 may include an integral bottom surface, and table 68 may provide just a framework, instead of a top surface 88, upon which such a bottom surface of containment bin 62 may rest.) Wall 86c of containment bin 62 includes therein a vacuum orifice 90 within which is placed a prefilter 92, adjacent to which there is then placed a secondary filter 94 which fits into an orifice (not shown) in the facing end of blower bin 64. As noted earlier, blower bin 64 contains therein a high efficiency particulate (HEPA) filter and fan for creating a negative air pressure within containment bin 62. In apparatus 60, however, the negative air system defined by blower bin 64 and containment bin 62 constitutes a secondary negative air pressure system, the primary negative air pressure system being established at the immediate vicinity of the saws, as will be described more fully hereinafter.

More specifically, as is shown in Figs. 5 and 6, each of saws 96a, 96b is surrounded by respective saw shrouds 98a, 98b that, as was noted earlier, are placed into respective apertures 84a, 84b in top surface 82 of containment bin 62. As can best be seen in Fig. 6 (which shows only one of saws 96a,

96b and saw shrouds 98a, 98b), saw shroud 98 is partially circular in cross-section and has a thickness sufficient to accommodate circular saw 96 therein. That generally circular shape is modified as though by defining a chord passing through said circle and then defining a plane coincident with said chord and passing through said circle in a direction perpendicular to the plane thereof, so that the intersection of said plane with the full thickness of shroud 98 then contains a rectangular aperture 100 therein, the long dimension of which lies parallel to the long dimension of saw 96 and through which a portion of saw 96 extends outwardly from shroud 98 in a direction perpendicular to the plane of aperture 100. Shroud 98 also includes a shroud lip 102 that lies in the plane of aperture 100 and extends outwardly from shroud 98 on all sides, the outer periphery of shroud lip 102 thus having the shape of a rectangle of substantially the same dimensions as aperture 100. A cutting support shoe 104, shaped to fit shroud lip 102 but extending somewhat outwardly therefrom and having a relatively long and narrow saw slit 106 parallel to its long dimension centered therein is mounted onto shroud lip 102 in a position such that the extreme edge of saw 96 protrudes through slit 106. Support shoe 104 may be mounted onto saw shroud 98 by means of screws 108 which pass through shroud screw holes 110 and are then threadedly engaged by shoe screw holes 112, or by similar means. Given fixed dimensions of saw shroud 98 and the radius of saw 96, the amount by which saw 96 will so protrude is defined by the thickness of shoe 104, hence when support shoe 104 is placed into contact with the surface of a wall, ceiling or floor panel into which a cut is intended to be made, the thickness of support shoe 104 defines the depth of cut of saw 96 into such a panel.

Figures 6 and 7 illustrate means for providing power to saw 96 through use of saw drive motor 114 and gear box 116, the structure and operation of which are entirely conventional and need not be described further herein except to note that gear box 116 provides an output rotational axis that is perpendicular to the rotational axis of drive motor 114. As noted earlier, drive motor 114 and gear box 116 are selected to provide an output rotational speed sufficiently slow to minimize throwing off of debris from the operation of saw 96, e.g., the present embodiment has employed the commercially available Brobo Waldron Model S300B. Thus, a drive axle 118 extends outwardly through opposite sides of gear box 116 and on one of such sides passes through bearing block 120 and then through a circular axle aperture 122 (Fig. 6) that is located in one side of saw shroud 98. Bearing block 120 may be attached to the side of shroud 98 by means of bearing blockscrews 124 which pass through shroud screw holes 126 in the side of shroud 98 and are then engaged by threaded bearing block screw holes 128, or by similar means.

Aperture 122 is positioned in the side of shroud 98 so as to permit attachment of saw 96 to axle 118 at a convenient location within shroud 98, i.e., so as to permit rotation of saw 96 therewithin while at the same time providing a desired amount of protrusion of the outer edge of saw 96 through saw slit 106 as described earlier. Saw 96 is attached to axle 118 by means of a disc-shaped cap 130, i.e., screws 132 pass through a pair of cap holes 134 that are oppositely located along a line which passes through the center of cap 130, and then through a first pair of saw holes 136 correspondingly located within saw 96, said screws 132 then being threadedly engaged by a pair of axle screw holes 138 that are correspondingly located at that end of axle 138 which extends outwardly from gear box 116 in the direction of shroud 98. Since screws are not typically of sufficient lateral mechanical strength to avoid being sheared off by the torque associated with driving a saw such as saw 96, cap 130 also includes a pair of hard metal pins 140 (only the outer ends of which are shown in Fig. 7) which are located along a line at 90° to the line including cap holes 134 and which likewise passes through the center of cap 130, pins 140 then passing through a second pair of saw holes 142 correspondingly located in saw 96 so as to enter within a pair of axle holes 144 correspondingly located in said end of axle 118. Pins 140 are of sufficient length so as to penetrate holes 144 to a depth such that the torque developed by the rotation of axle 118 may be transmitted to saw 96 without breakage of pins 140. Of course, saw 96 may be attached to axle 118 by various other means without departing from the scope of the invention, e.g., through the use of three or more pins distributed in a circle within and concentric with cap 130, said pins being fitted to corresponding holes in saw 96 and in the end of axle 118 and being used together with a single screw which passes through the center of cap 130 and saw 96 into the center of axle 118.

Figures 3b, 6 and 7 show the manner in which the saw and motor combination are physically mounted. Specifically, pivot shaft 146 is mounted laterally across containment bin 62 near to top surface 82 and wall 86c of containment bin 62. The two opposite ends (not shown) of shaft 146 may be attached to the facing interior sides of walls 86a and 86b in any convenient manner as will be well known in the art, e.g., as by simply bolting said ends of shaft 146 onto a structural member of containment bin 62 after the components described hereinafter that are connected to shaft 146 have been placed thereon. As can be seen in Fig. 3b,

the placement of shaft 146 is selected so as to permit the bottom of support shoe 104 to be placed approximately level with top surface 82 of containment bin 62. Mounting of the saw and motor combination to shaft 146 is accomplished through gear box 116 (to which saw motor 114 and saw shroud 98 are attached), said gear box 116 being in the general shape of a rectangular box but including along an edge thereof which lies parallel to and opposite from drive axle 118 a horn extension 148 having a hole therethrough (not shown) that is sized to fit over pivot shaft 146 and thus to allow extension 148 and hence gear box 116 (and motor 114 and saw 96 that are attached thereto) to be slideably moved along pivot shaft 146.

In order to fix the position of saws 96 along the length of shaft 146, set collars 150 are placed on pivot shaft 146 on a side of horn extension 148 that is opposite the location of saw 96. Collars 150 include friction screws 152 therein which extend in the direction of shaft 146, such that when screws 152 are turned inward, the ends of screws 152 become engaged with shaft 146. Thus, horn extension 148 and hence the entire assembly of motor 114, gearbox 116 and saw 96 may be positioned at a desired location along shaft 146 by tightening a set collar 150 down onto shaft 146 at an appropriate location and then positioning horn extension 148 adjacent thereto. That procedure may be carried out with respect to both of saws 96 as shown, e.g., in Fig. 3, so that the lateral position of both saws may be adjusted, unlike the more simple embodiment described with respect to Fig. 2 in which the position of only one of saws 12a and 12b as shown therein was described as being adjustable.

It is also necessary to fix the position of saw shrouds 98 along shaft 146, since the only physical connection between shrouds 98 and saws 98, as shown in Figs. 6 and 7, comes about through the passage of drive axle 118 (to which saw 96 is attached) into the interior of saw shroud 98 through aperture 122. Consequently, the position of saw shrouds 98 in the direction parallel to shaft 146 (and likewise parallel to drive axle 118) must also be fixed in order to prevent saw 96 from contacting the interior of shrouds 98, and also in order that the outer edge of saw 96 will be properly aligned with saw slit 106. So as to fix that position, shroud 98 includes on an outer side thereof opposite gear box 116 a pivot rod 154 that is colinear with the axis of drive axle 118 and onto which support link 156 is slideably attached through link hole 158 which passes through link 156 near a proximal end thereof. Link 156 comprises essentially an elongate flat bar which includes at its distal end a shaft hole 160 that is sized to fit over pivot shaft 146. A spacer cylinder 162 is attached to the same side of link 156 as that from which pivot rod 154 enters link 156, such that when link 156 is placed upon pivot rod 154, cylinder 162 lies on the side of link 156 nearest to motor 114 and gear box 116. Cylinder 162 has a length such that upon sliding cylinder 162 along pivot shaft 146 until the end of cylinder 162 opposite link 156 comes into contact with horn extension 148, while at the same time link 156 is slideably engaged with pivot rod 154 through pivot hole 158, bearing block 120 (which is attached to the side of shroud 98 nearest to gear box 116) likewise comes into contact with gear box 116. Also, the length of drive shaft 118 is such that when shroud 98 is so positioned, saw 96 becomes centered within shroud 98 so as to coincide with the location of saw slit 106.

Cylinder 162 may be attached to link 156 by cylinder screws 164 which pass by way of cylinder screw holes 166 through link 156, said screw holes 166 being distributed concentrically around shaft hole 160. Screws 164 may be of a length just sufficiently long to engage a set of threaded holes (not shown) correspondingly distributed within the near end of cylinder 162. In that case, in order for the position of shroud 98 to be fixed into the position just described, it would be necessary to afix a collar 150 onto pivot shaft 146 in contact with the outermost side of link 156 (i.e., opposite the side to which cyliner 162 is attached) while maintaining the desired positioning of shroud 98. In such a case, the relative positions of saw 96 and shroud 98 would not be fixed except when the assembly was fixedly placed upon a shaft such as pivot shaft 146, which could subject both saw 96 and shroud 98 to possible damage. It is preferable, therefore, that screws 164 be of such a length as to pass through the full length of cylinder 162 and then to threadedly engage a set of horn screw holes 168 located within the side of horn extension 148 nearest shroud 98, said screw holes 168 being correspondingly and concentrically distributed around the axis along which pivot shaft passes through horn extension 148. Of course, it continues to be appropriate to employ collars 150 against both link 156 and the side of horn extension 148 opposite therefrom, in order that the position of the motor 114, gear box 116, saw 96 and shroud 98 combination will be fixed as to motion along shaft 146 in either direction. However, collars 150 are not placed so tightly against link 156 and extension 148 as to inhibit the free rotation of the combination of motor 114, gear box 116, saw 96 and shroud 98 about shaft 146.

