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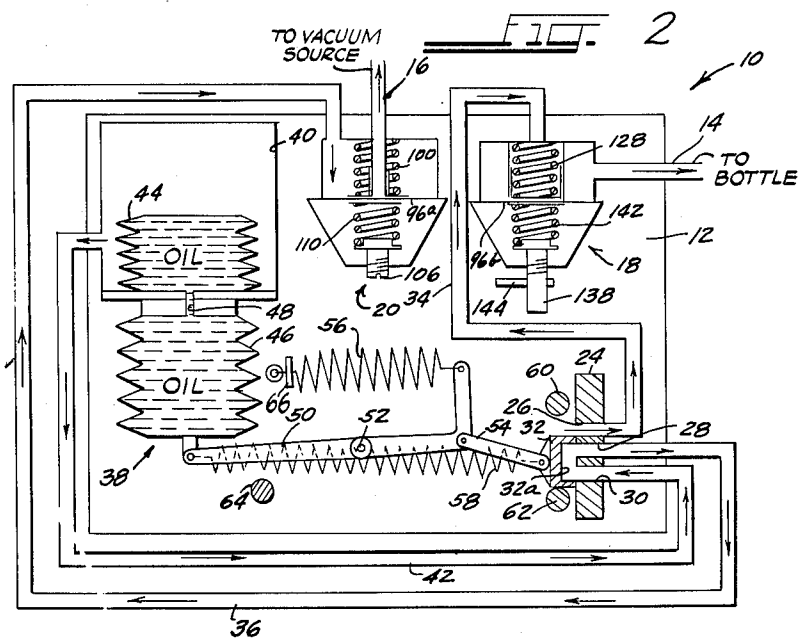
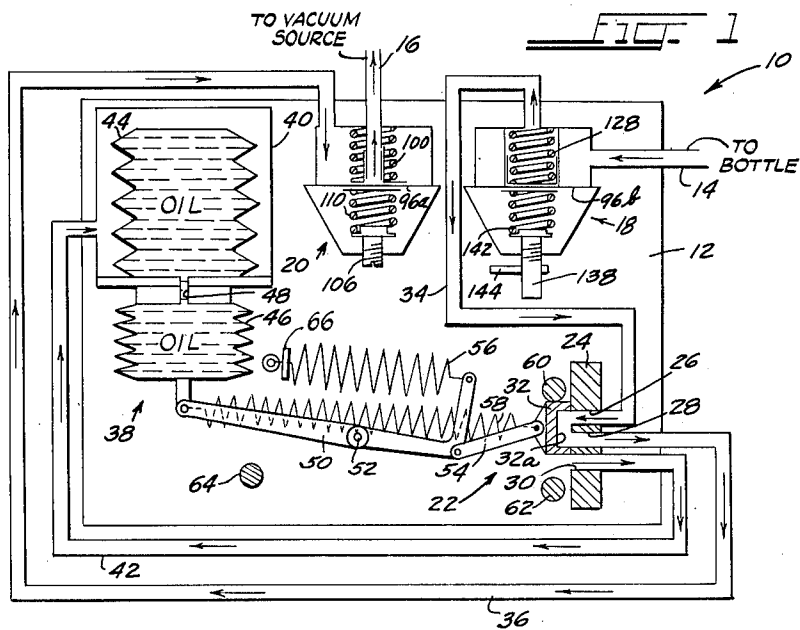
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INTERMITTENT VACUUM REGULATOR

Original Filed Jan. 26, 1959

3 Sheets-Sheet 1



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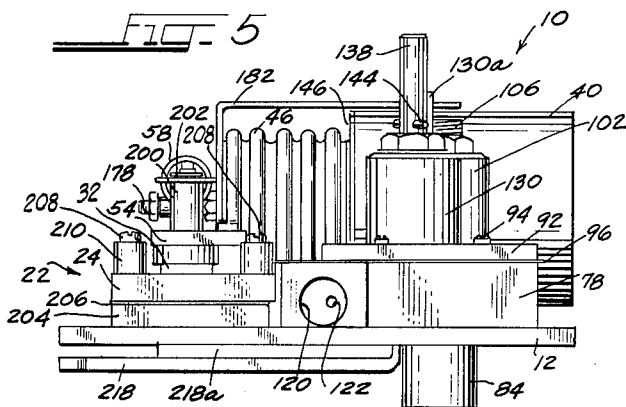
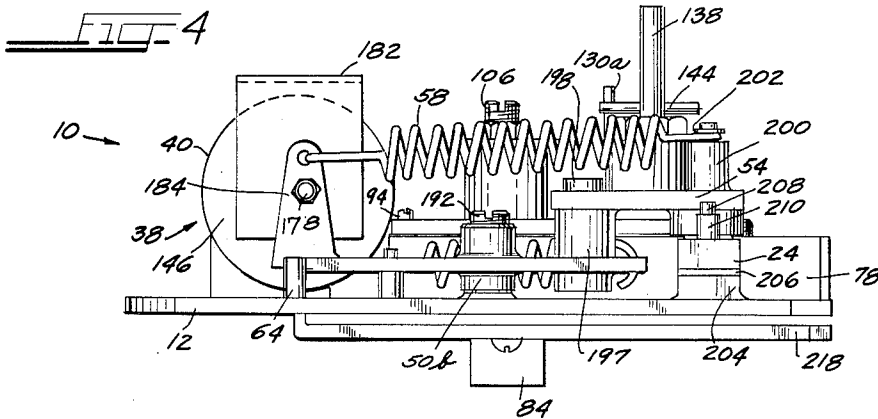
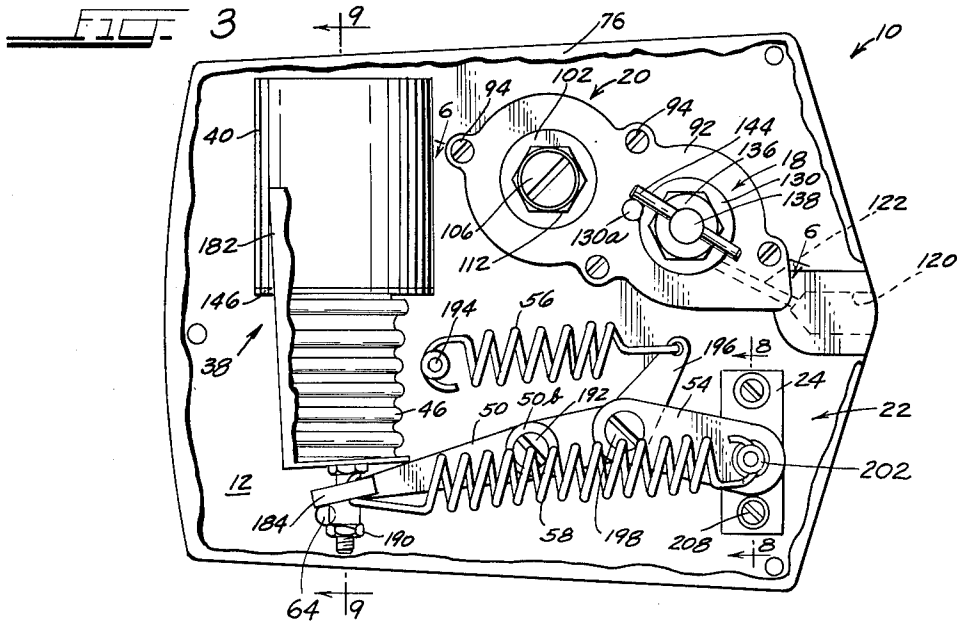
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3,208,467

