

[54] **HYDROSTATIC LEVELING APPARATUS WITH CONTROL OPERATOR**

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 [51] Int. Cl. **G01c 9/22**
 [58] Field of Search **33/367**

[56] **References Cited**
UNITED STATES PATENTS

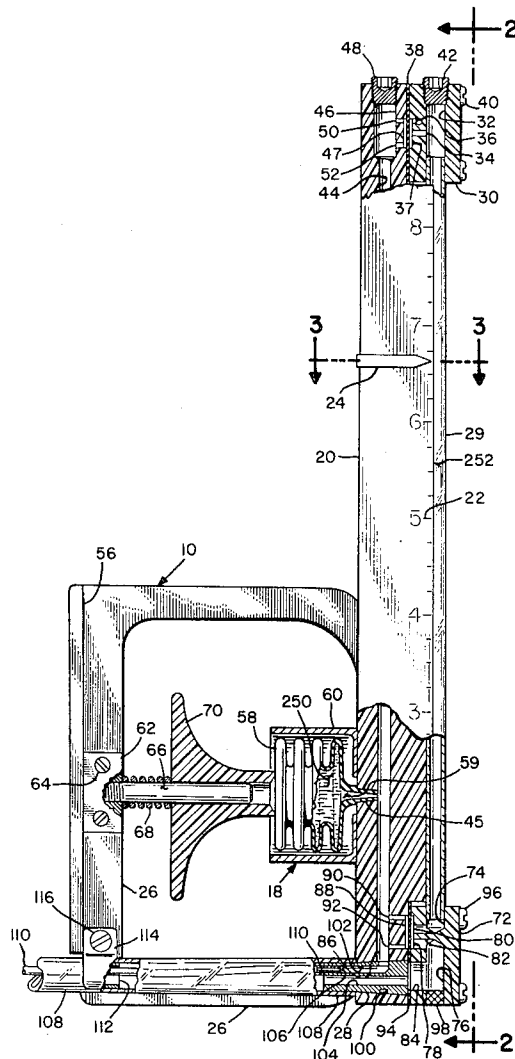
3,310,880 3/1967 Watts..... 33/367
 3,645,135 2/1972 Hadley..... 33/367

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[57] **ABSTRACT**

A liquid apparatus for determining level points including a reservoir assembly, a sight tube assembly, and a connecting liquid conduit is improved in order to prevent (1) the spillage or overflow of the liquid and (2) the passage of air bubbles into the conduit. Atmospheric vent valve assemblies are positioned above the liquid in the reservoir assembly and the sight tube assembly. Liquid valve assemblies are positioned adjacent the connections to the conduit on the reservoir assembly and the sight tube assembly. All four of these valve assemblies are controlled by a single remote control operator positioned on the sight tube assembly. Simplified alternative embodiments omit one or both of the valve assemblies on the reservoir assembly.

58 Claims, 10 Drawing Figures



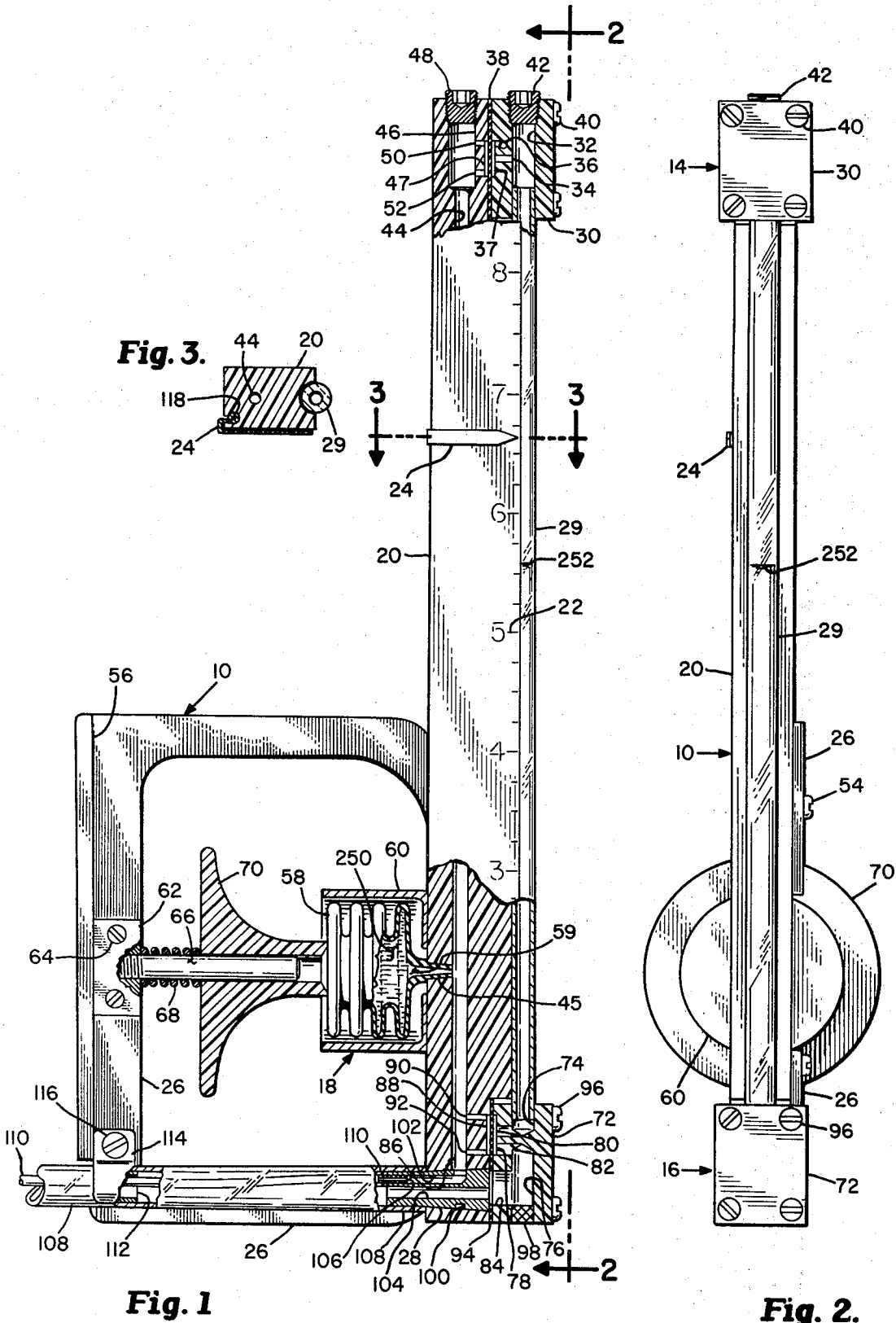


Fig. 3.

Fig. 1

Fig. 2.

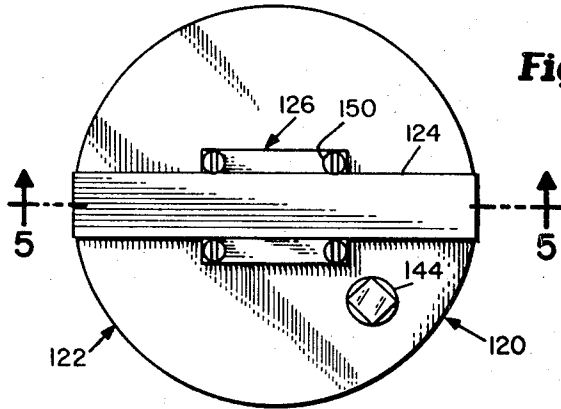


Fig. 4.