In order to carry out a sawing operation, one method of placing support shoe 104 into contact with a wall, ceiling or floor may be, e.g., in the embodiment adapted to the removal of ceiling panels shown in Fig. 3, simply to raise scissors jack 72

until contact is made. However, in Figs. 6-8 it is shown that such contact may be made more advantageously by moving the assembly of motors 114, gear boxes 116, saws 96 and shrouds 98 only, without it being necessary to move all of containment bin 62 and blower bin 64 and their contents. Operation of apparatus 60 thus becomes much more flexible and convenient, and requires the use of less power. As will be described hereinafter, the use of such a motion also permits adjustment in the mode of operation of the secondary negative air pressure system.

Specifically, gear box 116 includes a short lift arm 170 which, in the perspective of Figs. 6 and 7, extends outward and downward from the bottom of gear box 116 on a side opposite the placement of motor 114. A lift pin hole 172 passes laterally through lift arm 170 and accommodates lift pin 174 which also passes through bracket extensions 176 which extend outward from one flat side of L-shaped lift bracket 178, said extensions 176 being in a spaced-apart relationship so as to accommodate lift arm 170 therebetween. Bracket 178 is thus rotatably connected to lift arm 170.

Fixedly attached to bracket 178 on a (lower) side thereof opposite that including bracket extensions 176 is a lift rod 180 which extends outwardly from an upper end of and is operated by pneumatic lift cylinder 182, said lift cylinder 182 being of a commercial variety such as the Model SDR-32-4 sold by Clippard and being controlled by an external air supply as will be described hereinafter. The (lower) end of lift cylinder 182 opposite that from which lift rod 180 extends is rotatably attached in any convenient manner to an appropriate location at the bottom of containment bin 62. Such attachment may be made, e.g., to a bin cross-member 184 which extends across the bottom of containment bin 62 by means of a lift base 186 that is fixedly attached to cross-member 184 and includes base extensions 188 extending upwardly therefrom in a spaced-apart relationship so as to accommodate therebetween a cylinder base arm (not shown) which extends outwardly from said end of cylinder 182. Rotatable attachment is then made in a manner analogous to that by which lift rod 180 is attached to lift arm 171 of gear box 116, i.e., by a base pin 190 which passes through appropriately aligned holes in base extensions 188 and said cylinder base arm. Operation of lift cylinder 182 so as to increase or decrease the amount by which lift rod 180 extends outwardly therefrom will thus have the effect of raising or lowering saw shroud 98, gear box 116 and hence saw 96.

Figures 5 and 8 illustrate another effect brought about by such an upward or downward motion of the combination of saw shroud 98, gear box 116, saw 96 and hence cutting support shoe 104. In Figs. 5-8 it can be seen that saw shroud 98 includes a hollow vacuum outlet 192 on a side thereof opposite support shoe 104, i.e, leading out from the bottom thereof. Attached thereto in an airtight manner by proximal end 194 is a hollow flexible vacuum hose 196 which then leads out the bottom of containment bin 62 through a hole 197 which fits tightly around hose 196 to a distal end 198 which is attached in a similar manner to a HEPA vacuum pump 200. By application of power to vacuum pumps 200, a vacuum is drawn upon the interior of vacuum hose 196 and shroud 96, which will cause a flow of air as indicated by arrows 202 in Fig. 8. From Fig. 7 it is clear that the source of such air flow must be from around that part of saw 96 which extends outwardly from shroud 98 through saw slit 106, i.e, the portion of saw 96 that performs the actual cutting operation. In other words, contrary to the prior art, apparatus 60 provides a source of negative air pressure that is concentrated in the limited volume within which actual cutting takes place. Optimum operation of this primary negative air pressure system is found to occur with a vacuum or pressure differential measured at saw slit 106 of about 0.15 column inches of water.

Figure 8 also illustrates the operation of a secondary negative air pressure system of apparatus 60 Shroud 98 and support shoe 104 may be placed at such a height as to leave a gap 204, within aperture 84, between shoe 104 and containment bin 62. Application of power to blower bin 64 then draws a vacuum on the interior of containment bin 62 which results in a flow of air indicated by arrows 206 in Fig. 8. The source of such air flow is around the periphery of support shoe 104, as contrasted with the primary negative air pressure system which draws air through saw slot 106 immediately around the surface of saw 96. The size of gap 204 is adjustable by adjusting the height of shroud 98 above containment bin 62, thus providing some control over the speed and volume of air flow 206. The system thus serves as a secondary negative air pressure system for capturing any free particulate or fibrous matter that is formed in the sawing operation that is not captured by the primary system. Optimum operation of this secondary system is found to occur by maintaining within containment bin 62 a pressure differential of about 0.05 column inches of water.

When raising saw 96 to its cutting position shown in phantom in Fig. 8, and also when lowering it back to a rest position, it must be assured that support shoe 104 remains relatively level. At the same time, the opposition or "kickback" encountered when saw 96 engages a panel to be cut will apply significant opposing torque to saw 96. Since saw 96 and shroud 98 are rotatably connected through axle 118 as it passes through bear-

ing block 120, there will be a tendency for that torque to be transmitted frictionally to shroud 98. The direction of rotation of saw 96 as shown by arrow 208 in Fig. 8 is in the same direction as the forward motion of apparatus 60 shown by arrow 81 in Fig. 3. The direction of rotation of saw 96 is also such that the opposing torque will tend to rotate saw 96 and shroud 98 so as to force the trailing edge of shoe 106, with respect to the forward motion of saw 96 given by arrow 81, down and away from the panel being cut. In order to prevent such rotation, saw shroud 98 also includes a limiting post 210 which protrudes from the side thereof to which support link 156 is attached, post 210 being positioned as indicated in Fig. 7 so as to contact support link 156 and hence limit the described rotation of saw shroud 98. As saw 96 is raised or lowered by the operation of lift cylinder 182, bearing block 120 which is fixedly attached to shroud 98 rotates against the facing surface of gear box 116, and post 210 is able to slide along the facing surface of support link 156 so as not to inhibit that raising or lowering operation.

As shown in Figs. 6 and 7, provision is made for hydraulic damping of the "kickback" resulting from the operation of saw 96. Specifically, attached to the end of lift cylinder 182 from which lift rod 180 extends, and through which lift rod 180 also passes, is a stabilizer bracket 212. At an end thereof opposite to that attached to lift cylinder 182 there is a stabilizer hole 214 into which is inserted an elongate hydraulic stabilizer 216 from which there extends a stabilizer rod 218, the extended end of which is fixedly attached to the end of lift bracket 178 opposite to that at which lift rod 180 is attached (and opposite bracket extensions 176). Passing through stabilizer hole 214 and extending outward therefrom to the end of stabilizer bracket 212 there is a stabilizer slit 220, through which there passes transversely a stabilizer lock screw 222 which, upon tightening, causes the inner surfaces of stabilizer slit 220 to exert pressure upon hydraulic stabilizer 216 so as to clamp it into place. Stabilizer 216 thus operates "in parallel" with lift cylinder 182, in the sense that any motion of lift rod 180 into or out of lift cylinder 182 must be accompanied by a similar motion of stabilizer rod 218 into or out of hydraulic stabilizer 216, by virtue of the connection of both stabilizer rod 218 and lift rod 180 to stabilizer bracket 212. The effect of such a "parallel" motion is thus to add the hydraulic retarding force of stabilizer rod 218 to that of lift rod 180, to assist in damping any "kickback" forces that may be transmitted to lift bracket 178 from lift arm 170 of gear box 116. Such a retarding force must also, of course, affect the raising or lowering of saw 96 by the operation of lift cylinder 182. Stabilizer 216 may be of any appropriate commercial variety that is of a size to be accommodated by bracket 212 and to provide the amount of damping force necessary, e.g., the present embodiment employs the Type 5000 (Super K Model) of The Deschner Corporation that is sold under the trademark "Kinechek."

Turning again to Fig. 3, it is seen that apparatus 60 also includes a surfactant container 224 and an encapsulant container 226. A significant purpose of the present invention is to prevent the creation of free asbestos fibers as the result of the sawing operation by which asbestos-containing panels are cut free, and it has been found that said purpose may be greatly assisted by coating the surface of the panel to be cut, in the area of that surface in which the cut is to be made, with a surfactant material that will wet the material before it is cut. As shown in more detail in Fig. 9, surfactant container 224 includes surfactant outlet 228 in the top thereof, onto which is attached proximal end 230 of a first hollow, flexible surfactant line 232 having a distal end 234 which is attached to surfactant pump 236 mounted to end 238 of table 68 opposite the location of containment bin 62. Surfactant container 224 may be placed for convenience at end 240 of equipment platform 70, also opposite the location thereon of containment bin 62. Surfactant pump 236, which may be of any appropriate commercial variety such as Aro Pump No. 613-100-3, serves to pump surfactant material out of surfactant container 224 and impel it further into a second, flexible surfactant line 242, the proximal end 244 of which is attached to an outlet (not shown) of pump 236 in a manner similar to that by which the first surfactant line is attached to the inlet thereof. Distal end 246 of second surfactant line 242 is attached by similar means to surfactant distributor 248, which may be mounted in any convenient fashion to containment bin 62 and which divides the surfactant stream passing through second surfactant line 242 into two such streams. Specifically, two additional surfactant lines, i.e., third line 250a and fourth line 250b, are attached by respective proximal ends 252a, 252b thereof in a convenient manner to distributor outlets 254a, 254b of distributor 248, and the respective distal ends 256a, 256b of lines 250a, 250b are similarly attached to respective surfactant nozzles 258a, 258b. As shown in Fig. 3, nozzles 258a, 258b are mounted by nozzle blocks 260a, 260b to the exterior of wall 86c of bin 62 so as to be in line with the location of saws 96a, 96b.