INTERMITTENT VACUUM REGULATOR

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Original application Jan. 26, 1959, Ser. No. 789,012, now Patent No. 3,086,528, dated Apr. 23, 1963. Divided and this application July 11, 1962, Ser. No. 209,074
19 Claims. (Cl. 137-104)

This invention relates to a vacuum controlling device and, more particularly, to a new and improved intermittent vacuum regulating unit for alternately connecting a vacuum operated device to a vacuum source and the atmosphere. This application is a division of the copending application of Francis J. Eichelman and Eldridge H. Smiley, Serial No. 789,012, filed January 26, 1959, now Patent No. 3,086,528.

In the post operative care of patients following gastrointestinal surgery, it is often necessary to provide drainage from the stomach or the intestine by the use of Levin or Miller-Abbott tubes. These tubes are generally connected to a bottle to which different levels of vacuum are ultimately applied from a vacuum pump or line so that the drainage is collected in the bottle. However, if the vacuum bottle is elevated above the area to be drained and is alternately connected to vacuum and to the atmosphere, the back flow of drainage when the bottle is connected to the atmosphere serves to move obstructions from the catheter and thus facilitates the continuous removal of drainage. This alternate connection of the vacuum bottle is preferably accomplished by the insertion of an intermittent vacuum regulator unit between the vacuum source and the bottle.

Accordingly, one object of the present invention is to provide a new and improved intermittent vacuum regulator unit.

Another object is to provide a completely self-contained vacuum interrupter unit of a compact and easily fabricated construction.

Another object is to provide a vacuum interrupter unit including new and improved means for providing the necessary passageways for connecting the various components of the unit.

Another object is to provide a vacuum interrupter unit including new and improved valve means for alternately applying a vacuum pressure and atmospheric pressure to the drainage system and means for operating the valve means.

A further object is to provide a vacuum interrupter unit including both valve means for alternately connecting a vacuum bottle to the atmosphere and to vacuum and control means for adjusting the length of one or more portions of the cycle of operation of the valve means.

A still further object is to provide a self-contained vacuum interrupter unit including plural stage vacuum regulating means.

In accordance with these and many other objects, an embodiment of the invention comprises a new and improved intermittent vacuum regulating or I.V.R. unit which is interposed between a vacuum line or pump and a vacuum bottle connected to a drainage tube from a patient. The I.V.R. unit, which is compact and completely self-contained, includes an inlet connected to the vacuum line and an outlet connected to the vacuum bottle. To provide means for alternately connecting the vacuum bottle to the atmosphere and a vacuum line, the unit includes a valve assembly having three ports, a first of which is connected to the interrupter outlet through an outlet vacuum regulator and a second of which is connected to the interrupter inlet through an inlet vacuum regulator. In one setting of the valve assembly in which

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these two ports are in communication, vacuum is applied to the bottle through the inlet and outlet vacuum regulators. In another setting of the valve assembly, the first port is connected to the atmosphere so as to connect the vacuum bottle to the atmosphere.

To provide means for shifting the valve assembly between these two alternate positions, a vacuum actuated motor is provided comprising a sealed housing in which is disposed one portion of an oil filled bellows assembly. The bellows assembly is connected by a pivoted over-center linkage to a shiftable element of the valve assembly. The sealed housing is connected to the third port of the valve assembly so that, when the first two ports are in communication to apply vacuum to the bottle, the third port connects the interior of the housing to the atmosphere. This permits suitable resilient operating means connected to the linkage to contract the portion of the bellows assembly contained within the sealed housing so that the valve assembly is shifted to its other position in which the vacuum line is disconnected from the vacuum bottle and connected to the sealed housing. In this second position, the interrupter outlet and the connected vacuum bottle are placed in communication with the atmosphere. The application of vacuum to the sealed housing causes the extension of the portion of the bellows assembly contained within the housing so that the linkage shifts the valve assembly to its original position in which the housing is again connected to the atmosphere and vacuum is again applied to the bottle. This intermittent operation continues until the vacuum source is disconnected from the inlet to the I.V.R. unit.

In order to insure that the bottle is returned to atmospheric pressure following each application of vacuum thereto, the I.V.R. unit includes means for adjusting the length of the portion of the unit operating cycle during which the bottle is connected to the atmosphere. The inlet regulator can be adjusted to apply varying degrees of vacuum to the sealed housing so that the length of time required to operate the valve means from the position in which the bottle is connected to the atmosphere to the position in which the bottle is connected to vacuum can be varied. Since the time required to operate the valve means to its alternate position following the connection of the sealed housing to the atmosphere is fixed by the mechanical constants of the bellows assembly and the resilient operating means, for instance, the adjustment of the period during which the bottle is connected to the atmosphere effectively controls the total length of the entire operating cycle. Although the period during which the bottle is connected to vacuum is normally fixed by factory adjustment, the I.V.R. unit also includes means for adjusting this portion of the cycle. By the provision of the vacuum regulator in the outlet for the unit, the degree of vacuum applied to the bottle and the drainage tube extending to the patient can be suitably adjusted. Thus, the I.V.R. unit of the present invention is completely self-contained and does not require additional regulating and control apparatus.

In accordance with another feature of the present invention by which the I.V.R. unit is reduced in physical size to facilitate its manipulation in those applications in which it is mounted directly on the vacuum bottle rather than on a supporting wall or bracket, the various passageways for interconnecting the vacuum motor, the valve assembly, and the vacuum regulators are provided by a single manifold plate. This plate is provided with spaced recessed areas and is secured to a flat surface of a base plate on the other side of which the various regulating and operating components of the interrupter unit are disposed. Thus, all of the necessary fluid vacuum conveying means in the unit are provided by merely drilling holes through the base plate to the various housings

for the regulators, motor, and valve, and then disposing the manifold plate on the flat surface of the base plate with the recessed areas in communication with different ones of the holes. This materially reduces the cost of fabricating the interrupter unit and reduces the physical size thereof.