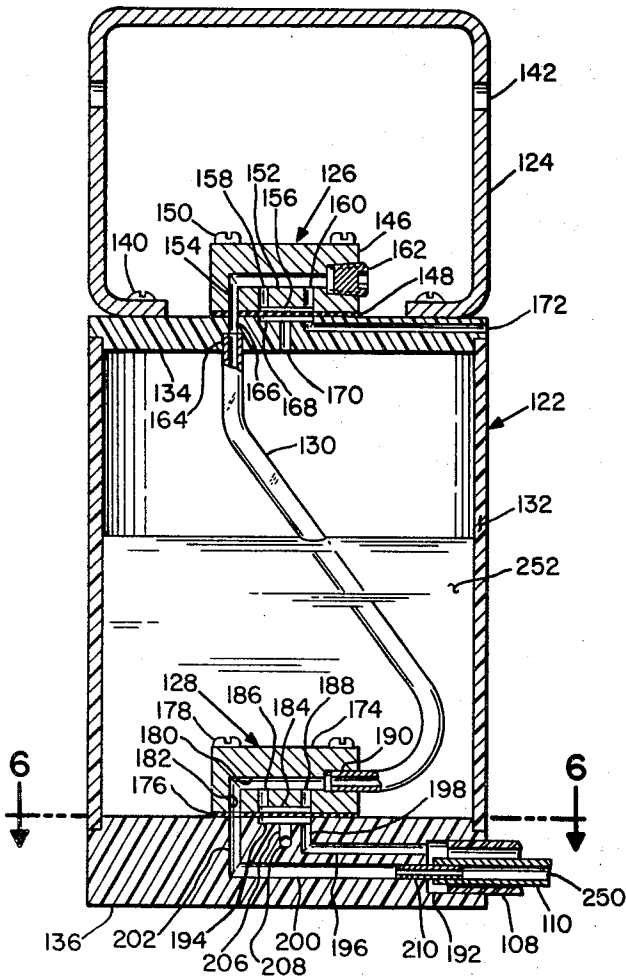


Fig. 5.

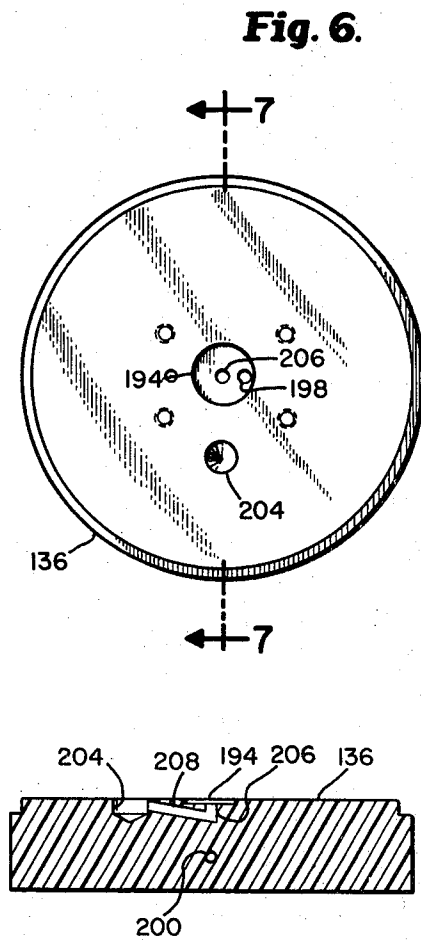


Fig. 6.

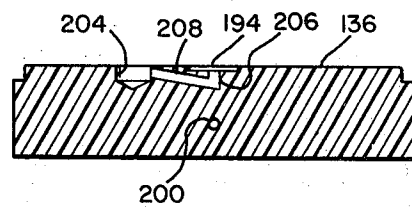


Fig. 7.

Fig. 10.

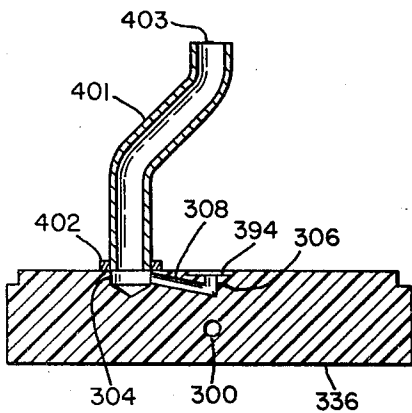
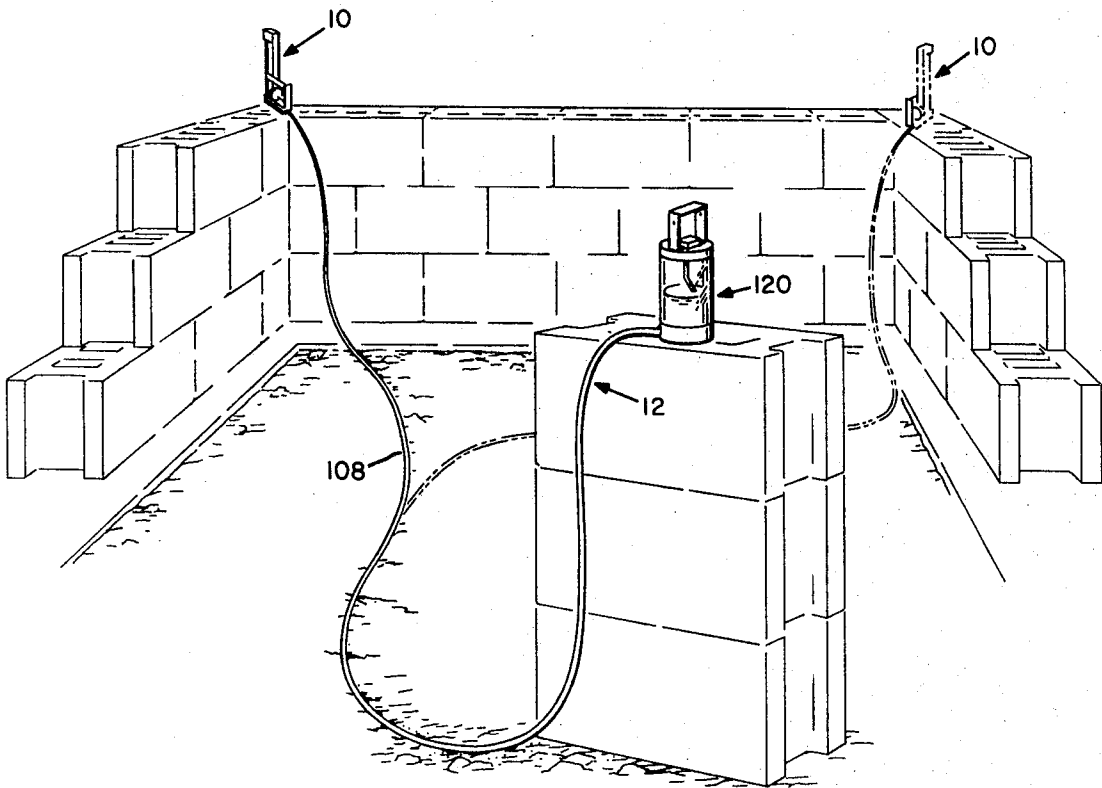


Fig. 8.

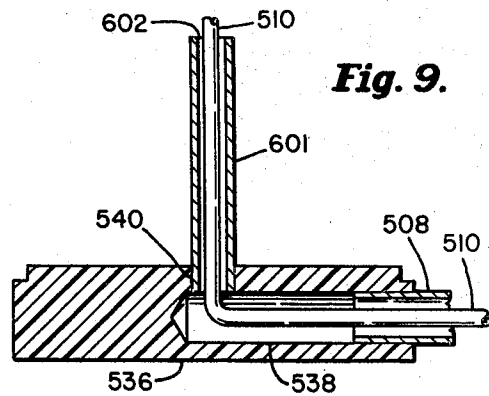


Fig. 9.

HYDROSTATIC LEVELING APPARATUS WITH CONTROL OPERATOR

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to improvements in hydrostatic leveling apparatus. The primary object of this invention is to provide a device of this character which makes use of the principle that a liquid will rise to the level of its source and can be employed for establishing an absolute level line or plane of level points and which will prevent (1) the escape of liquid from the apparatus and (2) the entrapment of air bubbles within the connecting liquid conduit.

Another object of the invention is the provision of a control operator on the sight tube assembly which, when manipulated, will open atmospheric vent valve assemblies above both (1) the liquid in the reservoir assembly and (2) the liquid in the sight tube assembly, thereby permitting accuracy at the time lines or points are established, but preventing spillage or overflow from these vents during movement, positioning, and storage.

A further object of the invention is the provision of valve assemblies on each end of the conduit to prevent the flow of liquid therethrough except when the control operator on the sight tube assembly is manipulated to an open position at the time points are established, thereby eliminating inaccuracy caused by the entrapment of air bubbles within the conduit.