It is clear that the ejection of surfactant material 262a, 262b from nozzles 258a, 258b as apparatus 60 proceeds in the direction of arrow 81 will cause the surface of the panel material that is about to be cut by respective saws 96a, 96b to be wetted by surfactant material 262a, 262b just prior to the contact therewith by respective saws 96a, 96b.

Surfactant material 262a, 262b may be of any convenient variety such as the material sold under the trade name of FIBRSELE by Northwest Coatings, Inc., of Edmonds, Washington, and serves in combination with a similar use of encapsulant material to be described hereinafter to minimize the amount of free asbestos fibers that are produced by the sawing operation of apparatus 60, i.e., of saws 96a, 96b. In addition, a portion of the surfactant is directed onto the blade surface of saw 96a and 96b as each of them is cutting, so as also to wet the newly cut, exposed surfaces of the panel. The result of applying surfactant 262 is that the very small asbestos fibers that are loosened in the sawing operation are weighted down by the surfactant so that they will either not fly loose at all, or if they do fly loose they may at least be captured by either the primary or secondary negative air pressure systems previously described.

Figures 3 and 9 show the similar use of an encapsulant. Encapsulant container 226 includes an encapsulant outlet 264 to which is attached the proximal end 266 of a first flexible, hollow encapsulant line 268, the distal end 270 of which is attached to encapsulant pump 272 which is conveniently mounted onto end 238 of table 68. Encapsulant pump 272, which may be of any appropriate commercial variety such as Aro Pump No. 650863-2 serves to draw encapsulant material from encapsulant container 226 and force said material therefrom through encapsulant line 268 and thence onward through additional lines as hereinafter described. Onto an outlet (not shown) of pump 272 is attached the proximal end 274 of a second encapsulant line 276, the distal end 278 of which is attached to encapsulant distributor 280 which may be conveniently mounted onto containment bin 62. Distributor 280 serves to divide a stream of encapsulant passing through line 276 into two such streams that pass from separate distributor outlets 282a, 282b, onto which are attached the respective proximal ends 284a, 284b of respective third and fourth encapsulant lines 286a, 286b, the respective distal ends 288a, 288b of which are attached to respective encapsulant nozzles 290a, 290b which, as shown in Fig. 8, are attached by respective encapsulant nozzle blocks 292a, 292b to wall 86d of containment bin 62. To apply encapsulant, nozzles 290a, 290b are positioned in a substantially straight line with the forward motion of saws 96a, 96b as the sawing operation proceeds, thus to provide a spray of encapsulant 294a, 294b onto a region of a panel that has just been sawed as apparatus 60 moves in the direction of arrow 81 in Fig. 3. Care must be taken not to direct any encapsulant 294 onto saws 96, which could cause them to bind.

Nozzles 258a, 258b and 294a, 294b provide atomization of the surfactant or encapsulant by hydraulic pressure alone, are typically operated by an auxiliary air line, and are exemplified by the Model 24AUA high pressure spray gun sold under the trade mark of "AutoJet" which requires a minimum of 75 pounds of air pressure for operation. The material used for encapsulant 294 is preferably of an adherent type that will form a quasi-solid film over the edges of newly cut panels of asbestos-containing materials so as to prevent any fibers that have been loosened by the cutting operation and that have not been captured by the negative air pressure processes previously described from being jarred loose by subsequent handling of those newly cut panels. The material previously noted as being used for surfactant may be also used as the encapsulant if less diluted.

The air supply necessary for the operation of surfactant pump 236 and encapsulant pump 272 is provided by pneumatic distribution manifold 296, which is conveniently located on equipment platform 70 underneath table 68. (See Fig. 3.) Surfactant pump 236 and encapsulant pump 272 are placed under a constant internal air pressure by respective pump air lines 298 and 300, respective proximal ends 302 and 304 of which are attached thereto by respective sleeve valves 306 and 308. Respective distal ends 310 and 312 of lines 298 and 300 are attached to pump tee 314, near a midpoint of which is attached by proximal end 316 a single main pump air line 318, the distal end 320 of which is attached to a main air line 322.

Main air line 322 provides the necessary pressure to operate surfactant pump 236 and encapsulant pump 272, and also pneumatic lift cylinders 182 for raising and lowering the position of saws 96. Air is provided to air line 322 from air supply 324, which is connected through a standard air line plug 325 as shown in Fig. 3a either to any available fixed source of air pressure, or to a mobile air compressor that may be used in conjunction with apparatus 60. The air so provided passes first through first ball valve 326, then through a first air pipe 328, and then through a first elbow 330 to which is attached through a second air pipe 332 a first air pressure regulator 334 which is used to establish the desired air pressure within the immediately adjacent portion of main air line 322. A third air pipe 336 leads from regulator 334 to filter 338 which is used to remove particulate matter from the air, and a fourth air pipe 340 then leads to lubricator 342 which is used to provide lubricant to the pneumatic equipment. Fifth air pipe 344 leads from lubricator 342 to ball valve 346, which is formed in the shape of a T and divides the air supply contained therein into two branches. Distal end 320 of main pump air line 318 is attached to "pump branch" 348 of ball valve 346 and provides air

pressure to operate surfactant pump 236 and encapsulant pump 272 as previously described. A second branch 350 of ball valve 346 provides air pressure for operating surfactant nozzles 258a, 258b and encapsulant nozzles 290a, 290b, while a third air branch provides air pressure for lift cylinders 182a, 182b for raising and lowering respective saws 96a, 96b.

In detail, branch 350 passes through second elbow 352 to a T-shaped joint 354, to a side of which is attached a manifold joint 356 which leads into air manifold 358. On an outlet side of manifold 350 are first spray air lines 360a, 360b, 360c, 360d, each one of which is used to supply the necessary air pressure for the operation of surfactant nozzles 258a, 258b and encapsulant nozzles 290a, 290b. For that purpose, first spray air lines 360a, 360b, 360c, 360d lead into respective spray control valves 362a, 362b, 362c, 362d, to which are attached respective second spray air lines 364a, 364b, 364c, 364d. Spray air line 364a is attached to the side of surfactant nozzle 258a, spray air line 364b is attached to the side of surfactant nozzle 258b, spray air line 364c is attached to the side of encapsulant nozzle 290a, and spray air line 364d is attached to encapsulant nozzle 290b. Spray control valves 362a, 362b, 362c, 362d retard or permit the passage of air through respective second spray air lines 364a, 364b, 364c, 364d so as to initiate or terminate the spraying of surfactant 262 from respective nozzles 258a, 258b, and of encapsulant 294 from respective nozzles 290a, 290b.

Connected to joint 354 opposite the connection thereto of second elbow 352 and in line therewith so as to form third air branch 366 is a sixth air pipe 368 which leads into second air regulator 370 which adjusts the air pressure in the remainder of main air line 322. An outlet T-pipe 372 leads from regulator 370 and has attached at a side thereof a first saw air line 374 to which is attached a first saw controller 376, out of which lead respective first "up" air line 378 and first "down" air line 380, respective distal ends 382 and 384 of which are then attached to opposite ends of one of lift cylinders 182. (See Fig. 7.) Air pressure that is exerted through air line 378 will cause the lift cylinder 182 to push the lift rod 180 that is contained therein outward and cause the corresponding saw 96 to be raised upward. Conversely, exertion of air pressure through air line 380 will cause lift rod 180 to move back into cylinder 182 so as to lower saw 96. The distribution of air pressure between "up" air line 378 and "down" air line 380 is controlled by saw controller 376. Also leading from T-pipe 372 opposite the connection thereto by second air regulator 370 and in line therewith is a seventh air pipe 386, a third elbow 388, and a second saw air line 390 which leads into second saw controller 392, out of which lead respective second "up" air line 394 and "down" air line 396, the connections and operation of which are the same with respect to a second saw 96 as was just described with respect to first saw controller 376 and a first saw 96. The construction and operation of saw controllers 376 and 392 will typically be identical, and since they are both subjected to essentially identical air pressures, it is immaterial to which of saws 96a or 96b either such controller is connected (so long as labelling or like means are employed to identify to an operator which saw is controlled by which controller). Saw controllers 376 and 392 are typically operated in unison, so that both of saws 96a, 96b are raised for sawing or lowered to a rest position at the same time, except in those instances in which it may be desired to carry out only a single cut with a saw 96, in which case only one of such saws 96 would be raised into its operating position.

Remote operation of apparatus 60 is provided by connection thereto through control cable 398 of a box-like control pendent 400 that may be hand held for ease of operation. Cable 398 includes six electrical control lines 402a, 402b, 402c, 402d, 402e, 402f which lead respectively to saw controllers 376, 392 and to spray control valves 362a, ..., 362d. Control pendent 400 includes on an end thereof closest to the operator a pair of push button switches 404a, 404b respectively for "prespray" so as to operate surfactant spray control valves 362a, 362b through electrical control lines 402a, 402b and for "postspray" so as to operate encapsulant spray control valves 362c, 362d through electrical control lines 402c, 402d. Similarly, control pendent. 400 also includes next adjacent to the operator a pair of push button switches 406a, 406b which connect to control lines 402e, 402f and thence to respective saw control valves 376 and 392 for raising saws 96 into the cutting position shown in phantom in Fig. 8. An additional, next adjacent push button saw control switch 408 is also provided on control pendent 400 and serves to provide "stop/down" control, i.e., it disconnects power to switches 406a, 406b that is being applied to raise either or both of saws 96a, 96b, and upon termination of that power the respective saw 96 is lowered by gravity to its rest position. Each of saw control valves 376 and 392 and spray control valves 362a, ... , 362d incorporate electrical relays (not shown) therein which, upon application of appropriate electrical power, serve to open or close off the flow of air therethrough and thus to control the operation of the respective saw lift cylinders 182 or spray nozzles 258a, 258b with respect to surfactant and 290a, 290b with respect to encapsulant. It is to be noted that there is no corresponding control provided for surfactant pump 236 and encapsulant

pump 272, inasmuch as surfactant air line 298 and encapsulant air line 300 that are respectively attached thereto are permanently connected through respective distal ends 310 and 312 thereof to pump tee 314 which provides a constant source of air pressure. Surfactant pump 236 and encapsulant pump 272 are thus in continuous operation when apparatus 60 is being used, and the spraying of said materials is controlled by controlling the respective nozzles therefor as just described.