Many other objects and advantages of the present invention will become apparent from the following detailed description when considered in conjunction with the drawings in which:

FIG. 1 is a schematic view of an intermittent vacuum regulator unit embodying the present invention shown in a position in which the vacuum bottle is connected to the vacuum source;

FIG. 2 is a schematic view similar to FIG. 1 showing the vacuum interrupter unit in a position in which the vacuum bottle is connected to the atmosphere;

FIG. 3 is a top plan view of the interrupter unit with a cover therefor broken away;

FIG. 4 is a side elevational view of the interrupter unit with the cover removed;

FIG. 5 is an end elevational view of the interrupter unit with the cover removed;

FIG. 6 is an enlarged sectional view taken along line 6—6 in FIG. 1 showing a pair of vacuum regulator assemblies;

FIG. 7 is a plan view of a manifold plate included in the interrupter unit;

FIG. 8 is a sectional view taken along line 8—8 in FIG. 1 showing a valve assembly; and

FIG. 9 is a sectional view taken along line 9—9 in FIG. 1 showing a vacuum motor.

Referring now to FIGS. 1 and 2 of the drawings, there is shown an intermittent vacuum regulator or I.V.R. unit, indicated generally as 10, having a base plate 12 on which the various components of the unit are mounted. An outlet line 14 connects the unit 10 to the vacuum inlet of the vacuum bottle, and an inlet line 16 connects the unit 10 to a vacuum line or pump. An outlet vacuum regulator assembly, indicated generally as 18, which is mounted on the base plate 12, is connected to the line 14 to provide means for adjusting the degree of vacuum applied to the vacuum bottle. An inlet regulator assembly, indicated generally as 20, which is also mounted on the base plate 12 is connected to the interrupter inlet line 16 to provide a means for adjusting the length of the period during which the bottle is connected to the atmosphere. The outlet line 14 is alternately connected to the atmosphere and the inlet line 16 by means of a valve assembly 22.

This valve assembly includes a valve block 24 having three ports 26, 28 and 30. The ports 26 and 30 are alternately placed in communication with the common port 28 by a valve slide 32 which is slidably mounted on the valve block 24 and which includes a recess 32a for bridging different pairs of the ports 26, 28 and 30. The port 26 is connected to the regulator 18 by a passageway 34. The common port 28 is connected to the inlet vacuum regulator 20 through a passageway 36. When the valve slide 32 is in the position illustrated in FIG. 1, the vacuum line is connected to the vacuum bottle through the inlet line 16, the vacuum regulator 20, the passageway 36, the port 28, the recess 32a, the port 26, the passageway 34, the regulator assembly 18 and the outlet line 14. Conversely, when the I.V.R. unit 10 is operated to the alternate position shown in FIG. 2, the vacuum bottle is connected to the atmosphere through the interrupter outlet line 14, the regulator assembly 18, the passageway 34, and the port 26.

To provide means for operating the valve assembly 22 by shifting the valve slide 32 relative to the valve block 24, a fluid operated motor, indicated generally as 38, is mounted on the base plate 12. The motor 38 comprises a sealed housing 40 which is connected to the port 30 in the valve assembly 22 through a passageway 42.

A first bellows element 44 mounted within the housing 40 and a second bellows element 46 disposed externally of the housing 40 are suitably filled with a somewhat viscous and non-compressible medium, such as oil, and are placed in communication with each other through a restricted orifice 48. The bellows elements 44 and 46 are alternately contracted and expanded by the intermittent application of vacuum to the interior of the housing 40 and by the application of a spring force to the bellows.

To provide means for transmitting the movement of the bellows elements 44 and 46 to actuate the valve assembly 22, a crank 50, which is pivotally mounted on the base 12 by a supporting post 52, is pivotally connected at one end to the bellows element 46 and is pivotally connected by a slide arm 54 to the valve slide 32. A tension spring 56 connected between the base plate 12 and the crank 50 normally moves the valve assembly 22 and the vacuum motor 38 to the position shown in FIG. 2. A tension spring 58 connected between the crank 50 and the slide arm 54 provides an over-center arrangement which tends to hold the valve slide 32 in the two alternate positions illustrated in FIGS. 1 and 2. In these positions, the opposite ends of the slide 32 engage a pair of stop elements 60 and 62 carried on the plate 12. A stop 64 on the plate 12 limits the movement of the crank 50 when the unit 10 is not in use.

When the I.V.R. unit 10 is to be placed in operation and assuming that the unit 10 is in the position illustrated in FIG. 2, the vacuum applied to the inlet line 16 extends through the regulator assembly 20, the passageway 36, the port 28, the recess 32a, the port 30, and the passageway 42 to the interior of the housing 40. The reduced pressure condition produced within the housing 40 renders the atmospheric pressure acting on the exterior bellows element 46 effective to compress this element and to force the viscous medium within the element 46 through the restricted orifice 48 into the bellows element 44, thereby extending this element. The compression of the exterior bellows element 46 pivots the crank 50 in a clockwise direction around the post 52 to the position illustrated in FIG. 1. In doing so, the crank 50 and the slide arm 54 shift the valve slide 32 out of contact with the stop 62, through the center position, and into contact with the stop 60. In this position, the recess 32a interconnects the ports 26 and 28 so that vacuum is applied from the line 36 through the passageway 34 and the vacuum regulator assembly 18 to the outlet line 14. Thus, vacuum is now applied to the vacuum bottle.

When the valve slide 32 moves to the position illustrated in FIG. 1, the port 30 is opened to the atmosphere to equalize the pressure within the housing 40. This equalization of the pressure permits the motor spring 56 to pivot the crank 50 in a counterclockwise direction so that the element 46 is extended and viscous fluid is forced through the restricted orifice 48 into the exterior bellows element 46. When the crank 50 moves in a counterclockwise direction, the slide arm 54 moves the valve slide 32 out of contact with the stop 60, through the center position, and into contact with the stop 62 (FIG. 2). In this position, the passageway 34 and the regulator 18 connect the vacuum bottle to the atmosphere, and vacuum is again applied to the interior of the housing 40 to operate the motor 38 so that the valve assembly 22 is operated. This intermittent operation of the valve assembly 22 alternately connects the outlet line 14 and the vacuum bottle to the atmosphere and to the vacuum supplied at the inlet line 16.

To provide means for adjusting the length of time that the bottle is connected to the atmosphere and thus the total length of each operating cycle of the unit 10, the inlet regulator assembly 20 can be adjusted to apply different levels of vacuum to the sealed housing 40. The varying pressure differentials produced across the bellows elements 44 and 46 determine the length of time required for the unit 10 to move from the position shown

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in FIG. 2 to that shown in FIG. 1 and thus determine the length of time that the vacuum bottle is connected to the atmosphere. It is desirable to provide this adjustment in order to insure that the vacuum bottle is actually returned to atmospheric pressure after each application of vacuum thereto. This adjustment of the length of part of the operating cycle of the unit 10 also serves to control the length of the entire operating cycle because the portion of this cycle during which the bottle is connected to vacuum is relatively fixed by the force applied by the motor spring 56 and by the constants of the bellows assembly, such as the area of the orifice 48 and the viscosity of the medium in the bellows element 44 and 46. Although this portion of the operating cycle of the unit 10 is generally determined by factory adjustment, suitable means 66 (FIGS. 1 and 2), such as a lead screw, can be provided for adjusting the effective force of the motor spring 56 to increase or decrease the length of time that the bottle is connected to vacuum. By suitable adjustment of the outlet regulator assembly 18, the degree of vacuum applied to the bottle can be easily varied.