An additional object of the invention is the provision of a hydrostatic leveling apparatus with valve assemblies which may be biased to a closed position to prevent spillage and air bubble entrapment. A single control operator on the sight tube assembly is conveniently positioned so that, with the reservoir assembly positioned, a single unskilled worker can manipulate the one control operator and determine a plane of level points with the sight tube assembly, thereby eliminating the need for a second worker and the need for the one worker to return to the reservoir assembly between level point determinations.

A still further object of the invention is the provision of an alternative apparatus which utilizes two controlled atmospheric vent valve assemblies, but only one liquid valve assembly on the sight tube end of the connecting conduit, thereby simplifying the apparatus.

A still further object of the invention is the provision of an alternative apparatus which utilizes one controlled atmospheric vent valve assembly on the sight tube assembly and one controlled liquid valve assembly on the sight tube assembly, since the lighter and more portable sight tube assembly is the most frequent source of air bubble entrapment and liquid spillage.

A still further object of the invention is the provision of alternative embodiments which provide an indicator-liquid outlet positioned at the geometric center of the reservoir so that, when the reservoir is substantially more than one half full of indicator-liquid, the escape of air bubbles from the reservoir assembly into the conduit is prevented even during accidental upset or inversion of the reservoir. This centered outlet configuration may be used with any of the two, the three, or the four valve assembly configurations.

A final object of the invention is the provision of an apparatus designed for rugged use, without mainte-

nance, and comprised of components that are economical to fabricate, simple to assemble, and which will reduce the cost of the leveling apparatus so that any workman can secure the benefits of the precision leveling without extensive training or background experience, thereby increasing the level of skill of the workman and the quality of his work product.

2. Description of the Prior Art

The prior patents in the hydrostatic leveling art disclosing (1) closure means for atmospheric vents and (2) liquid control means to prevent (a) liquid spillage from the apparatus and/or (b) air bubble entrapment in the connecting liquid conduit cover a time span of over eighty years. These patents, directed to one or more problems solved by applicant's apparatus, are grouped as to structure or operation and discussed below.

U.S. Pat. Nos. 825,760; 872,183; 914,945; 1,203,702; 2,308,088; 2,558,004; 3,117,381; 3,212,195; 3,269,023; and 3,443,319 disclose unbiased manual atmospheric vent control valves which require a workman to open and close each vent each time the apparatus is used, stored, or transported. U.S. Pat. Nos. 909,529 and 3,330,045 disclose biased manual atmospheric vent valves. U.S. Pat. Nos. 503,149; 1,576,470; 2,150,048; 2,614,572; and 2,814,127 disclose float type atmospheric vent valves which prevent spillage due to overflow whenever the apparatus is oriented vertically, but do not prevent spillage due to upset or inversion of the apparatus. U.S. Pat. Nos. 1,060,602 and 1,216,129 disclose multiple trap type atmospheric vent valves in combination with multiple liquid compartments which prevent liquid spillage since the amount of liquid outside the connecting conduit is small, and which prevent spillage when the major portion of the indicator liquid is sealed between flexible membranes. U.S. Pat. Nos. 2,614,572 and 3,443,319 disclose atmospheric vent valves which require the vertical orientation of the apparatus to be operative. U.S. Pat. No. 965,659 discloses a thimble valve to control the closing of an atmospheric vent. U.S. Pat. No. 3,048,927 discloses an atmospheric porous, but mercury impervious covering for atmospheric vents which works well when the liquid utilized is mercury, but will not prevent leakage with most commonly utilized liquids for leveling apparatus. U.S. Pat. Nos. 762,072; 872,183; 1,060,602; 1,216,129 and 3,330,045 disclose thin flexible membranes to prevent the spillage of indicator liquid from the apparatus. When the apparatus is new and is used in warm temperatures these membranes are quite successful; however, they introduce inaccuracy when used in cold temperature and when slight loss of flexibility occurs due to aging. Further, such thin membranes are susceptible to tearing either due to aging or elastic overload. U.S. Pat. No. 3,048,927 also discloses a porous flexible membrane used for a similar purpose with mercury as the indicator-liquid. U.S. Pat. Nos. 872,183; 1,060,602; and 1,216,129 disclose leveling apparatus in which three separate indicator-liquid chambers are utilized to eliminate the entrapment of air bubbles within the connecting conduit. This requires at least two flexible membranes to contain the major portion of the liquid within the connecting conduit and these membranes are also subject to aging, temperature dependent elasticity changes, and tearing. U.S. Pat. Nos. 909,529; 914,945;

3,132,428; 3,212,195; and 3,443,319 disclose unbiased liquid control valves requiring manual operation each time the apparatus is used, stored, or transported. U.S. Pat. Nos. 2,558,004 and 2,641,061 disclose spring biased indicator-liquid control valves on a level sight assembly.

In a more general aspect, the present practice, in most occupations which require a workman to determine level points or planes, is to use ordinary bubble levels for relatively short distances and to use a surveyor's level for longer distances. These present practices are both costly and time consuming. Various hydrostatic leveling devices are available commercially but have not gained the wide commercial usage by tradesmen which a simpler, self-contained apparatus should have obtained during the past eighty years.

To summarize the pertinent patented prior art and the present commercial practice, there is no commercially available hydrostatic leveling apparatus that is simple, prevents liquid spillage, prevents air bubble entrapment in the connecting conduit, and provides positive atmospheric venting of both reservoir and sight tube with a single remote control operator positioned so that an unskilled workman may operate the control operator with the same hand that is also used to position the sight tube assembly. The complexities and limitations of the prior art devices discussed above are considered to have limited the commercialization of such devices. Applicant's invention is directed to the elimination of prior art complexities and the incorporation of novel features to overcome the operational deficiencies of the discussed prior art and the present commercial practice.

SUMMARY

The approach utilized by the applicant has been (1) to design a ruggedized hydrostatic leveling apparatus which can withstand the rigors of all types of trades usage in all weather conditions without maintenance, filling, or calibration; (2) to simplify both the construction and method of use for such apparatus so that it may be used by the average workman without extensive training; and (3) to produce a product which will gain ready acceptance in the commercial market by overcoming the limitations of the prior art devices.

The present invention includes a first embodiment of hydrostatic leveling apparatus with a sight tube assembly having the novel features of a remote control operator adjacent the handle, an atmospheric vent valve assembly connected to the control operator, and an indicator-liquid flow control valve assembly also connected to the control operator, whereby a single control operator provides a single workman with complete control of the apparatus with one hand; eliminates the most frequent causes of liquid spillage and overflow; and provides positive atmospheric venting of the indicator liquid portion of the sight tube during elevational positioning of the sight tube assembly and yet provides (1) positive sealing of the atmospheric vent at times between usage, during storage, and during transport, and (2) positive prevention of air bubbles entering the connecting indicator-liquid conduit from the sight tube. When used in applications where the position of the reservoir assembly is not subject to upset a conventionally vented reservoir combined with this sight tube assembly provides a simple and versatile apparatus. Additional protection is obtained by combining an indica-

tor-liquid outlet configuration having a geometrically-centered reservoir location and by maintaining the indicator-liquid level in the reservoir substantially more than half full, thereby preventing air bubbles from entering the indicator-liquid conduit from the reservoir, as taught by the prior art.

A second embodiment of applicant's apparatus includes the features of the first embodiment described above and also (1) an additional atmospheric vent valve assembly on the reservoir assembly, (2) a control-liquid network comprising a first conduit connecting the sight tube vent valve assembly to the sight tube indicator-liquid flow control valve assembly and a second conduit connecting the reservoir assembly vent valve assembly to the sight tube indicator-liquid flow control valve assembly, and (3) the remote control operator connected to the control-liquid network, whereby additional protective control is gained in those applications where the reservoir assembly may be subject to upset or inversion during use, storage, or transport. This embodiment may also use the centrally located indicator-liquid outlet configuration described above.

An additional and most highly refined embodiment of applicant's apparatus includes the features of the second embodiment described above and also (1) an additional indicator-liquid flow control valve assembly positioned on the reservoir assembly and (2) the necessary third control-liquid conduit in the control-liquid network connecting this reservoir assembly indicator-liquid flow control valve assembly to the remote control operator on the sight tube assembly. This embodiment provides all the advantages of the first and second embodiments described above and additional positive protection against the escape of air bubbles from the reservoir into the indicator-liquid conduit during agitation or vibration of the reservoir assembly while upset or inverted.