Next adjacent to "stop/down" control switch 408 on control pendent 400 is located another pair of push button switches 410a, 410b which control the application of power in a manner well known in the art to respective motors 114a, 114b for operating respective saws 96a, 96b. The electrical power for all of switches 404 ... 410 on pendent 400 is provided through electrical control cable 398, which is connected in turn through cable 412 as shown in Fig. 3a to plug 414, which is a standard wall plug for 240V/3-phase electrical power. Cable 412 also provides power to saw motors 114a, 114b, for which the Brobo Waldown Model S300B provides a spindle speed that may be switched alternatively between the recommended speeds of 32 rpm for heavy cutting in the case that the material to be cut may include some amount of metal, or 60 rpm for lighter cutting in which it is desired to minimize vibrations. Cable 412 likewise provides power to operate HEPA vacuum pumps 200a, 200b.

The power which gives apparatus 60 its mobility through drive wheels 78a, 78b is provided by DC drive motor 416 which may be connected alternatively to battery charger/power inverter 418 or to battery pack 410. Battery charger/power inverter 418 also receives electrical power from cable 412, and may be used to operate drive motor 416 directly in the case that there is a convenient source of electrical power. or may be used to charge battery pack 420 for occasions when such a power source is not available, and on those occasions drive motor 416 may be driven from battery pack 420 while using battery charger/power inverter 418 as a power inverter in a well known manner. Control of drive motor 416 whether from battery pack 420 or from power received through cable 412 is provided by motor drive control switch 422 which is also located on control pendent 400 and which provides the necessary switching for either low or high speed movement in either a forward direction (as shown in arrow 81 of Fig. 3a) or in a reverse direction. In accordance with the specifications for the Mark Industries Model 25E Marklift, those low and high speeds are 1.5 mph and 3.5 mph, respectively. Steering switch 424 which is also located on control pendent 400 controls the application of power to a hydraulic steering mechanism (not shown) for turning steering wheels 76a, 76b in a desired left or right direction. Equipment lift control switch 426 which is likewise located on control pendent 400 controls power to a hydraulic equipment lift cylinder 428 for moving scissors jack 72 and hence equipment platform 70 upward or downward. As shown in Fig. 3b, control pendent 400 connects through control cable 398 to a hydraulic control module 430 to which is connected a hydraulic reservoir 432 for operating in a well known manner all of the hydraulic equipment of apparatus 60. Control pendent 400 also includes an oversized push button emergency switch 434 which, for safety reasons, will disconnect the power to the several pieces of equipment embodied in apparatus 60.

The present invention is not limited to the embodiment shown as apparatus 60, which is particularly adapted to the removal of panels from a ceiling. As shown in Figs. 12a and 12b, the same procedures as have been described with reference to apparatus 60 may also be employed for embodiments of the invention that are adapted to the removal of panels from a vertical wall, shown as apparatus 60′ of Fig. 12a, or from a floor, shown as apparatus 60″ of Fig. 12b. Modifications that must be made for such applications will consist essentially in no more than relocation and reorientation of containment bin 62 and blower bin 64, and saws 96 and like equipment that are contained therein. Thus, in Fig 12a, apparatus 60′ is shown to include both a containment bin 62a′ for making vertical cuts in a wall, and containment bin 62b′ for making horizontal cuts in a wall. The vertical motion necessary for the sawing operation of a saw contained within containment bin 62a′ must be provided by an additional vertical drive motor (not shown), through the use of the same kind of vertical lift apparatus 20 as was employed in the embodiment of Fig. 1 to raise and lower containment bin 10, or by other such means that will be well known in the art. Similarly, Fig. 12b illustrates the attachment of a containment bin 62″ directed towards the bottom of apparatus 60″ for making cuts in a floor, without the need to include an equipment platform 70 or scissors jack 72 and the like since the vertical placement of the saws contained within containment bin 62″ (i.e., saws 96a″, 96b″) may be provided by lift cylinders 182″ corresponding to those which in apparatus 60 position saws 96a, 96b. In all other significant respects, the embodiments shown as apparatus 60′ and 60″ may be identical to apparatus 60.

While the simplest embodiment of the invention as shown in Figs. 1 and 2 provides a degree of containment for free asbestos fibers derived from sawing that has not previously been found in the art, apparatus 60 also comprises an embodiment that is much more convenient. The use of appara-

tus 60 has resulted in a post-removal count, as measured using a standard aggressive sampling technique, of free asbestos fibers having an aspect ratio (length/width) of 3:1 and being longer than 5 microns of an average 0.0032 fibers/cc, said average being taken over 15 samples with a range of 0.0024-.0047 fibers/cc and a standard deviation of 0.00096. Exposure levels during the asbestos removal process have consistently been below the "action level" of 0.1 fibers/cc. Such results constitute a substantial improvement over results that have previously been reported and considerably less than the counts specified by existing requirements under either state or federal regulation. The success in attaining such a low count must be attributed to the present invention as a whole, but particularly to the use of containment bin 62, both the pre-spray of surfactant and post-spray of encapsulant, and the use of both primary and secondary negative air pressure systems. Additional safety is provided by control pendent 400 which permits the operator to be physically removed from the area in which the asbestos removal process is taking place. It should then be understood that various modifications to the invention may be made by those of ordinary skill in the art without departing from the scope thereof, hence the foregoing description is not to be interpreted as limiting, the true scope of the invention being given only by the following claims and equivalents thereof.

Claims

1. A method for removing panels of building materials that may contain asbestos from buildings, comprising:
providing a moveable containment bin having one or more saws each having a saw blade contained therein for sawing through said panels;
placing said containment bin into abutting contact with a planar surface of a selected portion of said panel;
applying a negative air pressure to the interior of said containment bin and thereby drawing an air current into the interior of said containment bin, said air current passing in close proximity to said one or more saws;
sawing said panel into removable panel sections;
removing said panel sections.

2. The method of claim 1 further comprising the step of applying a surfactant material to said selected portion of said panel prior to sawing.

3. The method of claim 2 further comprising applying surfactant material to each saw blade in the course of sawing.

4. The method of claim 3 further comprising providing the step of applying an encapsulant material to the selected portion of said panel after said sawing.

5. An apparatus for removing panels of building materials that may contain asbestos from buildings, comprising:
at least one containment bin;
one or more saws mounted within said containment bin, each said saw having a saw blade that extends outward from a selected side of said containment bin;
a source of negative air pressure for drawing a current of air past said one or more saw blades through the interior of said containment bin;
means for placing said selected side of said containment bin into proximity with a panel of building material and sawing loose a selected portion of said panel; and
means for removing said selected portion of said panel.

6. The apparatus of claim 5 further comprising means for applying a surfactant material to an area of said panel of building material prior to sawing within said area.

7. The apparatus of claim 6 further comprising means for applying said surfactant material to each saw blade in the course of sawing.

8. The apparatus of claim 7 further comprising means for applying encapsulant material to said area of said panel of building material after sawing.

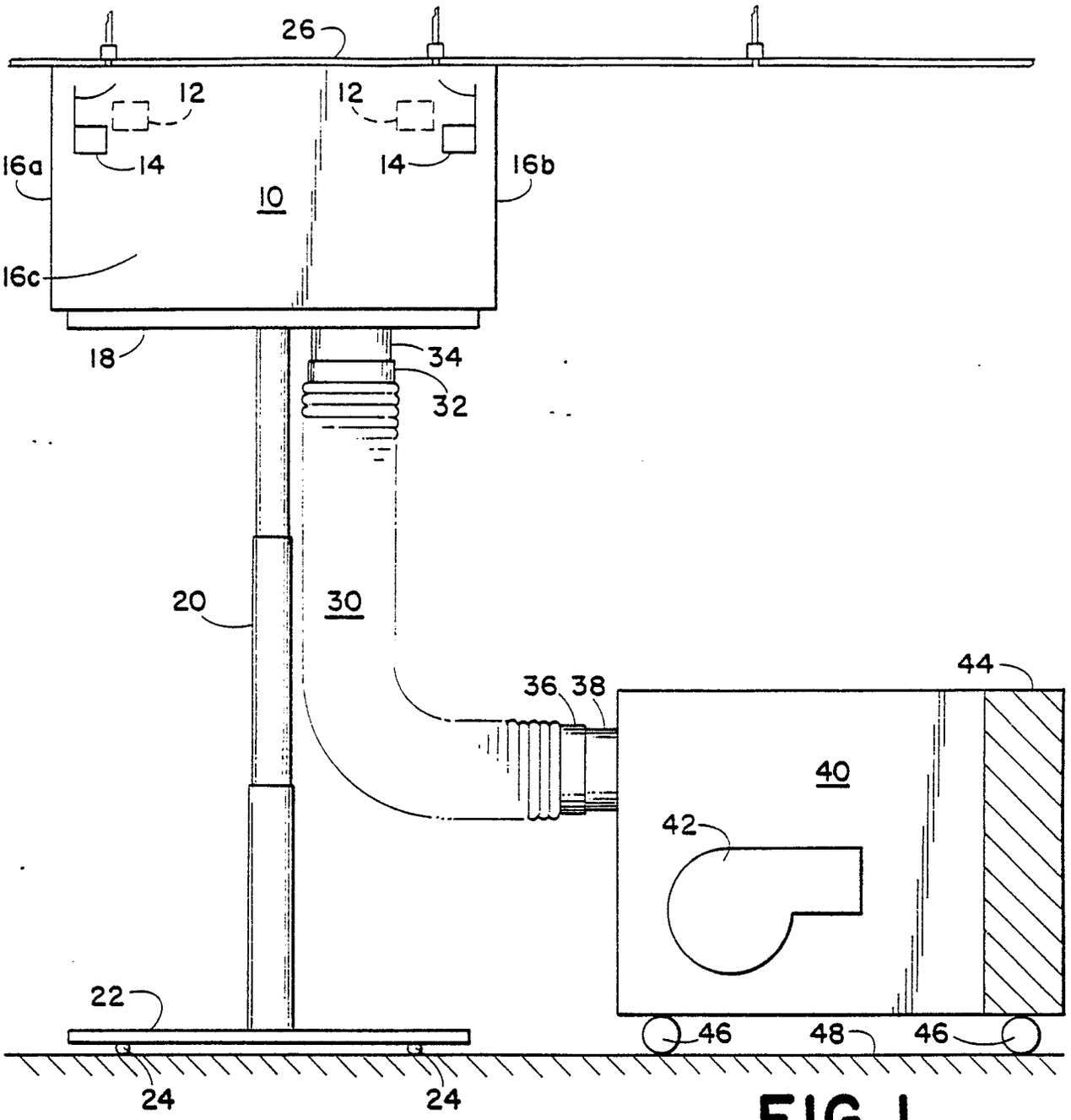
9. The apparatus of claim 8 further comprising transport means for transporting said apparatus to the vicinity of said selected portion of said panel.