In one interrupter unit 10 constructed in accordance with the present invention, the regulator assembly 18 can be set to provide a vacuum to the bottle which is adjustable between ninety and one hundred and twenty millimeters of mercury when a vacuum of between eight and twenty-eight inches of mercury is supplied to the inlet line 16. With this inlet vacuum, the regulator 20 and the motor spring 56 can be adjusted to cause the motor 38 to have a total operating cycle of around twenty seconds, i.e., the bottle is alternately connected to vacuum and to the atmosphere for periods of approximately ten seconds. Since the regulators 18 and 20 are connected in series through the valve assembly 22 when the vacuum is applied to the bottle, the regulator assembly 20 also provides a coarse adjustment device or a means for limiting the highest degree of vacuum applied to the regulator 18 to a selected range. Units of this type can also be constructed to operate with an inlet vacuum of as low as seven millimeters of mercury.

Referring more specifically to FIGS. 3-9 of the drawings, the I.V.R. unit 10 including the base plate 12 and the various components mounted thereon is enclosed by a housing 76 (FIG. 3) to which the plate 12 is secured. The housing 76 includes an opening (not shown) in its front wall through which the adjusting means for the outlet vacuum regulator 18 extends and also includes a window positioned adjacent the vacuum motor 38. The base plate 12, on which all of the elements of the unit 10 are mounted, supports the components 18, 20, 22 and 38, for instance, on an upper side and is provided with a substantially flat lower surface or wall. To provide a means for mounting the vacuum regulator assemblies 18 and 20 on the upper surface of the base plate 12, this plate is provided with an elongated projecting or bossed portion 78 (FIGS. 4, 5 and 6) defining a pair of separate recesses 80 and 82 in which are mounted the inlet vacuum regulator 20 and the outlet vacuum regulator 18, respectively.

Referring now more specifically to the inlet vacuum regulator 20 (FIG. 6) which controls the degree of vacuum applied to the vacuum motor 38, the base plate 12 is provided with an internally threaded boss 84 on its lower wall surface which is adapted to be connected to a vacuum pump or line. The bore of the portion 84 is placed in communication with the cavity or chamber 80 by a passageway 86 which extends upwardly through a boss 88 formed in the upper surface of the plate 12. An outlet for the chamber 80 is provided by an aperture or opening 90 which extends through the base plate 12.

The cavities 80 and 82 in which the vacuum regulator assemblies 18 and 20 are mounted are closed by a cover or cap plate 92 which is secured to the upstanding portion 78 by a plurality of headed fasteners 94. A resilient element 96, which is interposed between the lower

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surface of the cover plate 92 and the upper edge of the upstanding portion 78, not only seals the cavities 80 and 82 but also provides a pair of separate resilient diaphragms forming portions of the assemblies 18 and 20. The element 96 includes an enlarged and integrally formed portion 96a forming a first diaphragm which is disposed within the chamber 80 and which moves into and out of contact with the upper end of the bossed portion 88 to provide valve means for controlling communication between the inlet passageway 86 and the outlet 90. More specifically, the lower surface of the diaphragm 96a is engaged by a guide ring 98 which is urged upwardly by a compression spring 100 interposed between the base plate 12 and a flange on the guide ring 98. Thus, the diaphragm 96a is normally held out of engagement with the upper end of the bossed portion 88 so that the inlet line 16 connected to the bossed portion 84 is in communication with the outlet passageway 90 through the chamber 80 and the passageway 86.

To provide means for moving the diaphragm 96a toward the boss 88 with varying degrees of resilient pressure, the cover plate 92 is provided with a bossed portion 102 defining a cavity 103 within which is disposed a spring housing 104 normally resting on the upper surface of the diaphragm 96a. A pressure regulating screw 106 is threadedly mounted in an opening in the upper wall of the boss 102 and includes a depending reduced diameter portion 106a which is received within an opening 108 formed in the spring housing 104. A compression spring 110 is interposed between the pressure regulating screw 106 and the spring housing 104 in a position encircling the depending portion 106a. Thus, when the position of the regulating screw 106 is adjusted, different resilient forces are applied to the spring housing 104 by the compression spring 110 for moving the diaphragm 96a toward the upper end of the boss 88. A jam nut 112 which bears against the upper end of the boss 102 and threadedly engages the regulating screw 106 locks the element 106 in an adjusted position.

When the vacuum line is connected to the boss 84, the reduction in the pressure within the chamber 80 permits the atmospheric pressure in the chamber 103 and the spring 110 to force the diaphragm 96a downwardly toward the upper end of the boss 88 against the opposing resilient force provided by the compression spring 100. If the vacuum supplied by the inlet line 16 does not exceed the degree of vacuum to which the assembly 20 has been adjusted, the diaphragm 96a does not move into engagement with the upper end of the boss 88. However, if the degree of vacuum exceeds the value to which the regulator assembly 20 has been adjusted, the vacuum within the chamber 80 causes the atmospheric pressure within the chamber 103 together with the biasing force provided by the spring 110 to move the diaphragm 96a into contact with the upper end of the boss 88, thereby closing off communication between the outlet passageway 90 and the inlet passageway 86. Accordingly, by adjusting the regulator screw 106 to increase the compressional force applied by the spring 110, the vacuum supplied to the outlet passage 90 is reduced. By reducing the preset compression of the spring 110, the vacuum supplied to the outlet passage 90 is increased. Since the adjustment of the operating cycle of the vacuum motor 38, as set forth above, is determined in part by the adjustment of the inlet vacuum regulator 20, the setting of the regulator 20 does not require frequent adjustment. Accordingly, the position of the pressure regulating screw 106 can be adjusted only by removing the cover 76.

Referring now more specifically to the outlet pressure regulator assembly 16 (FIG. 6) which is used to control the degree of vacuum supplied over the outlet line 14 to the vacuum bottle, this assembly is disposed within the chamber or cavity 82 on the base plate 12 and is also enclosed by the cover plate 92 and sealed by the resilient element 96. An inlet to the chamber 82 from the valve

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means 22 is provided by a hole 114 which is in communication with an opening 116 in a boss 118 formed in the base plate 12 within the cavity 82. The outlet from the vacuum regulator 18 to the vacuum bottle is provided by a passageway 122 (FIGS. 3 and 5) which extends from the chamber 82 through the upstanding portion 78 to an internally threaded bore 120 which receives a threaded adapter connected either to the cover of the vacuum bottle or to a conduit extending to the vacuum inlet of the bottle. The portion of the flexible element 96 disposed within the chamber 82 includes an enlarged portion forming a second diaphragm 96b which moves into and out of contact with the upper end of the boss 118 to provide a valve for selectively opening and closing communication between the inlet opening 114 and the outlet passageway 122.