In the embodiments utilizing a control-liquid network and requiring a control-liquid conduit from the sight tube assembly to the reservoir assembly the control-liquid conduit is most compactly positioned within the indicator-liquid conduit. This configuration eliminates any abrasion of the smaller control-liquid conduit. Other portions of the control-liquid network are positioned entirely within the sight tube assembly and the reservoir assembly and are thereby protected from damage or abrasion.

The combination of at least some of the above novel features in a ruggedized hydrostatic leveling apparatus, namely: (1) a remote control operator on the sight tube assembly operable by one hand while also using the same hand for positioning the sight tube assembly; (2) an atmospheric vent valve assembly operatively connected to the remote control operator; (3) an indicator-liquid flow control valve assembly on the sight tube assembly operatively connected to the remote control operator; (4) an atmospheric vent valve assembly on the reservoir assembly operatively connected to the remote control operator; (5) an indicator-liquid flow control valve assembly on the reservoir assembly operatively connected to the remote control operator; and (6) a control-liquid network solid filled with an incompressible control-liquid, permit the use of such leveling apparatus without complex valve manipulations, requiring two hands or two workmen, provide a single control operator under the control of a single unskilled

workman, and permit the workman to put the sight tube assembly down without worrying about vertical orientation, upset, spillage, or air bubble entrapment, thereby enhancing the versatility of such apparatus to the point that the relatively modest cost of the apparatus will be repaid in a very short period of usage.

BRIEF DESCRIPTION OF THE DRAWINGS

The objectives of the invention and the manner in which it is carried out will be apparent from the following description and the accompanying drawings, wherein:

FIG. 1 is an elevational view of the sight tube assembly embodying the invention, with portions broken away and shown in section to illustrate details of construction.

FIG. 2 is an elevational view of the sight tube assembly of FIG. 1 taken as indicated by viewing plane 2 — 2 on FIG. 1.

FIG. 3 is a sectional view of a portion of the sight tube assembly showing the details of an indicator thereon as indicated by cutting plane 3 — 3 on FIG. 1.

FIG. 4 is a top plan view of the reservoir assembly embodying the invention.

FIG. 5 is a central sectional elevational view of the reservoir assembly as indicated by cutting plane 5 — 5 on FIG. 4.

FIG. 6 is a top plan view of the bottom element of the reservoir assembly as indicated by viewing plane 6 — 6 on FIG. 5, with other elements omitted.

FIG. 7 is a sectional elevational view of the bottom element of the reservoir assembly illustrating the liquid passage between the reservoir port and the port of the valve assembly, taken as indicated by cutting plane 7 — 7 on FIG. 6.

FIG. 8 is a sectional elevational view of an alternative embodiment of the invention, taken along a similar cutting plane to that of FIG. 7, showing a curved indicator liquid outlet pipe and mounting ring secured to the bottom portion of the reservoir assembly.

FIG. 9 is a sectional elevational view of an additional embodiment of the invention, taken along a similar cutting plane to that of FIG. 5, showing a straight indicator liquid outlet pipe secured to the bottom portion of the reservoir assembly and the elimination of the indicator liquid valve assembly.

FIG. 10 is a perspective view of a hydrostatic leveling apparatus embodying the invention showing a typical use, with a second position of the sight tube assembly shown in phantom line.

The drawings have been drawn to full scale to represent the embodiment of a four valve assembly apparatus which has been extensively tested; however, changes in design and proportion would not change the inventive concept.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIGS. 1 and 2, the sight tube assembly 10 of applicants hydrostatic leveling apparatus 12 is shown. Sight tube assembly 10 includes an atmospheric vent valve assembly 14, an indicator-liquid flow control valve assembly 16, a remote control operator assembly 18, a standard 20 with an integral scale 22 and an adjustable indicator 24, a positioning and manipulating handle 26, a tapered connector 28, and a sight tube 29.

Valve assembly 14 includes a body 30 with a central bore 32, two ports 34 and 36, and a shallow cylindrical recess 37. Port 36 includes a first portion parallel to port 34 for a short distance and a second portion at a right angle which connects this first portion to the outside of body 30, and thereby provides a vent to the ambient atmosphere. A flexible diaphragm 38 performs the valve function and is secured between standard 20 and body 30 by four self-tapping screws 40. A plug 42 closes the upper portion of bore 32 and the upper end of sight tube 29 is cemented within the lower portion of bore 32. Standard 20 has a central bore or closed conduit 44 with an enlarged upper portion 46, a plug 48 closing the upper portion thereof, a shallow cylindrical recess 47, and two ports 50 and 52 connecting recess 47 to the enlarged upper portion 46 of bore 44. Sight tube 29 is cemented to a half-cylindrical recess in standard 20 throughout the visible portion thereof. The numerals of integral scale 22 and the height marks auxiliary thereto are cast within or otherwise applied to standard 20 with a zero starting point flush with the bottom of standard 20. Handle 26 is secured to standard 20 by two self-tapping screws 54 and a portion 56 at right angles to the main portion of handle 26 provides a comfortable gripping portion upon which to exert a squeezing pressure. Centrally located vertically within handle 26 is remote control operator assembly 18 secured to standard 20. Control operator assembly 18 includes a flexible operator element or bellows 58 cemented to standard 20 and the interior control-liquid portion 59 thereof is connected with bore 44 by a hole 45 through standard 20. A generally cylindrical shield 60 is cemented to standard 20 to provide protection for bellows 58 during storage and use. A shaft mounting block 62 is secured to handle 26 by two self-tapping screws 64. A guide shaft 66 is threaded into block 62 and has a compression spring 68 and a generally cone shaped pull knob 70 mounted in slidable relationship thereupon.

Indicator-liquid valve assembly 16 includes a body 72 with an upper bore 74 and a lower bore 76, a shallow cylindrical recess 78, and two ports 80 and 82 connecting recess 78 to bores 74 and 76 respectively. A connecting bore 84 is provided at a right angle to bore 76. The lower portion of standard 20 includes a tapered bore 86, a shallow cylindrical recess 88, and two ports 90 and 92 connecting recess 88 to the lower portion of bore 44. A flexible diaphragm 94 performs the valve function and is secured between standard 20 and body 72 by four self-tapping screws 96. The lower portion of bore 76 is closed by a plug 98 cemented therewithin. The upper portion of bore 74 has the lower portion of sight tube 29 cemented therewithin. Connector 28 is tapered to mate with bore 86, has a cylindrical recess 100 horizontally aligned with the lower portion of bore 44, has two bores 102 and 104 connecting with recess 100 and bore 84 respectively, and is cemented within bore 86. A short section of tubing 106 is press fitted within bore 102. A first closed conduit 108 and a relatively smaller second closed conduit 110 provide liquid connection to the two liquid circuits in sight tube assembly 10. One end of conduit 110 is cemented over tubing 106. A short rigid sleeve 112 is horizontally positioned within one end of conduit 108. Sleeve 112 is aligned with the outer portion of handle 26 and the end of conduit 108 is cemented to the exposed end of tapered connector 28. A hose clamp 114 is secured to

handle 26 by a self-tapping screw 116 and clamps conduit 108 to handle 26, with sleeve 112 preventing distortion of conduits 108 and 110.

Referring now to FIG. 3, a slot 118 with an enlarged inner portion is provided along the entire length of standard 20 to provide a frictional engagement with a cylindrical portion of indicator 24, thereby providing an easy vertical setting of indicator 24 on standard 20.