10. The apparatus of claim 9 further comprising remote means for operating said apparatus.

11. The apparatus of claim 10 wherein said means for placing said selected side of said containment bin into proximity with a panel of building material comprise vertical lifting means for cutting panels of building materials from ceilings within a building.

12. The apparatus of claim 10 wherein said means for placing said selected side of said containment bin into proximity with a panel of building material comprise vertical lifting means for cutting panels of building materials from a floor of a building.

13. The apparatus of claim 10 further comprising including two containment bins, the first said bin being moveable in a vertical direction for making vertical cuts on building walls, and the second said bin being moveable in a horizontal direction for making horizontal cuts on building walls.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16b
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FIG. 1

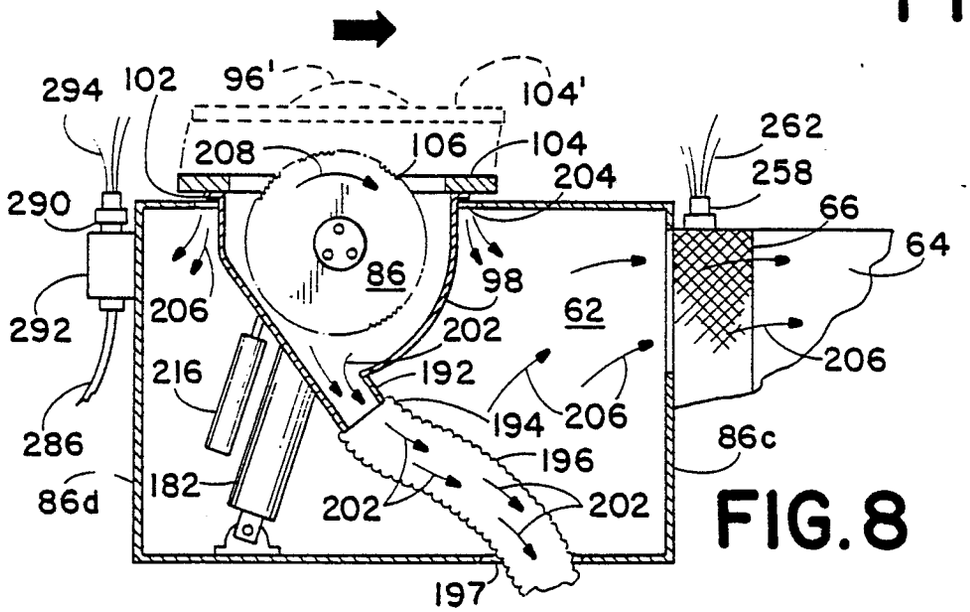
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FIG. 8