To normally move the diaphragm 96b out of contact with the upper end of the boss 118, a spring housing 124 is provided defining an inner opening 126 within which is disposed a compression spring 128 that is interposed between the base plate 12 and the upper end of the spring housing 124. The force provided by the compression spring 128 normally holds the diaphragm 96b out of contact with the upper end of the boss 118.

To provide adjusting means for regulating the vacuum supplied through the outlet passageway 122 to the vacuum bottle, the cover plate 92 includes a second boss 130 which defines a chamber 132. A spring housing 134 is disposed within the chamber 132 to rest on the upper surface of the flexible diaphragm 96b. An adjusting screw 136 is threadedly mounted in an opening in the upper wall of the boss 130 and is secured by a set screw (not shown) to an adjusting stem 138 having a reduced diameter lower portion 138a which is disposed within an opening 140 formed in the spring housing 134. A compression spring 142 disposed within the opening 140 engages the spring housing 134 at its lower end and, at its upper end, surrounds the reduced diameter portion 138a and bears against the adjusting screw 136. A pin 144 carried on the upper end of the adjusting stem 138 moves into engagement with a projecting portion 130a formed on the boss 130 to limit rotation of the adjusting screw 136 and the stem 138.

As indicated above, the outlet vacuum regulator assembly 18 is normally effective to place the valve means 22 in communication with the outlet line 14 through the openings 114 and 116, the chamber 82, the passageway 122, and the bore 120. The inlet opening 114 is connected to the vacuum source through the valve means 22 and the vacuum regulator assembly 20. Accordingly, the establishment of a partial vacuum condition within the chamber 82 causes the atmospheric force of the compression spring 142 to shift the diaphragm 96b downwardly toward the upper end of the boss 118 against the force of the compression spring 128. When the vacuum applied to the chamber 82 exceeds the desired amount, the forces provided by the atmospheric pressure within the chamber 132 and the compression spring 142 exceed the force provided by the biasing spring 128, and the diaphragm 96b moves into contact with the upper end of the boss 118, thereby closing off communication between the inlet opening 114 and the outlet passageway 122. When the vacuum is reduced within the chamber 82, the spring 128 moves the diaphragm 96b out of contact with the upper end of the boss 118 and places the inlet and the outlet in communication.

Thus, by adjusting the stem 138 to establish different degrees of resilient biasing pressure due to the compression spring 142, the degree of vacuum within the chamber 82 and, accordingly, that applied to the vacuum bottle can be adjusted. An increase in the compressional force provided by the spring 142 decreases the vacuum supplied to the vacuum bottle, and, conversely, a reduction in the biasing force of the spring 142 increases the vacuum applied to the bottle. Since the degree of vacuum

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that is required to be applied to the bottle and the drainage tube leading to the patient may vary, the outer end of the stem 138 extends outwardly through an opening provided in the housing 76 to receive a knob (not shown). The degree of adjustment is limited by the engagement of the stop pin 144 with the projecting portion 130a.

As indicated above, the fluid motor 38 (FIGS. 3-5 and 9) operates the valve means 22 to alternately connect the vacuum bottle to the atmosphere and to a source of vacuum and to alternately connect the motor 38 to the atmosphere and to the source of vacuum. In general, the vacuum motor 38 includes a pair of bellows elements 44 and 46, one of which is disposed within the sealed housing 40 and the other of which is positioned in the atmosphere and connected to a linkage for actuating the valve means 22. By the alternate application of atmospheric pressure and vacuum to the interior of the housing 40, the two bellows elements are alternately contracted and expanded to actuate the valve means 22.

The vacuum motor assembly 38 includes the housing 40 which is generally cup-shaped and which is closed at its open end by a closure plate or seal 146 (FIG. 9) defining a pair of annular grooved portions 148 and 150 and also the restricted orifice 48. A lower wall of the cup-shaped housing 40 is secured to a mounting block 152, and the mounting block 152 is in turn secured to the upper surface of the base plate 12. A passageway 154 extending through the housing 40, the supporting plate 152, and the base plate 12 provide an inlet passageway to the interior of the housing 40.

The bellows element 44, which is disposed within the housing 40, is secured to the annular grooved portion 150 by suitable means such as one or more turns of wire 156. The other end of the bellows element 44 is secured to an annular grooved portion 158 formed on a rear bellows end piece 160, again by suitable means such as one or more turns of wire 162. A bossed portion 160a of the plate 160 is provided with an axially extending aperture 163 which is normally closed by a screw 164 and a sealing washer 166. The screw 164 can be removed so that a suitable viscous and non-compressible material, such as oil, can be introduced through the opening 163. The elements 44 and 46, which are connected by the orifice 48, are provided with enough of the viscous material that with one of the bellows elements completely extended and with the other of the bellows elements completely collapsed the interiors of these elements are completely filled. The inner end of the exterior bellows element 46 is secured to the annular grooved portion 148 by one or more turns of wire 168. The outer end of the bellows element 46 is secured to an annular grooved portion 171 on a front bellows plate 172 by one or more turns of wire 174.

To provide means for connecting the end plate 172 and the vacuum motor 38 with the linkage for operating the valve means 22, the plate 172 is provided with a tapped bore 176 in which is threadedly mounted one end of a bellows shaft 178 having a headed portion 180. An L-shaped indicator 182 is mounted on the shaft 178 interposed between the front wall of the plate 172 and the headed portion 180 of the shaft 178 so as to be mounted on the motor 38 with a portion disposed in front of the window (not shown) in the housing 76. Thus, when the bellows element 46 is contracted and expanded, the indicator 182 reciprocates relative to the window to provide a visible indication that the interrupter unit 10 is in operation.

When the vacuum motor 38 is operated, the valve means 22 alternately connects the passageway 154 to the atmosphere and to vacuum. When the passageway 154 is connected to vacuum, the pressure within the housing 40 is reduced and the atmospheric pressure acting on the exterior bellows element 46 compresses this element and forces the viscous medium through the restricted opening 48 into the bellows element 44. In doing so,

the bellows shaft 178 is moved to the right (FIGS. 5 and 9). Alternatively, when the passageway 154 is connected to the atmosphere by the valve means 22, the pressure acting on the bellows elements 44 and 46 is equalized, and the spring 56 extends the bellows element 46 and contracts the bellows element 44, thereby moving the shaft 178 to the left (FIGS. 5 and 9).