Referring now to FIGS. 4 and 5, the reservoir assembly 120 of applicant's hydrostatic leveling apparatus 12 is shown. Reservoir assembly 120 includes a reservoir 122, a handle 124, an atmospheric vent valve or valve assembly 126, an indicator-liquid flow control valve assembly 128, and a closed conduit 130 connecting therebetween. Reservoir 122 includes a transparent cylindrical body 132, a circular top 134, and a circular bottom 136, with top 135 and bottom 136 cemented to body 132. Handle 124 is attached to top 134 of reservoir 122 by four self-tapping screws 140. Hanging holes 142 in each side of handle 124 permit suspension from a wire or other support when desired. A removable fill plug 144 is threaded into top 134 to provide access to add indicator-liquid. Valve assembly 126 includes a body 146, and a flexible diaphragm 148. Body 146 is secured to top 134 by four self-tapping screws 150 with diaphragm 148 secured therebetween. Body 146 has a central bore 152 which turns at right angles to provide a connecting portion 154, a shallow cylindrical recess 156, and two ports 158 and 160 connecting bore 152 to recess 156. A plug 162 closes one end of bore 152. Top 134 has an enlarged connecting bore 164, a reduced connecting bore 166 aligned with connecting portion 154, a shallow cylindrical recess 168, a port 170 which connects a recess 168 to the interior top portion of reservoir 122, and a port 172 which connects recess 168 to the outside of top 134, and thereby provides a vent to ambient atmosphere. The upper end of conduit 130 is cemented within bore 164.

Valve assembly 128 includes a body 174 and a flexible diaphragm 176. Body 174 is secured to bottom 136 by four self-tapping screws 178 with diaphragm 176 secured therebetween. Body 174 has a central bore 180 which turns at right angles to provide a connecting portion 182, a shallow cylindrical recess 184 and two ports 186 and 188 connecting bore 180 to recess 184. At the outer end of bore 180 an enlarged bore 190 is provided in alignment therewith. The lower end of conduit 130 is cemented within bore 190. Bottom 136 has an enlarged connecting bore 192, a shallow cylindrical recess 194, an indicator-liquid connecting bore 196 which is connected to recess 194 through a port 198, and a control-liquid connecting bore 200 which is connected to connecting portion 182 of bore 180 by a bore 202.

Referring in detail to FIGS. 5, 6, and 7, a shallow cylindrical bore 204 is provided in bottom 136, thereby providing an indicator-liquid outlet. A small central port 206 parallel to bore 204 and an angled bore 208 are provided in bottom 136 to connect recess 194 to bore 204 to provide indicator-liquid flow to port 198 and bore 196 whenever valve assembly 128 is open.

Referring now to FIGS. 1 and 5, the liquid connecting portions of reservoir assembly 120 and sight tube assembly 10 will be further described. A short section of tubing 210 is press fitted within bore 200. One end of conduit 110 is cemented over tubing 210 and one

end of conduit 108 is cemented within bore 192, thereby connecting reservoir assembly 120 to sight tube assembly 10 and establishing two separate liquid conduits therebetween, a first conduit 108 for indicator-liquid and a second conduit 110 for control-liquid.

Referring now to FIG. 8, a circular bottom 336 analogous to bottom 136 is shown. Bore 304, port 306, bore 308, recess 394, and bore 300 are similar to bore 204, port 206, bore 208, recess 194, and bore 200 respectively, shown in FIG. 7. The sole difference between the embodiment shown in FIG. 7 and the apparatus of FIG. 8 is the addition of a curved indicator-liquid outlet pipe 401 and a pipe mounting ring 402. Pipe 401 and ring 402 are cemented to bottom 336 in alignment with bore 304. Pipe 401 is curved to avoid valve assembly 128; extends exactly one half the distance from bottom 336 to top 134; and the top of pipe 401 is aligned with the central axis of body 132, thereby providing an additional safety feature for applicant's apparatus. Whenever reservoir 122 is substantially over half full of indicator-liquid, the top end 403 of pipe 401 which is positioned in the geometric center of reservoir 122 is always covered with liquid even if reservoir assembly 120 is accidentally tipped over, or even inverted, and no air bubbles can ever enter conduit 108 from reservoir 122 to cause inaccuracy in the readings of sight tube 29.

Referring now to FIG. 9, a cylindrical bottom 536 having the general outline of bottom 136 is shown, the view being taken along the same cutting plane as that of FIG. 5. A bore 538 in bottom 536 receives one end of conduit 508 cemented therewithin. Conduit 508 is identical to conduit 108. A straight indicator-liquid outlet pipe 601 is cemented within a central vertical bore 540. One end of conduit 510, identical to conduit 110, passes through conduit 508, bore 538, bore 540, pipe 601, and out through the top end 602 of pipe 601 to be secured to valve assembly 126 in place of the upper end of conduit 130. Pipe 601 is centered on the axis of body 132, extends exactly one half the distance from bottom 536 to top 134, and provides a top end 602 in the geometric center of reservoir 122. The embodiment of FIG. 9 provides the same advantage as the embodiment of FIG. 8 in preventing entrapment of air bubbles in conduit 508 during upset or inversion of reservoir assembly 120.

It will be understood that the embodiment of FIG. 9 may be used without pipe 601 if the uses to which the leveling apparatus is to be subjected are such that there is little danger of upsetting reservoir assembly 120.

Leveling apparatus 12 has two liquid systems. A first liquid system includes the interiors of valve assembly 126, conduit 130, valve assembly 128, conduit 110, valve assembly 16, conduit 44, valve assembly 14, and bellows 58 which are solid filled with an incompressible control-liquid 250 at assembly, preferably by connecting a vacuum source to enlarged upper portion 46, while liquid 250 is admitted by connecting a liquid source to bore 152 as is well known in the solid filling art. Removable plugs 48 and 162 are provided for this purpose. Bellows 58 should be partially compressed during this operation so that the natural unstressed configuration of bellows 58 will exert a tendency to draw liquid 250 therewithin except when compression spring 68 pushes knob 70 against bellows 58. A second liquid system includes the interior of reservoir 122

which is filled substantially more than one half full; conduit 108 which is solid filled; the interior of sight tube 29 which is filled at least partially so that no air bubbles can enter conduit 108 from sight tube 29; and the interior portions of valve assemblies 128 and 16 which lie between reservoir 122 and sight tube 29, respectively, and conduit 108 which are solid filled with an incompressible indicator-liquid 252. Fill plug 144 is provided for this purpose.

Referring now to FIG. 10, a typical illustration of the use of applicant's hydrostatic leveling apparatus 12 is shown. Reservoir assembly 120 is positioned at a level which is approximately the desired level to be established or checked, such as on the top surface of a pile of blocks. Sight tube assembly 10 is then positioned with its bottom surface resting on a first corner of a block foundation and pull knob 70 is squeezed to open both vent valve assemblies 14 and 126 and both indicator-liquid valve assemblies 16 and 128, thereby permitting indicator-liquid 252 in reservoir 122 and sight tube 29 to establish a common level, with air free liquid surfaces vented to the ambient atmospheric pressure. Indicator 24 is moved on standard 20 to record the free surface of liquid 252 within sight tube 29 and pull knob 70 is released to close valve assemblies 14, 16, 126, and 128. Sight tube assembly 10 is now moved to a second corner of the block foundation and pull knob 70 is again squeezed while sight tube assembly 10 is positioned with its bottom surface resting on the second corner. The free liquid surface in sight tube 29 is again read and compared to the position of indicator 24 to check any difference in the heights of the foundation corners. A similar procedure could be used in establishing level lines or a plane of level points in carpentry or piping operations.

Elements 20, 26, 28, 30, 58, 60, 62, 70, 124, 134, 136, 146, and 174 have been designed specifically for injection molding in order to reduce the cost of providing bores and porting. A typical plastic to be used to form these parts is polyvinyl chloride. Other injection moldable plastics having good dimensional stability and compatibility with indicator-liquid 252 and control-liquid 250 could be used. In addition, where cementing of elements has been referenced, other means of joining may be used, such as, clamps, press fittings, and cold or hot welding. Screws 40, 54, 64, 96, 116, 140, 150, and 178 could be replaced by rivets, studs, or other connecting means. Further, flanges may be added to elements 134 and 136 to provide for ease of coiling and storage of conduits 108 and 110, as taught by U.S. Pat. No. 2,558,004; 2,641,061; and 3,330,045. Other valve assemblies, such as small spool valves with O-ring seals may be substituted in place of valve assemblies 14, 16, 126, and 128.