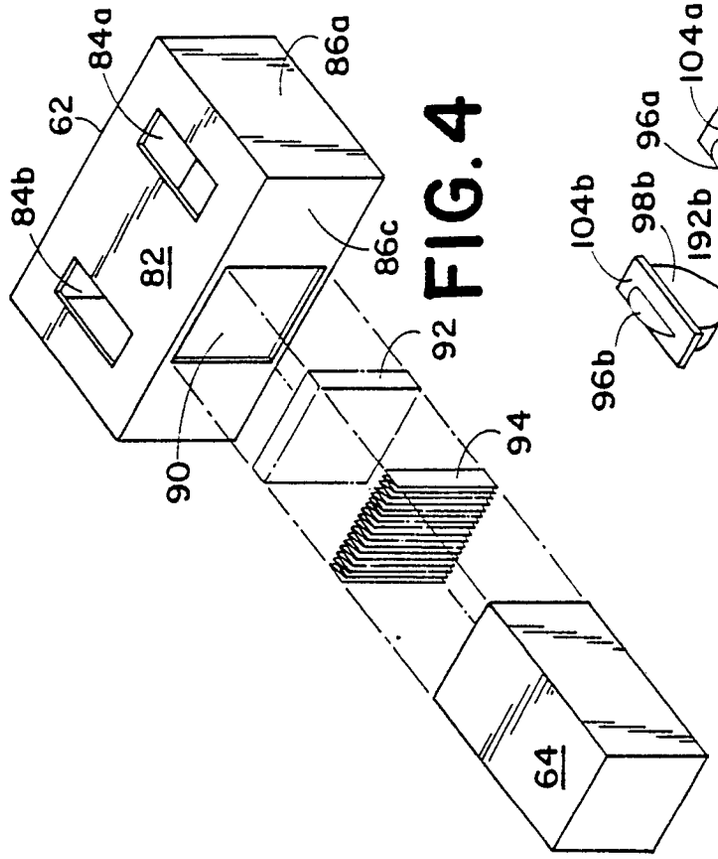


FIG. 4

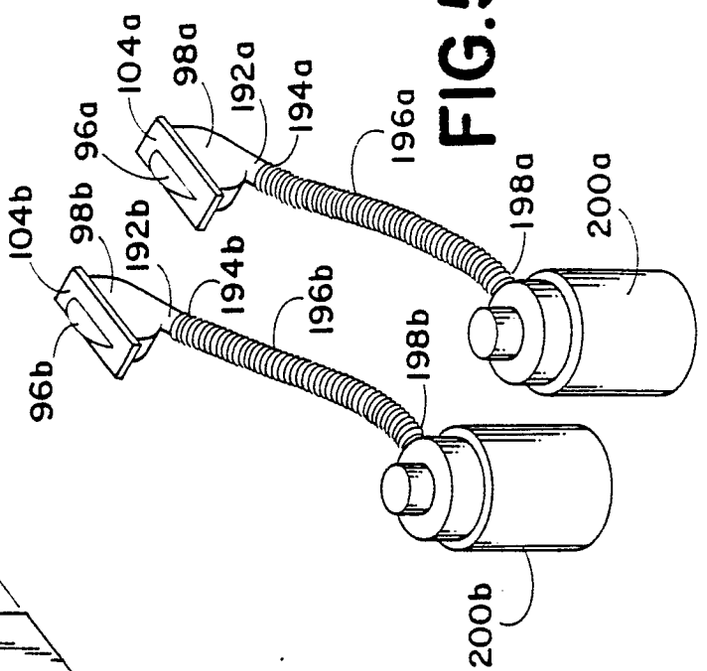


FIG. 5

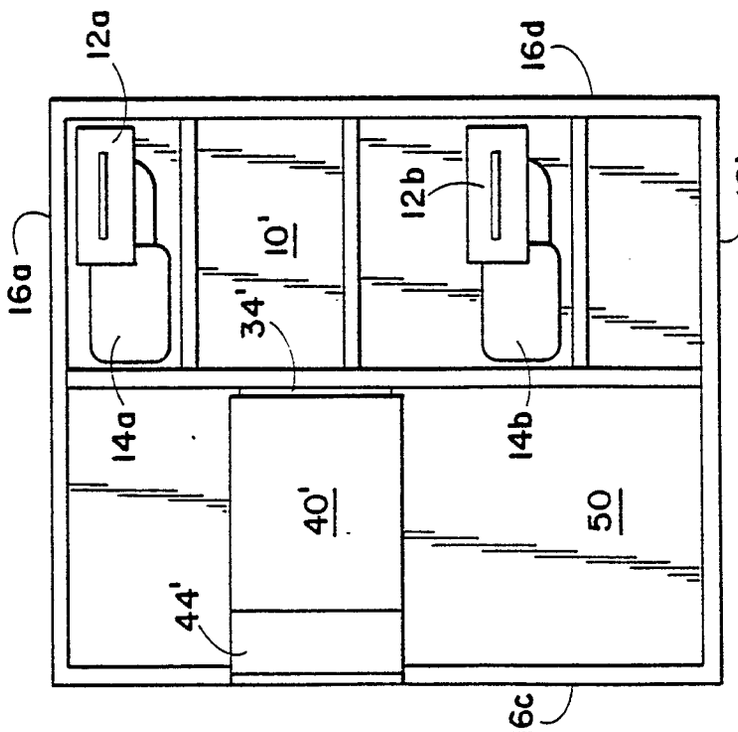
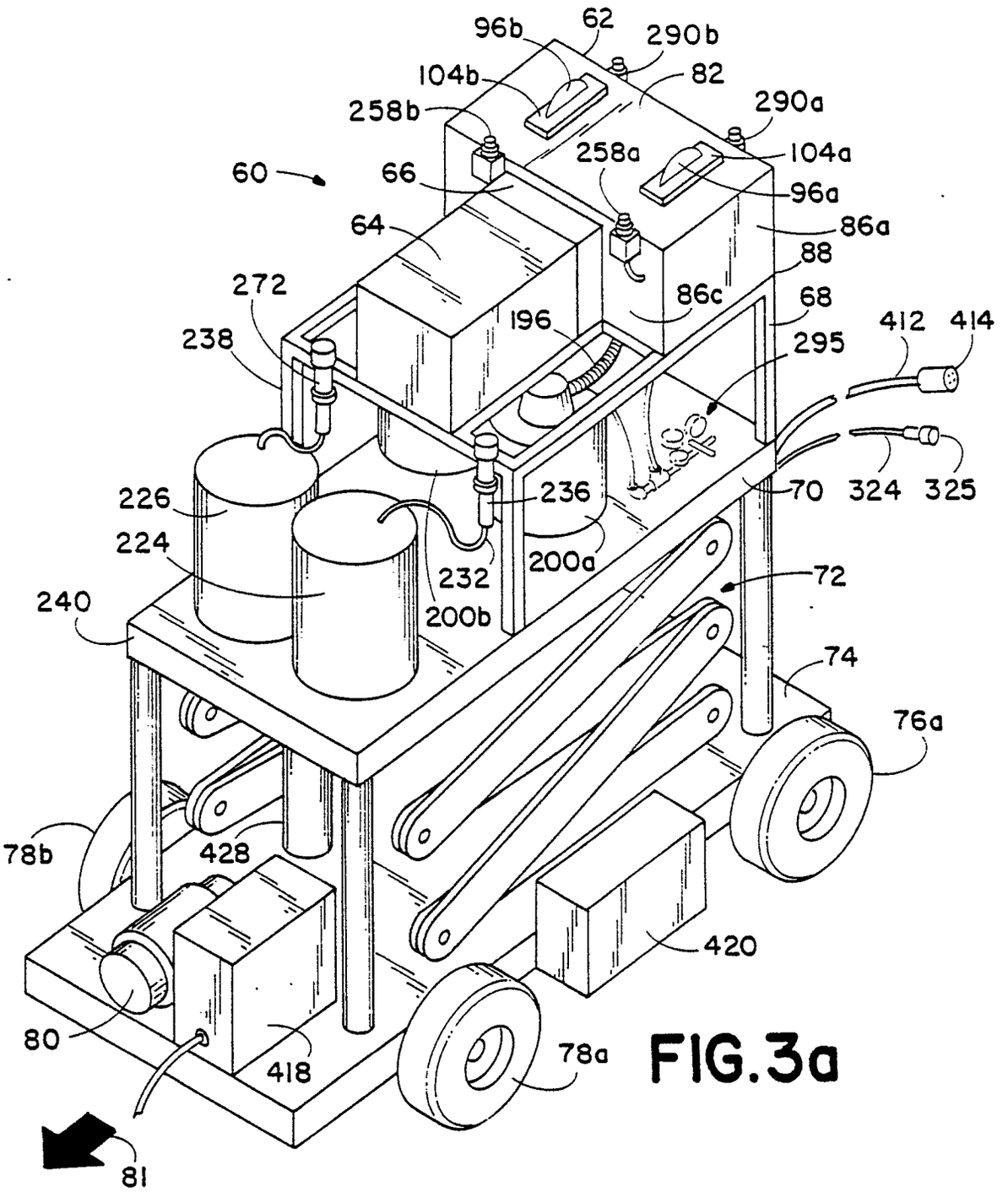


FIG. 2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290a
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70
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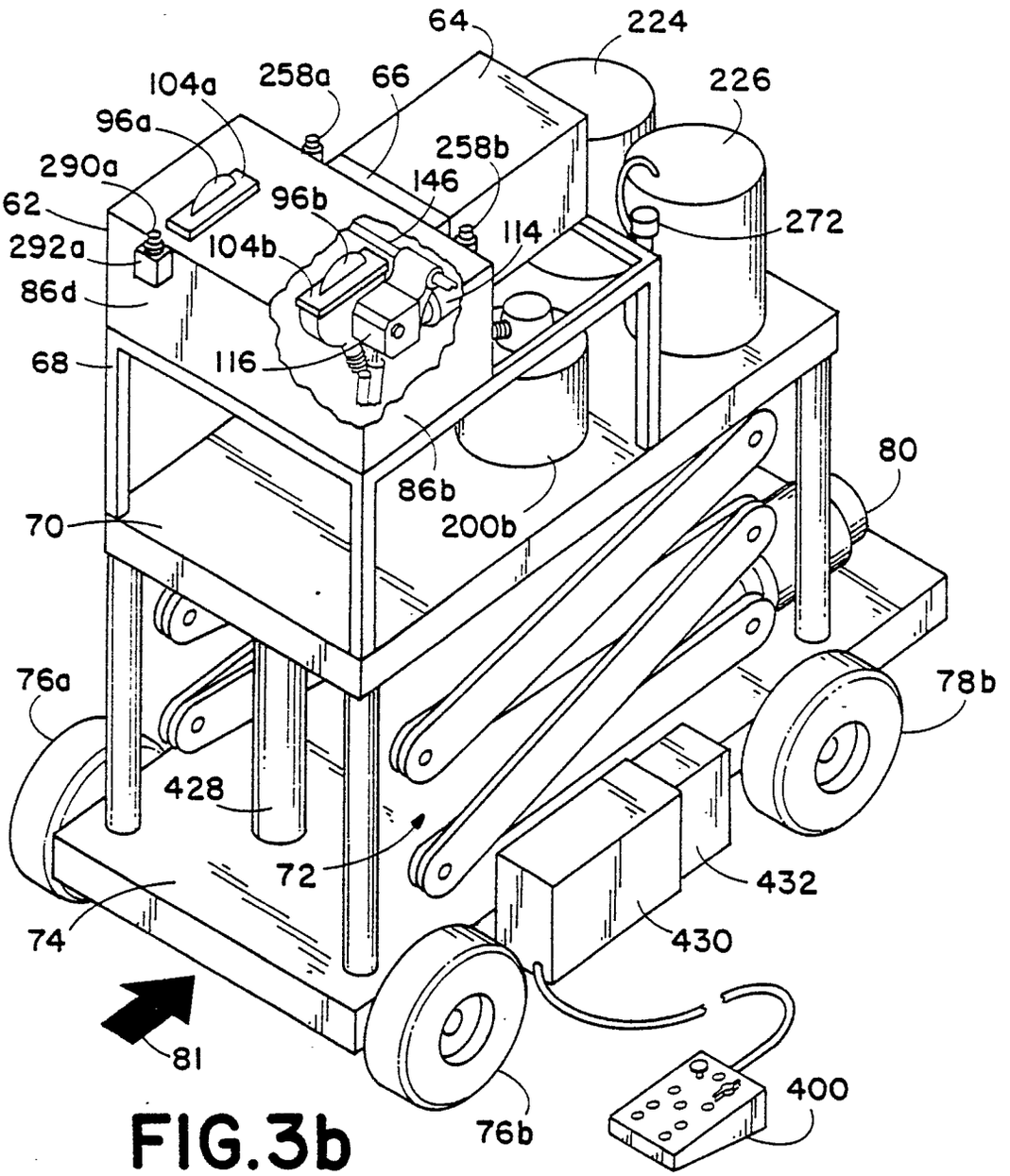
FIG.3a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80
86b
200b
70
76a
78b
428
72
432
74
430
81
400
76b