As indicated above, the crank 50 and the slide arm 54 connect the vacuum motor assembly 38 to the valve means 22 so that the operation of the motor 38 shifts the valve means 22 between its two opposite positions. The crank 50 includes an upwardly extending portion 184 (FIGS. 4 and 9) having an aperture through which the shaft 178 extends. The upstanding portion 184 is movably journaled between the headed portion 180 on the bellows shaft 178 and a thrust bearing 186 which is secured to the shaft 178 by one or more washers 188 and a pair of jam nuts 190. An intermediate portion of the crank 50 is provided with a boss 50b (FIG. 4) through which a shouldered screw 192 extends so as to pivotally mount the crank 50 intermediate its ends on the upper wall of the base plate 12. The tension spring 56 is connected at one end to the base plate 12 by a pin 194 (FIG. 3) and is connected at its other end to an angular portion 196 formed integral with the crank 50. One end of the slide arm 54 is provided with a boss 197 through which a shouldered screw 198 extends to pivotally connect this end of the arm 54 to an intermediate portion of the crank 50. The other end of the slide arm 54 is provided with an upwardly extending boss 200 having a projecting portion to which one end of the tension spring 58 is connected and held in place by a snap ring 202. The other end of the tension spring 58 is connected to the upstanding portion 184 on the crank 50. Thus, when the bellows motor 38 reciprocates, the crank 50 is alternately pivoted in clockwise and counterclockwise directions to shift the position of the free end of the slide arm 54, thereby to operate the valve means 22.

Referring now more specifically to the valve assembly 22 (FIG. 8), this assembly controls the alternate application of vacuum and atmospheric pressure to both the motor 38 and the vacuum bottle. The valve assembly 22 includes the valve block 24 which is secured to an upstanding portion 204 on the base plate 12 with the ports 26, 28 and 30 aligned with similar openings passing through the projecting portion 204 and the plate 12. A sealing gasket 206 is interposed between the lower surface of the valve block 24 and the upper surface of the projecting portion 204. The valve block 24 is secured to the base plate 12 by a pair of headed fasteners 208 which extend through a pair of plastic sleeves 210 and aligned openings in the valve block 24, the gasket 206, and the base plate 12. The plastic sleeves 210 provide the stop members 60 and 62 described above. To provide a shiftable support for the valve slide 32, one end of the slide arm 54 is provided with a depending portion defining a downwardly opening, cylindrical recess 212 (FIG. 8) in which the valve slide 32 is disposed. The cylindrical recess 212 is in communication with an opening 214 which is formed in the boss 200 and in which is disposed a compression spring 216 for urging the valve slide 32 into sliding contact with the lapped or polished upper surface of the valve block 24. In the position illustrated in FIG. 8, the recess 32a places the ports 28 and 30 in communication. Alternatively, when the position of the slide arm 54 is shifted to the right, the recess 32a places the ports 26 and 28 into communication.

In accordance with another feature of the present invention, the I.V.R. unit 10 includes a manifold plate 218 (FIG. 7) which is secured to the flat or lower surface of the base plate 12 to provide the fluid passageways for interconnecting the various components of the unit 10. More specifically, the manifold plate 218 includes a plurality of ribs 218a defining three recessed pockets or

areas 220, 222 and 224 which effectively provide the passageways 34, 36 and 42 shown in FIGS. 1 and 2, respectively. The manifold plate 218 is secured to the flat lower surface of the base plate 12 by a pair of threaded fasteners which pass through two bossed portions 226 and 228. A gasket (not shown) can be interposed between the ribs 218a and the lower wall of the plate 12 to produce a gas tight bond with the plate 12.

When the manifold plate 218 is secured to the lower surface of the base plate 12, the port 26 is in communication with one end of the recess 220 and the opening 114 (FIGS. 6 and 7), which provides an inlet to the outlet vacuum regulator assembly 18, is in communication with the recess 220 spaced from the port 26. Thus, the recess 220 provides a portion of the passageway 34 shown schematically in FIGS. 1 and 2. Similarly, the port 28 in the valve assembly 22 is in communication with an elongated finger 222a of the recess 222, and the inlet passageway 90 (FIGS. 6 and 7) for the inlet regulator assembly 20 is also in communication with the recess 222. Thus, the recess 222 and the elongated portion 222a thereof provide the passageway indicated schematically as 36 in FIGS. 1 and 2. The port 30 is in communication with an elongated finger 224a of the recess 224, and the enlarged portion of this recess is in communication with the opening 154. The recess 224 and the elongated portion 224a thereof form the passageway indicated schematically as 42 in FIGS. 1 and 2. Thus, the manifold plate 218 secured to the flat lower surface of the base plate 12 provides the passageways for interconnecting the valve means 22 with the regulators 18 and 20 and the vacuum motor 38.

Referring now more specifically to the operation of the intermittent vacuum regulator unit 10, the vacuum inlet to the bottle is connected, by means of the outlet line 14, to the bore 120 in the base plate 12. Similarly, the inlet line 16 is connected to the boss 84 to connect a vacuum line or pump to the interrupter unit 10. Assuming that the valve means 22 is in a position in which the recess 32a bridges the ports 28 and 30 (FIGS. 2 and 8), the interior of the housing 40 is placed in communication with the vacuum source over a fluid conveying system including the passageway 154 (FIGS. 7 and 9), the recess 224, the elongated portion 224a, the port 30, the recess 32a, the port 28, the elongated portions 222a, the recess 222, the inlet passageway 90, the chamber 80, and the passage 86.

The reduction in the pressure within the housing 40 permits the atmospheric pressure to compress the exterior bellows element 46 so that the viscous medium therein is forced through the restricted orifice 48 into the interior bellows element 44, thereby extending the element 44. The compression or contraction of the element 46 pivots the crank 50 in a clockwise direction against the force of the spring 56. In so moving, the crank 50 shifts the slide arm 54 from the position illustrated in FIGS. 2, 3 and 8 to one in which the recess 32a in the valve slide 32 bridges the ports 26 and 28. The overcenter arrangement including the spring 58 is effective to hold the arm 54 in contact with the stop 210 shown at the right in FIG. 8. In this position, the port 30 is connected to the atmosphere.

The interconnection of the ports 26 and 28 applies vacuum to the bottle over a fluid system including the bore 120, the passageway 122, the chamber 82, the openings 116 and 114, the recess 220, the port 26, the recess 32, the port 28, the elongated portion 222a, the recess 222, the passageway 90, the chamber 80 and the passageway 86. Accordingly, vacuum is maintained on the bottle until such time as the valve assembly 22 is returned to the position illustrated in FIGS. 2 and 8.