The detailed operation of applicant's hydrostatic leveling apparatus 12 will now be described. The three conventional components are:

1. reservoir assembly 120 including reservoir 122, atmospheric vent 172, indicator-liquid outlet 204, and an internal volume;

2. sight tube assembly 10 including sight tube 29, positioning handle 26 adapted to be used by one hand, atmospheric vent 36, and an internal volume; and

3. closed conduit 108 connecting reservoir assembly 120 and sight tube assembly 10. Conduit 108 and at least a substantial portion of the internal volumes of reservoir 122 and sight tube 29 are adapted to be filled

with incompressible indicator-liquid 252 when in use. The novel components combined with these components are:

4. valve assembly 14 supported on reservoir assembly 120 adjacent vent 172 and which is adapted to control the passage of fluid between the interior of reservoir 122 and the surrounding atmosphere;

5. valve assembly 126 supported on sight tube assembly 10 adjacent vent 36 and which is adapted to control the passage of fluid between the interior of sight tube 29 and the surrounding atmosphere;

6. valve assembly 16 supported on reservoir assembly 120 and which is adapted to control the passage of fluid between reservoir assembly 120 and conduit 108;

7. valve assembly 128 supported on sight tube assembly 10 and which is adapted to control the passage of fluid between sight tube assembly 10 and conduit 108;

8. closed conduit 44 connecting valve assemblies 14 and 16;

9. closed conduit 130 connecting valve assemblies 126 and 128;

10. closed conduit 110 connecting reservoir assembly 120 and sight tube assembly 10; and

11. remote control operator assembly 18 supported on sight tube assembly 10, including operator element 58 having open and closed positions, and being positioned adjacent handle 26 of sight tube assembly 10 so that a user may manipulate operator element 58 to select one of the open or closed positions by using one hand while also using the same hand for positioning sight tube assembly 10.

Operator element 58 and valve assemblies 14, 126, 16 and 128 each have an interior control-liquid portion. Conduits 130, 44, and 110 comprise a control-liquid network, and interior portion 59 of operator element 58 is connected to this control-liquid network.

Interior portion 59 of operator element 58, the control-liquid network, and the interior control-liquid portions of valve assemblies 14, 126, 16 and 128 are solid filled with incompressible control-liquid 250.

Reservoir assembly 120; sight tube assembly 10; conduit 108; valve assemblies 14, 126, 16, and 128; operator assembly 18; and the control-liquid network are connected so that whenever operator element 58 is in a closed position, valve assemblies 14 and 126 close atmospheric vents 36 and 172 and valve assemblies 16 and 128 prevent the passage of fluid between reservoir assembly 120 and sight tube assembly 10 through conduit 108, and whenever operator element 58 is in an open position, valve assemblies 14 and 126 open atmospheric vents 36 and 172 and valve assemblies 16 and 128 permit the passage of fluid between reservoir assembly 120 and sight tube assembly 10 through conduit 108.

In the embodiment shown, operator element 58 is a flexible bellows made of durable plastic and is a commercially available item used by chemists and pharmacists to dispense liquids in drop quantities. An alternative operator element would be a biased cylinder with O-ring seals, which could be moved sufficiently to change the volume of the control-liquid system enough to flex the diaphragms 38, 94, 148, and 176.

In the embodiment shown, valve assemblies 14, 126, 16, and 128 include flexible diaphragm elements 38, 94, 148, and 176 respectively, which are adapted to be flexed to provide the necessary valve action. The dia-

phragm elements have been fabricated from polyurethane film .010 inch thick, having the properties of high resistance to ozone, sunlight, gamma radiation, gasoline, kerosene, and other aliphatic petroleum products. Because this plastic contains no plasticizer, it doesn't outgas in hard vacuums and fatigue life is extremely high. It is very tough and exhibits very good abrasion and tear resistance and sub-zero flexibility is excellent, with the embrittlement point about -100°F . These diaphragms can be fabricated from other materials having similar characteristics. It should be noted that for purposes of clarity in illustration, diaphragm elements **38**, **94**, **148**, and **176** have been shown in a central position, but that while in use after the solid-filling of the control-liquid network, they will normally be in either the open or closed position, flexed against shallow cylindrical recesses **37**, **78**, **194**, and **168** or recesses **47**, **88**, **184**, and **156**. These eight recesses have been exaggerated for purposes of illustration and are approximately 0.020 inch deep.

In order to clarify the novel valving functions of apparatus **12**, the operation of the control-liquid network is now described in functional sequence. The function of the control-liquid network is to deflect diaphragms **38**, **94**, **148**, and **176** which operate as valves to permit venting or sealing of indicator-liquid **252** in sight tube **29** and reservoir **122**, as well as permitting liquid **252** to communicate from reservoir **122** to sight tube **29**. The control-liquid network comprises bellows **58** and a series of conduits which permit control-liquid **250** to communicate with the rear side of diaphragms **38**, **94**, **148**, and **176**. Bellows **58** is spring loaded by spring **68** to be normally compressed, thereby displacing liquid **250** out of bellows **58** and into recesses **47**, **88**, **184**, and **156** behind diaphragms **38**, **94**, **148**, and **176** in a manner that seals ports **36**, **80**, **172**, and **206**. In this position, liquid **252** is prevented from communicating from sight tube **29** to reservoir **122** or vice-versa, by the closed position of diaphragms **176** and **94**. The closed position of valves **16** and **128** also prevents air located above the surface of liquid **252** or air bubbles entrapped therewithin from entering conduit **108**. In addition, valves **14** and **126** are closed when bellows **58** is in the compressed condition thereby preventing spillage of liquid **252** should apparatus **12** be upset during transit or storage. Conversely, when pull knob **70** is retracted, the external spring load on bellows **58** is eliminated; bellows **58** expands; and liquid **250** is pulled from recesses **47**, **88**, **184**, and **156**, thereby deflecting diaphragms **38**, **94**, **148**, and **176** and opening ports **36**, **80**, **172**, and **206**. The opening of ports **36** and **172** vents the surface of liquid **252** in both sight tube **29** and reservoir **122** to atmosphere; and the opening of ports **80** and **206** permits liquid **252** to communicate from reservoir **122** to sight tube **29** or vice-versa, through conduit **108**.

While conduit **110** has been shown positioned within conduit **108** between reservoir assembly **120** and sight tube assembly **10**, it will be understood that other configurations may be used, it being preferred that conduit **110** be supported by conduit **108** between reservoir assembly **120** and sight tube assembly **10**. The conduit **108** that has been used is commercially available polyvinyl chloride tubing $\frac{3}{8}$ inch outside diameter and $\frac{1}{16}$ inch wall thickness. The conduit **110** that has been used is also commercially available polyvinyl chloride tubing of 0.056 inch inside diameter and 0.020 inch wall

thickness. Conduits **108** and **110** could be extruded in integral form as is common in welding hose.

In order to protect against air bubble entrapment in conduit **108** which originates from reservoir assembly **120**, reservoir **122** is designed to be symmetrical and has a geometric center. An indicator-liquid outlet **403** is positioned at the geometric center of reservoir **122** and reservoir **122** is filled with incompressible indicator-liquid **252** to a point exceeding one half of the internal volume of reservoir **122**.

Incompressible control-liquid **250** and incompressible indicator-liquid **252** may be any liquid having the desired characteristics of low temperature coefficient of expansion, low viscosity, and compatibility with conduits **108** and **110**, bellows **58**, diaphragms **38**, **94**, **148**, and **176**, and the other portions of apparatus **12** which they must contact. A preferred liquid that has been used is a silicone fluid, dimethyl siloxane polymer, having thermal stability, low surface tension and oxidation resistance, and which is commercially available as Dow Corning **200** fluid. It is desirable to add a dye to liquids **250** and **252** for ease of reading liquid levels and to note the solid filling of conduits **108** and **110** which are preferably transparent or translucent.

In view of my invention and disclosures set forth above, other variations and modifications will become evident to others skilled in the art to obtain all or part of the benefits of my invention without copying the structures and methods shown, and I therefore claim all such variations insofar as they fall within the reasonable spirit and scope of my claims.