FIG.3b

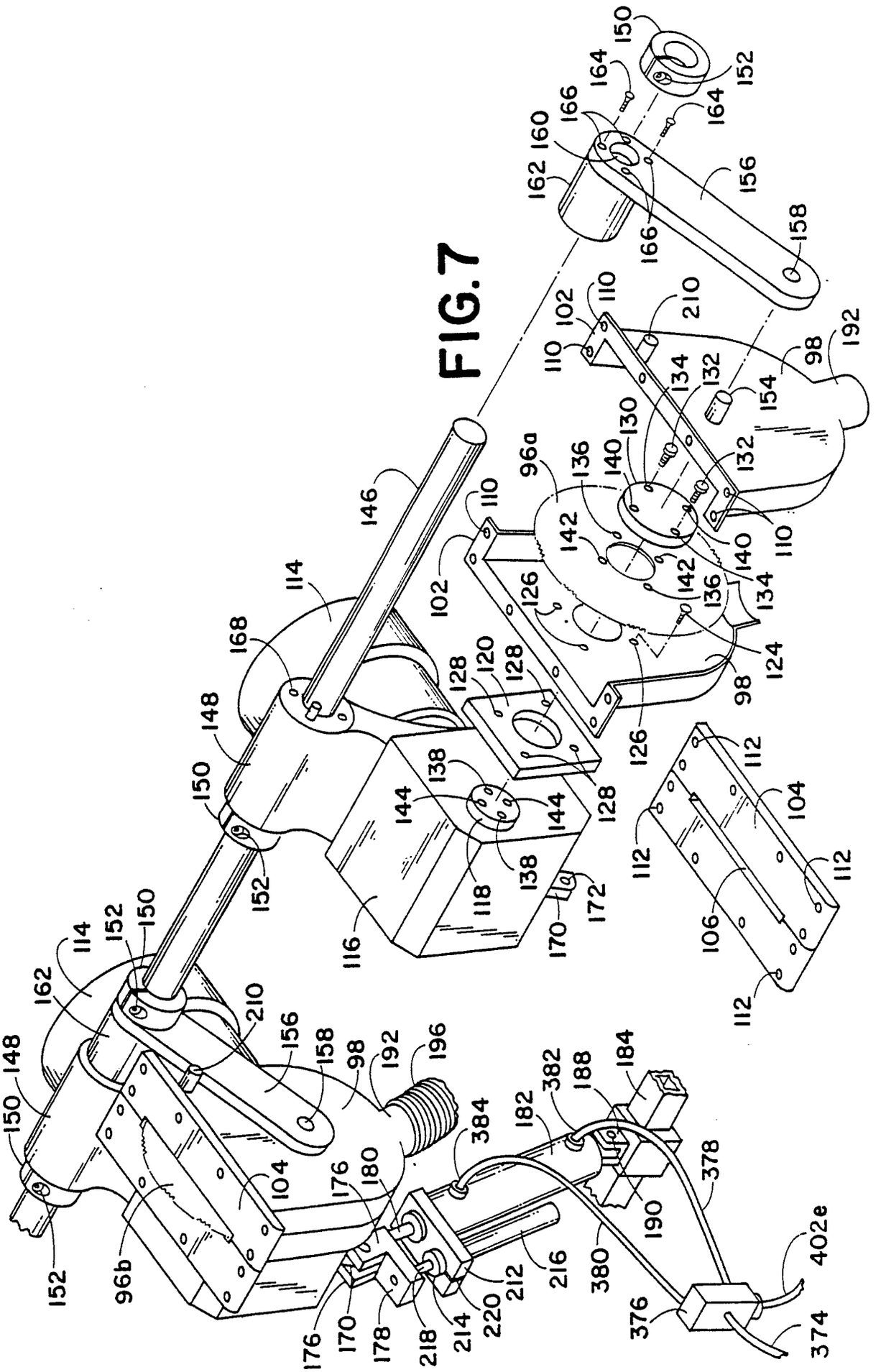

FIG.7

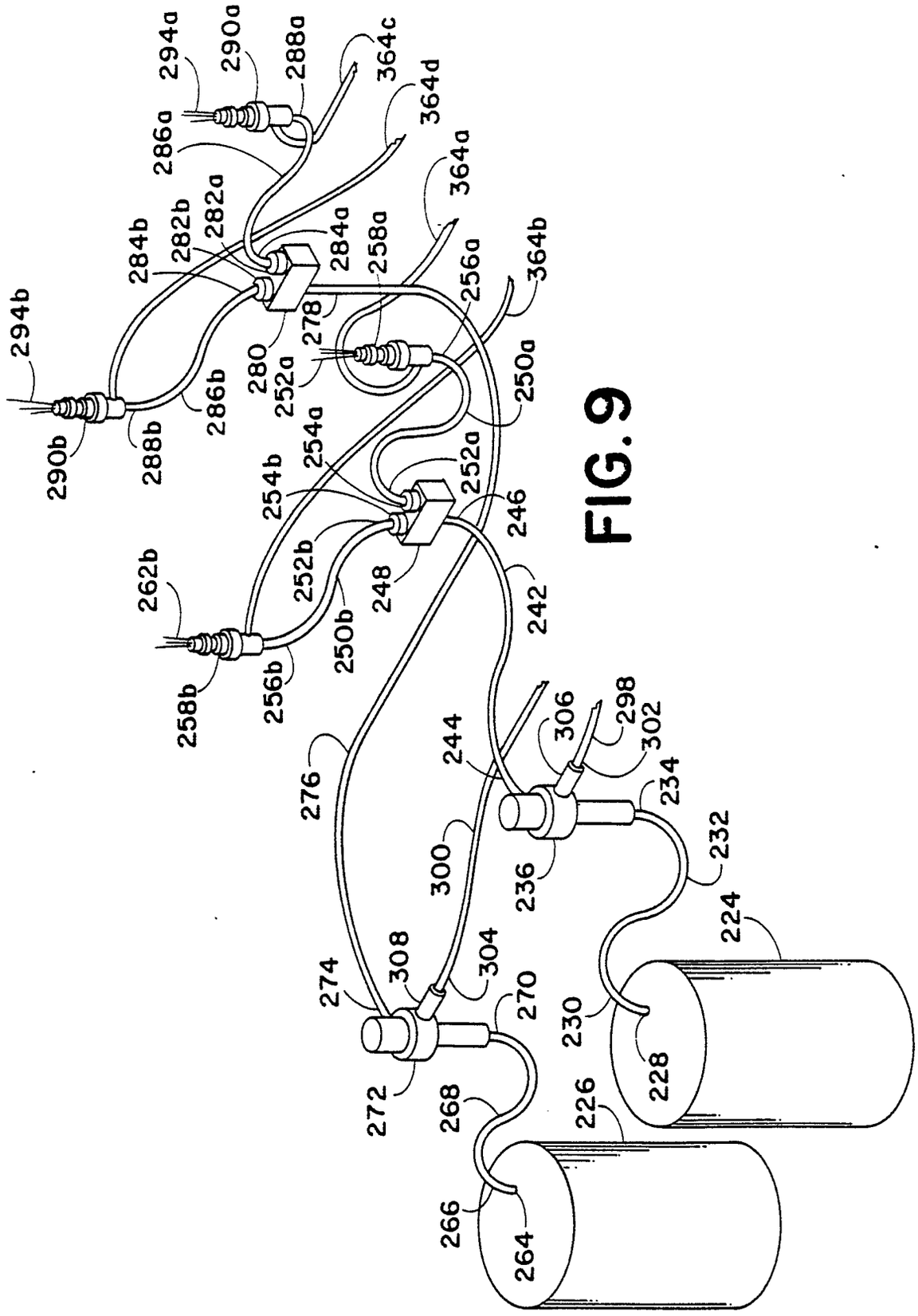
294a
290a
288a
364c
364d
286a
364a
284b
282b
282a
284a
258a
256a
364b
294b
280
278
252a
250a
290b
288b
286b
254a
254b
252a
246
262b
252b
248
242
250b
258b
256b
306
298
302
276
244
234
300
232
236
224
274
308
304
230
270
228
272
268
226
266
264

FIG. 9

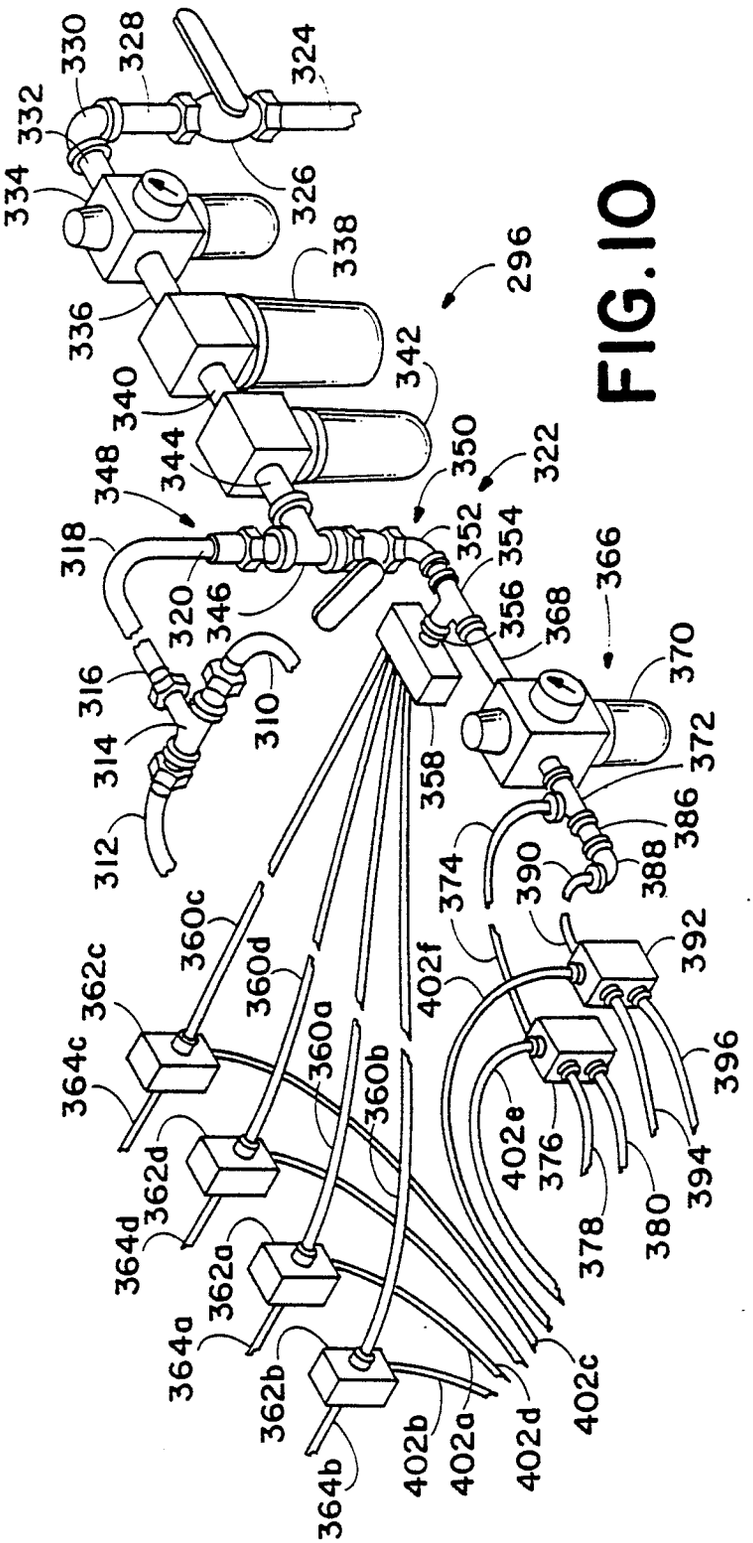
312
314
316
310
318
320
346
348
344
340
336
334
332
330
328
324
326
338
342
296
322
350
352
354
356
358
368
366
370
372
386
388
390
374
402f
392
396
394
380
378
376
402e
402c
402d
402a
402b
364b
362b
364a
362a
364d
362d
364c
362c
360c
360d
360a
360b