When the valve assembly 22 is operated to the position shown schematically in FIG. 1, the port 30 is connected to the atmosphere so that the interior of the housing 40 is also placed in communication with the atmosphere

through the recess 224. This equalizes the pressures acting on both of the bellows elements 44 and 46 so that the spring 56 is now effective to pivot the crank 50 in a counterclockwise direction. This expands the bellows element 46 and displaces a portion of the fluid from the bellows element 44 into the bellows element 46. The counterclockwise movement of the crank 50 returns the slide arm 54 to the position shown in FIGS. 2 and 8 in which the port 26 is again connected to the atmosphere and in which the ports 28 and 30 are placed in communication. The connection of the port 26 to the atmosphere terminates the application of vacuum to the bottle and connects this bottle to the atmosphere. The interconnection of the ports 28 and 30 again supplies vacuum through the inlet vacuum regulator 20 to the interior of the housing 40 so that the vacuum motor 38 is operated through a cycle identical to that described above. This intermittent operation of the vacuum motor 38 under the control of the valve assembly 22 continues for so long as vacuum is supplied to the inlet line 16. Accordingly, during this intermittent operation, the vacuum bottle is alternately connected to a source of vacuum and to the atmosphere.

One particularly desirable method of using the intermittent vacuum regulator unit is to place the vacuum bottle with the unit 10 connected thereto at an elevation that is above that of the area of the patient that is to be drained. The drainage tube is connected between the elevated vacuum bottle and the area, and a vacuum source is connected to the unit 10. The operation of the I.V.R. unit 10 is now initiated so that, during one portion of the cycle, the application of vacuum to the bottle causes a flow of drainage from the patient through the tube and into the bottle. On the alternate portion of each of its operating cycles, the unit 10 returns the bottle to atmospheric pressure so that the fluid contained in the tube flows back toward the patient to clear obstructions from the tube. Thus, it is necessary to adjust the cycle of the unit 10 to provide for the connection of atmosphere to the bottle for a long enough period of time to insure that the bottle actually returns to atmospheric pressure so that the back flow of the fluid in the drainage tube is accomplished. If the bottle is operated between varying levels of vacuum, the fluid entrapped in the drainage tube cannot flow back toward the patient to clear obstructions.

Although the present invention has been described with reference to a particular embodiment thereof, it should be understood that those skilled in the art may make many other modifications and embodiments thereof which will fall within the spirit and scope of the principles of this invention.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. A vacuum interrupter for use with a vacuum line comprising a base plate having a generally flat side, an opposite side, and a plurality of spaced openings passing through said plate from said flat side to said opposite side;

a vacuum operated motor mounted on said opposite side of said base plate;

interrupter outlet means on said opposite side of said base plate;

valve means operated by said motor for alternately connecting said vacuum line to said motor and said interrupter outlet means;

and means including said openings and a single recessed plate secured to said flat side of said base plate for placing said valve means in communication with said motor and said interrupter outlet means.

2. A vacuum interrupter unit for use with a vacuum line comprising a base plate defining a plurality of spaced openings;

a sealed bellows housing mounted on said plate and having an inlet in communication with a first one of said openings;

a bellows assembly including two extensible portions connected by a restricted orifice;

means mounting one of said extensible portions in said housing;

an interrupter inlet connected to said vacuum line;

an interrupter outlet;

valve means mounted on said base plate and including a second, a third, and a fourth one of said openings;

a manifold plate secured to said base plate and defining first, second and third passageways, said first passageway connecting said first and second openings, said second passageway connecting said third opening and said interrupter inlet, said third passageway connecting said fourth opening and said interrupter outlet;

and means connected to said bellows assembly for operating said valve means to place said third opening in alternate communication with said second and fourth openings.

3. The vacuum interrupter set forth in claim 2 in which said valve means includes means for alternately connecting said second and fourth openings to the atmosphere.

4. A vacuum interrupter unit for use with a vacuum line comprising a base plate having a generally flat side and a plurality of spaced openings passing through said plate from said flat side to the other side thereof;

a vacuum operated motor mounted on said other side of said plate and having a motor inlet in communication with a first one of said openings;

interrupter inlet means on said base plate adapted to be connected to said vacuum line and in communication with a second one of said openings;

interrupter outlet means on said base plate and including a third one of said openings;

valve means mounted on said other side of said base plate and in communication with others of said openings;

a generally flat manifold plate secured to said flat side of said base plate and including means defining a plurality of passageways for placing said first, second, and third openings in communication with said other openings;

and means carried on said other side of said base plate and actuated by said vacuum operated motor for operating said valve means to alternate positions to alternately connect said interrupter inlet to said motor inlet and said interrupter outlet.

5. The vacuum interrupter unit set forth in claim 4 in which said interrupter outlet means includes a vacuum regulator carried on said other side of said base plate.

6. The vacuum interrupter unit set forth in claim 4 in which said interrupter inlet means includes a vacuum regulator carried on said other side of said base plate.

7. The vacuum interrupter unit set forth in claim 4 in which said means for operating said valve means comprises a resiliently biased over-center linkage connected between said motor and said valve means for biasing said valve means toward one or the other of its alternate positions.

8. A vacuum interrupter unit for use with a vacuum line comprising a base assembly defining a first, a second and a third passageway;

a sealed housing mounted on said base assembly and in communication with said first passageway;

a bellows assembly including a portion disposed in said sealed housing;

interrupter inlet means mounted on said base assembly and including a vacuum regulator connected between said second passageway and said vacuum line;

interrupter outlet means mounted on said base assembly and including a vacuum regulator connected to said third passageway;

the vacuum regulators included in said interrupter inlet and outlet means each comprising a hollow upstanding projecting portion formed on said base assembly, means in said hollow portion defining a valve seat, a

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resilient diaphragm disposed adjacent said valve seat, and adjustable resilient means for biasing said resilient diaphragm toward said valve seat;
 an upstanding portion on said base assembly defining three ports in communication with said first, second and third passageways;
 a valve plate slidably mounted on said upstanding portion and including a recess for bridging two of said ports;
 a crank pivotally mounted on said base assembly and connected to said bellows assembly; and
 means pivotally connecting said crank to said valve plate, expansion and contraction of said bellows assembly actuating the crank to shift said valve plate between two spaced positions in which said recess bridges different pairs of said ports to alternately place said first and second and said second and third passageways in communication.

9. The unit set forth in claim 8 including resilient means connected between said crank and said base assembly for biasing said bellows assembly and said valve plate to a position in which said first and second passageways are in communication.

10. The unit set forth in claim 8 including resilient means connected between said valve plate and said crank for biasing said valve plate toward either of said two spaced positions.

11. A vacuum interrupter assembly comprising a base plate having a plurality of openings therein;
 a pressure regulator mounted on said base plate and including an inlet and an outlet in communication with a first one of said openings;
 a vacuum line connected to said inlet;
 a pressure operated motor mounted on said plate and including an inlet in communication with a second one of said openings;
 an interrupter outlet;
 valve means carried on said base plate and including three ports in communication with a third, a fourth, and a fifth one of said openings;
 a manifold plate carried on said base plate and including means defining a first passageway connecting said first opening with said third opening, a second passageway connecting said second opening with said fourth opening, and a third passageway connecting said fifth opening with said interrupter outlet;
 and means carried on said base plate and actuated by said motor for operating said valve means to place one of said ports in alternate communication with the other two of said ports so that said regulator outlet is alternately connected to said motor inlet and said interrupter outlet.