Having thus described my invention, what I claim as new and desire to secure by letters Patent is:

1. In a hydrostatic leveling apparatus, said apparatus including

- a reservoir assembly including a reservoir, said reservoir having an atmospheric vent, an indicator-liquid outlet, and an internal volume;
- a sight tube assembly including a sight tube and a positioning handle adapted to be used by one hand, said sight tube having an atmospheric vent, and an internal volume; and
- a closed conduit connecting said reservoir assembly and said sight tube assembly, said conduit and at least a substantial portion of said internal volumes of said reservoir and said sight tube adapted to be filled with incompressible indicator-liquid when in use, the improvement comprising:
 - a first valve assembly supported on said sight tube assembly adjacent said vent of said sight tube and adapted to control the passage of fluid between the interior of said sight tube and the surrounding atmosphere;
 - a second valve assembly supported on said sight tube assembly and adapted to control the passage of fluid between said sight tube assembly and said conduit;
 - a remote control operator assembly supported on said sight tube assembly, said operator assembly including an operator element, said operator element having open and closed positions, being positioned adjacent said handle of said sight tube assembly so that a user may manipulate said operator element to select one of said open and said closed positions therefor by using said one hand while also using said one hand for positioning said sight tube assembly; and

said reservoir assembly; said sight tube assembly; said conduit; said first and second valve assemblies; and said operator assembly so correlated that whenever said operator element is in said closed position, said first valve assembly closes said atmospheric vent of said sight tube and said second valve assembly prevents the passage of fluid between said reservoir assembly and said sight tube assembly through said conduit, and whenever said operator element is in said open position, said first valve assembly opens said atmospheric vent of said sight tube and said second valve assembly permits the passage of fluid between said reservoir assembly and said sight tube assembly through said conduit.

2. The apparatus of claim 1 wherein said operator element is a flexible bellows.

3. The apparatus of claim 2 wherein each of said first and second valve assemblies includes a flexible diaphragm element adapted to be flexed to provide the valve action thereof.

4. The apparatus of claim 1 wherein each of said first and second valve assemblies includes a flexible diaphragm element adapted to be flexed to provide the valve action thereof.

5. The apparatus of claim 4 wherein said reservoir has a geometric center; said indicator-liquid outlet of said reservoir is positioned at said geometric center of said reservoir; and

said substantial portion of said reservoir which is adapted to be filled with incompressible indicator-liquid exceeds one half of said internal volume of said reservoir, whereby air bubbles are precluded from entering said conduit from said reservoir regardless of the orientation of said reservoir assembly.

6. The apparatus of claim 1 wherein said reservoir has a geometric center; said indicator-liquid outlet of said reservoir is positioned at said geometric center of said reservoir; and

said substantial portion of said reservoir which is adapted to be filled with incompressible indicator-liquid exceeds one half of said internal volume of said reservoir, whereby air bubbles are precluded from entering said conduit from said reservoir regardless of the orientation of said reservoir assembly.

7. The apparatus of claim 6 wherein said operator element is a flexible bellows.

8. The apparatus of claim 7 wherein each of said first and second valve assemblies includes a flexible diaphragm element adapted to be flexed to provide the valve action thereof.

9. In a hydrostatic leveling apparatus, said apparatus including

a reservoir assembly including a reservoir, said reservoir having an atmospheric vent, an indicator-liquid outlet, and an internal volume;

a sight tube assembly including a sight tube and a positioning handle adapted to be used by one hand, said sight tube having an atmospheric vent, and an internal volume; and

a first closed conduit connecting said reservoir assembly and said sight tube assembly, said first conduit and at least a substantial portion of said inter-

nal volumes of said reservoir and said sight tube adapted to be filled with incompressible indicator-liquid when in use, the improvement comprising: a first valve assembly supported on said reservoir assembly adjacent said vent of said reservoir and adapted to control the passage of fluid between the interior of said reservoir and the surrounding atmosphere, said first valve assembly having an interior control-liquid portion;

a second valve assembly supported on said sight tube assembly adjacent said vent of said sight tube and adapted to control the passage of fluid between the interior of said sight tube and the surrounding atmosphere, said second valve assembly having an interior control-liquid portion;

a third valve assembly supported on said sight tube assembly and adapted to control the passage of fluid between said sight tube assembly and said first conduit, said third valve assembly having an interior control-liquid portion;

a second closed conduit connecting said second and third valve assemblies;

a third closed conduit connecting said reservoir assembly and said sight tube assembly, and said second and third conduits comprising a control-liquid network;

a remote control operator assembly supported on said sight tube assembly, said operator assembly including an operator element, said operator element having open and closed positions, having an interior control-liquid portion, being positioned adjacent said handle of said sight tube assembly so that a user may manipulate said operator element to select one of said open and said closed positions therefor by using said one hand while also using said one hand for positioning said sight tube assembly, and said interior control-liquid portion of said operator element being connected to said control-liquid network;

said interior control-liquid portion of said operator element, said control-liquid network, and said interior control-liquid portions of said first, second, and third valve assemblies being solid filled with an incompressible control-liquid; and

said reservoir assembly; said sight tube assembly; said first conduit; said first, second, and third valve assemblies; said operator assembly; and said control-liquid network so correlated that whenever said operator element is in said closed position, said first and second valve assemblies close said atmospheric vents and said third valve assembly prevents the passage of fluid between said reservoir assembly and said sight tube assembly through said first conduit, and whenever said operator element is in said open position, said first and second valve assemblies open said atmospheric vents and said third valve assembly permits the passage of fluid between said reservoir assembly and said sight tube assembly through said first conduit.

10. The apparatus of claim 9 wherein said operator element is a flexible bellows.

11. The apparatus of claim 10 wherein each of said first, second, and third valve assemblies includes a flexible diaphragm element adapted to be flexed to provide the valve action thereof.

12. The apparatus of claim 11 wherein said third conduit is positioned within said first conduit between said reservoir assembly and said sight tube assembly.

13. The apparatus of claim 11 wherein said third conduit is supported by said first conduit between said reservoir assembly and said sight tube assembly.

14. The apparatus of claim 11 wherein said reservoir has a geometric center; said indicator-liquid outlet of said reservoir is positioned at said geometric center of said reservoir; and

said substantial portion of said reservoir which is adapted to be filled with incompressible indicator-liquid exceeds one half of said internal volume of said reservoir, whereby air bubbles are precluded from entering said conduit from said reservoir regardless of the orientation of said reservoir assembly.

15. The apparatus of claim 14 wherein said third conduit is supported by said first conduit between said reservoir assembly and said sight tube assembly.

16. The apparatus of claim 14 wherein said third conduit is positioned within said first conduit between said reservoir assembly and said sight tube assembly.

17. The apparatus of claim 9 wherein each of said first, second, and third valve assemblies includes a flexible diaphragm element adapted to be flexed to provide the valve action thereof.

18. The apparatus of claim 17 wherein said third conduit is positioned within said first conduit between said reservoir assembly and said sight tube assembly.

19. The apparatus of claim 17 wherein said third conduit is supported by said first conduit between said reservoir assembly and said sight tube assembly.

20. The apparatus of claim 17 wherein said reservoir has a geometric center; said indicator-liquid outlet of said reservoir is positioned at said geometric center of said reservoir; and

said substantial portion of said reservoir which is adapted to be filled with incompressible indicator-liquid exceeds one half of said internal volume of said reservoir, whereby air bubbles are precluded from entering said conduit from said reservoir regardless of the orientation of said reservoir assembly.

21. The apparatus of claim 20 wherein said third conduit is supported by said first conduit between said reservoir assembly and said sight tube assembly.

22. The apparatus of claim 20 wherein said third conduit is positioned within said first conduit between said reservoir assembly and said sight tube assembly.

23. The apparatus of claim 9 wherein said third conduit is positioned within said first conduit between said reservoir assembly and said sight tube assembly.

24. The apparatus of claim 23 wherein said operator element is a flexible bellows.

25. The apparatus of claim 24 wherein said reservoir has a geometric center; said indicator-liquid outlet of said reservoir is positioned at said geometric center of said reservoir; and

said substantial portion of said reservoir which is adapted to be filled with incompressible indicator-liquid exceeds one half of said internal volume of said reservoir, whereby air bubbles are precluded from entering said conduit from said reservoir re-

gardless of the orientation of said reservoir assembly.

26. The apparatus of claim 9 wherein said third conduit is supported by said first conduit between said reservoir assembly and said sight tube assembly.