FIG. 10

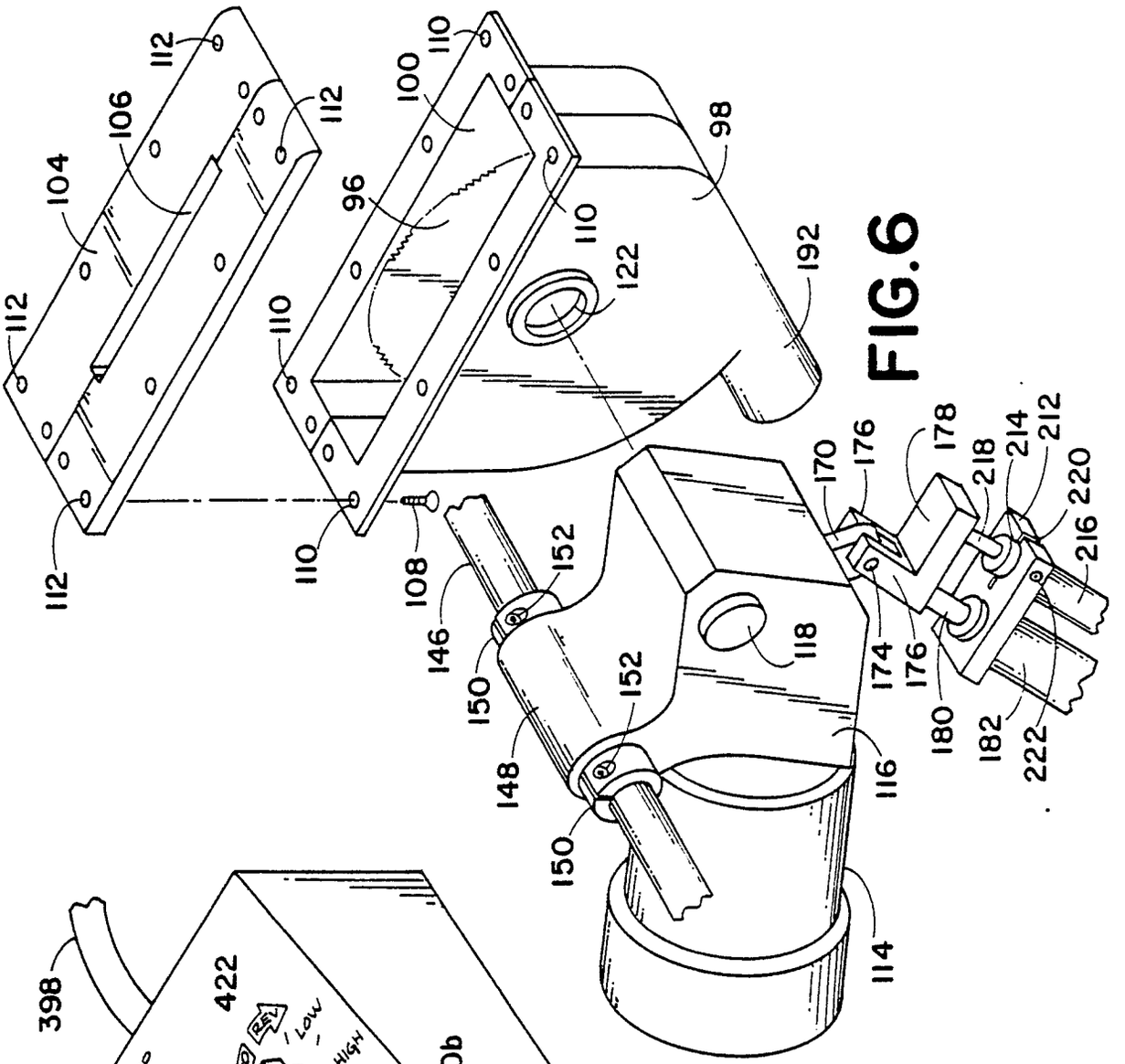
112
106
104
112
112
112
100
110
98
96
110
122
192
110
110
108
146
152
150
148
152
118
116
150
114
170
176
178
218
214
212
216
220
174
176
180
182
222

FIG.6

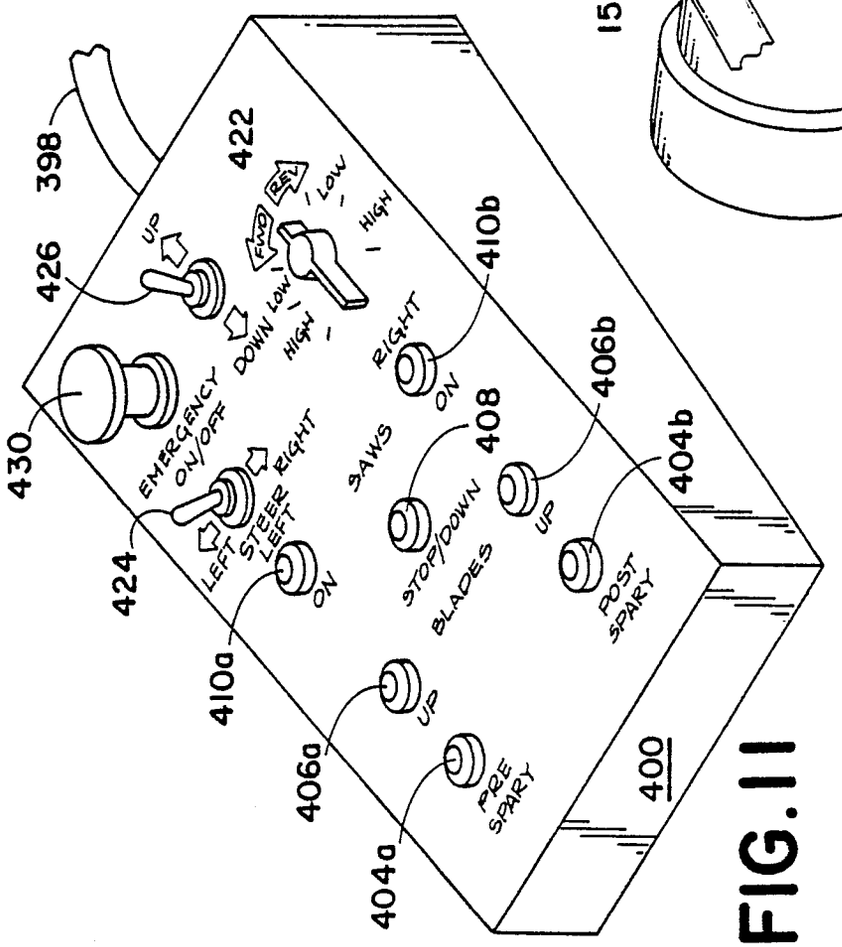
398
422
426
UP
DOWN
FWD
REV
LOW
HIGH
LOW
HIGH
410b
RIGHT
ON
406b
430
EMERGENCY
ON/OFF
408
SAWS
404b
424
LEFT
STEER
RIGHT
LEFT
ON
STOP/DOWN
BLADES
UP
POST
SPARY
410a
406a
UP
PRE
SPARY
404a
400

FIG. 11

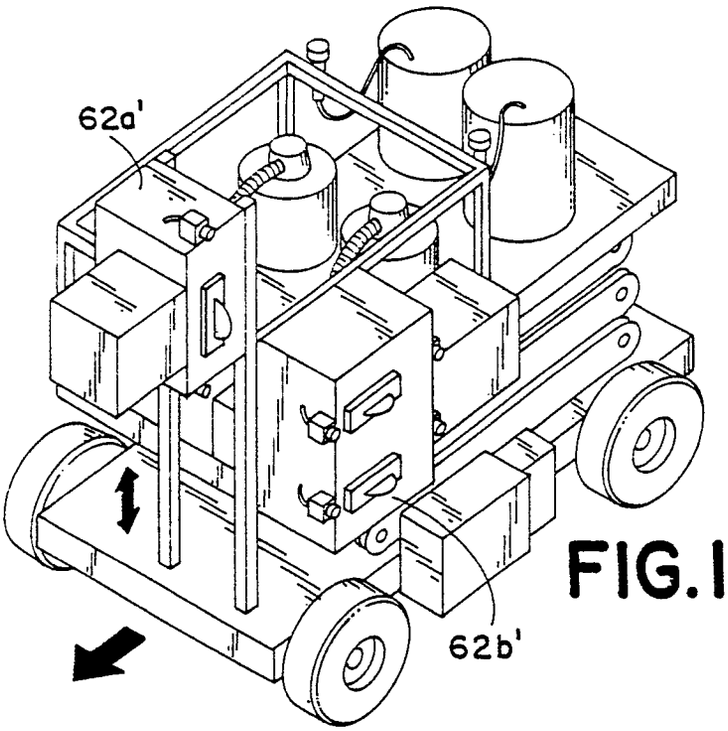

FIG.12a

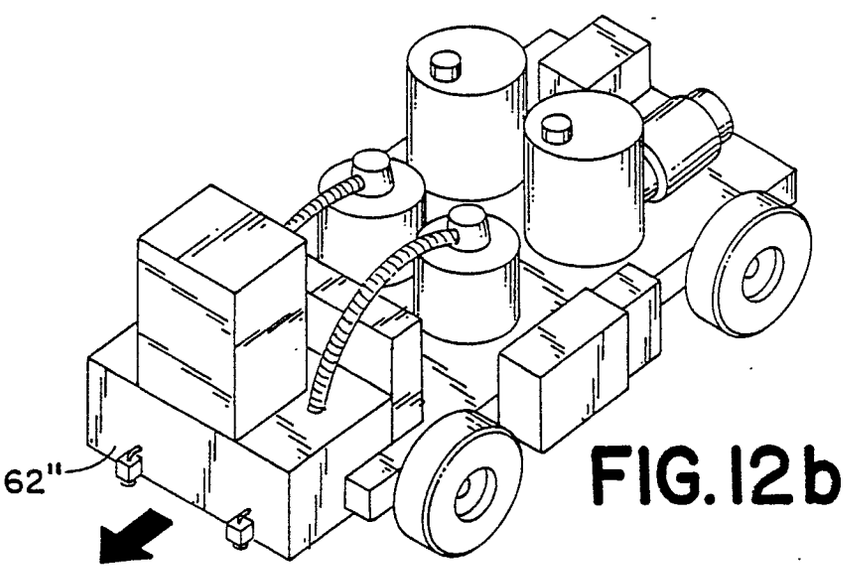

FIG.12b