12. A vacuum interrupter unit for use with a vacuum line comprising a base plate having a pair of hollow portions projecting outwardly from one side of said plate and a generally flat opposite side, said plate including an opening passing through said plate from within each of said hollow portions to said opposite side;
 interrupter inlet means in communication with one of said hollow portions and adapted to be connected to said vacuum line;
 interrupter inlet means in communication with one of other of said hollow portions;
 separate vacuum regulator means in each of said hollow portions and including a single resilient element having portions disposed in both of said hollow portions for regulating the inlet and outlet vacuum;
 valve means on said base plate for controlling the interconnection of said interrupter outlet and inlet means;
 and fluid conveying means including said openings for interconnecting said valve means with both of said vacuum regulator means.

13. The vacuum interrupter unit set forth in claim 12 in which said fluid conveying means includes a plate car-

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ried on said opposite side of said base plate and having separate recessed areas connecting said openings to said valve means.

14. A vacuum interrupter unit for use with a vacuum line comprising a base plate;
 an interrupter inlet mounted on said plate and adapted to be connected to said line;
 an interrupter outlet mounted on said plate;
 a vacuum operated motor mounted on said base plate;
 a valve block on said plate including three spaced ports, a first one of said ports being connected to said inlet, a second one of said ports being connected to said outlet, and a third one of said ports being connected to said motor;
 a lever pivotally mounted on said base at a pivot point intermediate its ends and connected to said motor at one side of said pivot point;
 an arm pivotally mounted on said lever at the other side of the pivot point and defining a recessed portion;
 resilient means interconnected between a point on the lever at said one side of the pivot point and said arm;
 and a valve slide mounted in said recessed portion and slidable over said valve block, said valve slide including an opening for connecting two of said ports;
 operation of said motor pivoting said lever in two opposite directions to shift said arm and said valve slide to two opposite positions in which different pairs of said openings are connected by said valve slide.

15. An intermittent vacuum regulator unit for use with a source of vacuum and a vacuum utilizing means comprising
 a generally uniplanar base structure having one generally flat side and a plurality of spaced openings passing through the plate from an opposite side to the flat side;
 a vacuum operated motor carried on and projecting outwardly from the opposite side of the base structure in communication with at least one of the spaced openings;
 a valve assembly connected to and operated by the vacuum motor for controlling the application of vacuum to the utilizing means, said valve assembly being carried on and projecting outwardly from the opposite side of the base structure, said valve assembly also being in communication with at least one of the spaced openings; and
 a generally uniplanar manifold plate secured to and carried on the flat side of the base structure and forming passageways communicating with the spaced openings to place the valve assembly and vacuum motor in communication.

16. The intermittent vacuum regulator set forth in claim 15 including at least one projecting portion carried on and extending outwardly from the opposite side of the base structure;
 and a vacuum regulator assembly disposed in said projecting portion and in communication with one of the spaced openings.

17. In an apparatus for controlling the application of vacuum from a vacuum source to a vacuum receiver, a first vacuum line extending to the vacuum source, a second vacuum line extending to the vacuum receiver, a fluid powered motor means having a fluid inlet, valve means operable to a first position to connect the first line to the fluid inlet and the second line to the atmosphere and to a second position to connect the fluid inlet to the atmosphere and the first line to the second line,
 means coupling the valve means to the motor means to alternately actuate the valve means between the first and second positions,
 means for controlling the motor means to operate the valve means from its second position to its first position in a fixed interval of time so that the valve means remains in its second position for a fixed

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interval of time to connect the first line to the second line for a fixed interval of time during each cycle of operation of the valve means,

vacuum regulator means in the first line in a position between the vacuum source and the valve means to be connected between the vacuum source and the motor means in the first position of the valve means and to be connected between the vacuum source and the second line in the second position of the valve means,

and means for adjusting the vacuum regulator means to change only the interval required by the motor means to operate the valve means from its first position to its second position to vary the interval that the vacuum receiver is connected to the atmosphere independently of the interval that the vacuum receiver is connected to the vacuum source.

18. In an apparatus for controlling the application of vacuum from a vacuum source to a vacuum receiver, a first vacuum line extending to the vacuum source, a second vacuum line extending to the vacuum receiver, a fluid powered motor means having a fluid inlet, valve means operable to a first position to connect the first line to the fluid inlet and the second line to the atmosphere and to a second position to connect the fluid inlet to the atmosphere and the first line to the second line,

means coupling the valve means to the motor means to alternately actuate the valve means between the first and second positions,

means for controlling the motor means to operate the valve means from its second position to its first position in a fixed period of time so that the valve means remains in its second position for a fixed period of time to connect the first line to the second line for a fixed period of time during each cycle of operation of the valve means,

first vacuum regulator means in the first line in a position between the vacuum source and the valve means to be connected between the vacuum source and the motor means in a first position of the valve means and to be connected between the vacuum source and the second line in the second position of the valve means,

means for adjusting the first vacuum regulator means to supply a vacuum falling within a given range of

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values to regulate only the period required by the motor means to operate the valve means from its first position to its second position thereby varying the period that the vacuum receiver is connected to the atmosphere independently of the period that the vacuum receiver is connected to the vacuum source, second vacuum regulator means in the second line in a position between the valve means and the vacuum receiver to be connected in series with the first vacuum regulator means when the valve means is in its second position,

and means for adjusting the second vacuum regulator means to apply a selected vacuum to the vacuum receiver only when the valve means is in its second position which is within the given range of values set by said first vacuum regulator means.

19. A vacuum interrupter unit for use with a vacuum line comprising a base plate defining a plurality of spaced openings;

a bellows assembly including an inlet in communication with a first one of said openings;

an interrupter inlet connected to said vacuum line; an interrupter outlet;

valve means mounted on said base plate and including a second, a third, and a fourth one of said openings; a manifold plate secured to said base plate and defining first, second, and third passageways, said first passageway connecting said first and second openings, said second passageway connecting said third opening and said interrupter inlet, said third passageway connecting said fourth opening and said interrupter outlet;

and means connected to said bellows assembly for operating said valve means to place said third opening in alternate communication with said second and fourth openings.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,208,467

September 28, 1965

Francis J. Eichelman et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 12, line 18, for "alernate" read -- alternate --;
column 13, line 62, for "inlet" read -- outlet --; same line
62, for "one of" read -- the --.

Signed and sealed this 14th day of June 1966.

(SEAL)

Attest:

ERNEST W. SWIDER

Attesting Officer

EDWARD J. BRENNER

Commissioner of Patents