27. The apparatus of claim 26 wherein said operator element is a flexible bellows.

28. The apparatus of claim 27 wherein said reservoir has a geometric center; said indicator-liquid outlet of said reservoir is positioned at said geometric center of said reservoir; and

said substantial portion of said reservoir which is adapted to be filled with incompressible indicator-liquid exceeds one half of said internal volume of said reservoir, whereby air bubbles are precluded from entering said conduit from said reservoir regardless of the orientation of said reservoir assembly.

29. The apparatus of claim 9 wherein said reservoir has a geometric center; said indicator-liquid outlet of said reservoir is positioned at said geometric center of said reservoir; and

said substantial portion of said reservoir which is adapted to be filled with incompressible indicator-liquid exceeds one half of said internal volume of said reservoir, whereby air bubbles are precluded from entering said conduit from said reservoir regardless of the orientation of said reservoir assembly.

30. The apparatus of claim 29 wherein said third conduit is positioned within said first conduit between said reservoir assembly and said sight tube assembly.

31. The apparatus of claim 29 wherein said third conduit is supported by said first conduit between said reservoir assembly and said sight tube assembly.

32. The apparatus of claim 29 wherein each of said first, second, and third valve assemblies includes a flexible diaphragm element adapted to be flexed to provide the valve action thereof.

33. The apparatus of claim 29 wherein said operator element is a flexible bellows.

34. In a hydrostatic leveling apparatus, said apparatus including

a reservoir assembly including a reservoir, said reservoir having an atmospheric vent, an indicator-liquid outlet, and an internal volume;

a sight tube assembly including a sight tube and a positioning handle adapted to be used by one hand, said sight tube having an atmospheric vent, and an internal volume; and

a first closed conduit connecting said reservoir assembly and said sight tube assembly, said first conduit and at least a substantial portion of said internal volumes of said reservoir and said sight tube adapted to be filled with incompressible indicator-liquid when in use, the improvement comprising:

a first valve assembly supported on said reservoir assembly adjacent said vent of said reservoir and adapted to control the passage of fluid between the interior of said reservoir and the surrounding atmosphere, said first valve assembly having an interior control-liquid portion;

a second valve assembly supported on said sight tube assembly adjacent said vent of said sight tube and adapted to control the passage of fluid between the

interior of said sight tube and the surrounding atmosphere, said second valve assembly having an interior control-liquid portion;

a third valve assembly supported on said reservoir assembly and adapted to control the passage of fluid between said reservoir assembly and said first conduit, said third valve assembly having an interior control-liquid portion;

a fourth valve assembly supported on said sight tube assembly and adapted to control the passage of fluid between said sight tube assembly and said first conduit, said fourth valve assembly having an interior control-liquid portion;

a second closed conduit connecting said first and third valve assemblies;

a third closed conduit connecting said second and fourth valve assemblies;

a fourth closed conduit connecting said reservoir assembly and said sight tube assembly, and said second, third, and fourth conduits comprising a control-liquid network;

a remote control operator assembly supported on said sight tube assembly, said operator assembly including an operator element, said operator element having open and closed positions, having an interior control-liquid portion, being positioned adjacent said handle of said sight tube assembly so that a user may manipulate said operator element to select one of said open and said closed positions therefor by using said one hand while also using said one hand for positioning said sight tube assembly, and said interior control-liquid portion of said operator element being connected to said control-liquid network;

said interior control-liquid portion of said operator element, said control-liquid network, and said interior control-liquid portions of said first, second, third, and fourth valve assemblies being solid filled with an incompressible control-liquid; and

said reservoir assembly; said sight tube assembly; said first conduit; said first, second, third, and fourth valve assemblies; said operator assembly; and said control-liquid network so correlated that whenever said operator element is in said closed position, said first and second valve assemblies close said atmospheric vents and said third and fourth valve assemblies prevent the passage of fluid between said reservoir assembly and said sight tube assembly through said first conduit, and whenever said operator element is in said open position, said first and second valve assemblies open said atmospheric vents and said third and fourth valve assemblies permit the passage of fluid between said reservoir assembly and said sight tube assembly through said first conduit.

35. The apparatus of claim 34 wherein said operator element is a flexible bellows.

36. The apparatus of claim 35 wherein each of said first, second, third, and fourth valve assemblies includes a flexible diaphragm element adapted to be flexed to provide the valve action thereof.

37. The apparatus of claim 36 wherein said fourth conduit is positioned within said first conduit between said reservoir assembly and said sight tube assembly.

38. The apparatus of claim 36 wherein said fourth conduit is supported by said first conduit between said reservoir assembly and said sight tube assembly.

39. The apparatus of claim 36 wherein said reservoir has a geometric center; said indicator-liquid outlet of said reservoir is positioned at said geometric center of said reservoir; and

said substantial portion of said reservoir which is adapted to be filled with incompressible indicator-liquid exceeds one half of said internal volume of said reservoir, whereby air bubbles are precluded from entering said conduit from said reservoir regardless of the orientation of said reservoir assembly.

40. The apparatus of claim 39 wherein said fourth conduit is supported by said first conduit between said reservoir assembly and said sight tube assembly.

41. The apparatus of claim 39 wherein said fourth conduit is positioned within said first conduit between said reservoir assembly and said sight tube assembly.

42. The apparatus of claim 34 wherein each of said first, second, third, and fourth valve assemblies includes a flexible diaphragm element adapted to be flexed to provide the valve action thereof.

43. The apparatus of claim 42 wherein said fourth conduit is positioned within said first conduit between said reservoir assembly and said sight tube assembly.

44. The apparatus of claim 42 wherein said fourth conduit is supported by said first conduit between said reservoir assembly and said sight tube assembly.

45. The apparatus of claim 42 wherein said reservoir has a geometric center; said indicator-liquid outlet of said reservoir is positioned at said geometric center of said reservoir; and

said substantial portion of said reservoir which is adapted to be filled with incompressible indicator-liquid exceeds one half of said internal volume of said reservoir, whereby air bubbles are precluded from entering said conduit from said reservoir regardless of the orientation of said reservoir assembly.

46. The apparatus of claim 45 wherein said fourth conduit is supported by said first conduit between said reservoir assembly and said sight tube assembly.

47. The apparatus of claim 45 wherein said fourth conduit is positioned within said first conduit between said reservoir assembly and said sight tube assembly.

48. The apparatus of claim 34 wherein said fourth conduit is positioned within said first conduit between said reservoir assembly and said sight tube assembly.

49. The apparatus of claim 48 wherein said operator element is a flexible bellows.

50. The apparatus of claim 49 wherein said reservoir has a geometric center; said indicator-liquid outlet of said reservoir is positioned at said geometric center of said reservoir; and

said substantial portion of said reservoir which is adapted to be filled with incompressible indicator-liquid exceeds one half of said internal volume of said reservoir, whereby air bubbles are precluded from entering said conduit from said reservoir regardless of the orientation of said reservoir assembly.

51. The apparatus of claim 34 wherein said fourth conduit is supported by said first conduit between said reservoir assembly and said sight tube assembly.

52. The apparatus of claim 51 wherein said operator element is a flexible bellows.

53. The apparatus of claim 52 wherein said reservoir has a geometric center; said indicator-liquid outlet of said reservoir is positioned at said geometric center of said reservoir; and

said substantial portion of said reservoir which is adapted to be filled with incompressible indicator-liquid exceeds one half of said internal volume of said reservoir, whereby air bubbles are precluded from entering said conduit from said reservoir regardless of the orientation of said reservoir assembly.

54. The apparatus of claim 34 wherein said reservoir has a geometric center; said indicator-liquid outlet of said reservoir is positioned at said geometric center of said reservoir; and said substantial portion of said reservoir which is

adapted to be filled with incompressible indicator-liquid exceeds one half of said internal volume of said reservoir, whereby air bubbles are precluded from entering said conduit from said reservoir regardless of the orientation of said reservoir assembly.

55. The apparatus of claim 54 wherein said fourth conduit is positioned within said first conduit between said reservoir assembly and said sight tube assembly.

56. The apparatus of claim 54 wherein said fourth conduit is supported by said first conduit between said reservoir assembly and said sight tube assembly.

57. The apparatus of claim 54 wherein each of said first, second, third, and fourth valve assemblies includes a flexible diaphragm element adapted to be flexed to provide the valve action thereof.

58. The apparatus of claim 54 wherein said operator element is a flexible bellows.

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