United States Patent [19]

Burns

[11] **3,788,338**

[45] **Jan. 29, 1974**

[54] **VACUUM SEWAGE CONVEYING WITH VACUUM OPERATED VALVE**

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[22] Filed: **June 29, 1971**

[21] Appl. No.: **157,936**

[52] **U.S. Cl.** **137/1,** 4/1, 137/205

[51] **Int. Cl.** **E03d 1/00**

[58] **Field of Search** ..... 137/205, 395, 1, 1 C; 4/77, 4/1; 251/31

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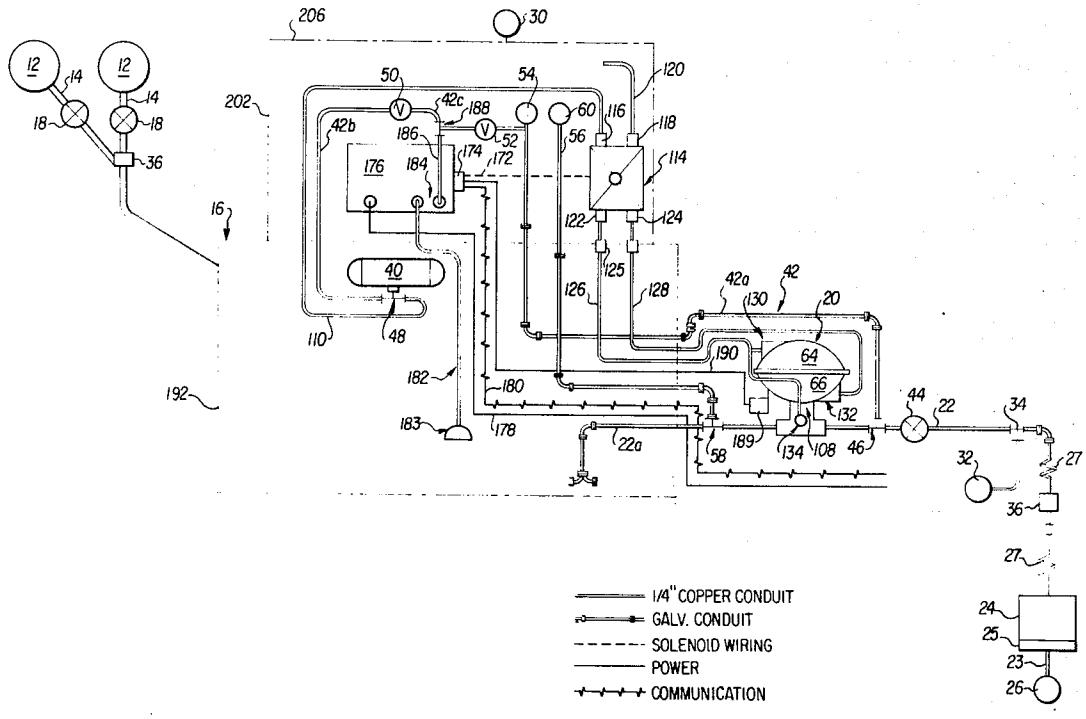
[57] **ABSTRACT**

A method and apparatus for conveying sewage by vacuum induced plug flow wherein sewage is drawn from a sewage collecting region into a vacuum line conduit, through a vacuum operated valve in that conduit, and is conveyed toward the source of vacuum by vacuum induced plug flow involving the interposition of volumes of air between plugs of sewage. A control zone in an operator portion of the vacuum valve is controllable by a low pressure reservoir for opening the valve. The reservoir is maintained at a low pressure through a vacuum tap conduit communicable with the reservoir and the vacuum line conduit.

The sewage collecting region may be an underground collecting tank which contains, in a dry compartment, equipment for controlling operation of the vacuum valve which may be located outside the collecting region in a separate housing just below grade. Electrical power used at the collecting region may be supplied solely from a central panel through cable laid in a trench along the vacuum line conduit.

A rigid pipe assembly in the collecting tank is connected several feet above the tank bottom, but below grade, to a pipe assembly of the vacuum valve, and the orientation may be such as to permit disconnection of pipes at the vacuum valve without causing leakage in the region where workmen must stand.

28 Claims, 7 Drawing Figures



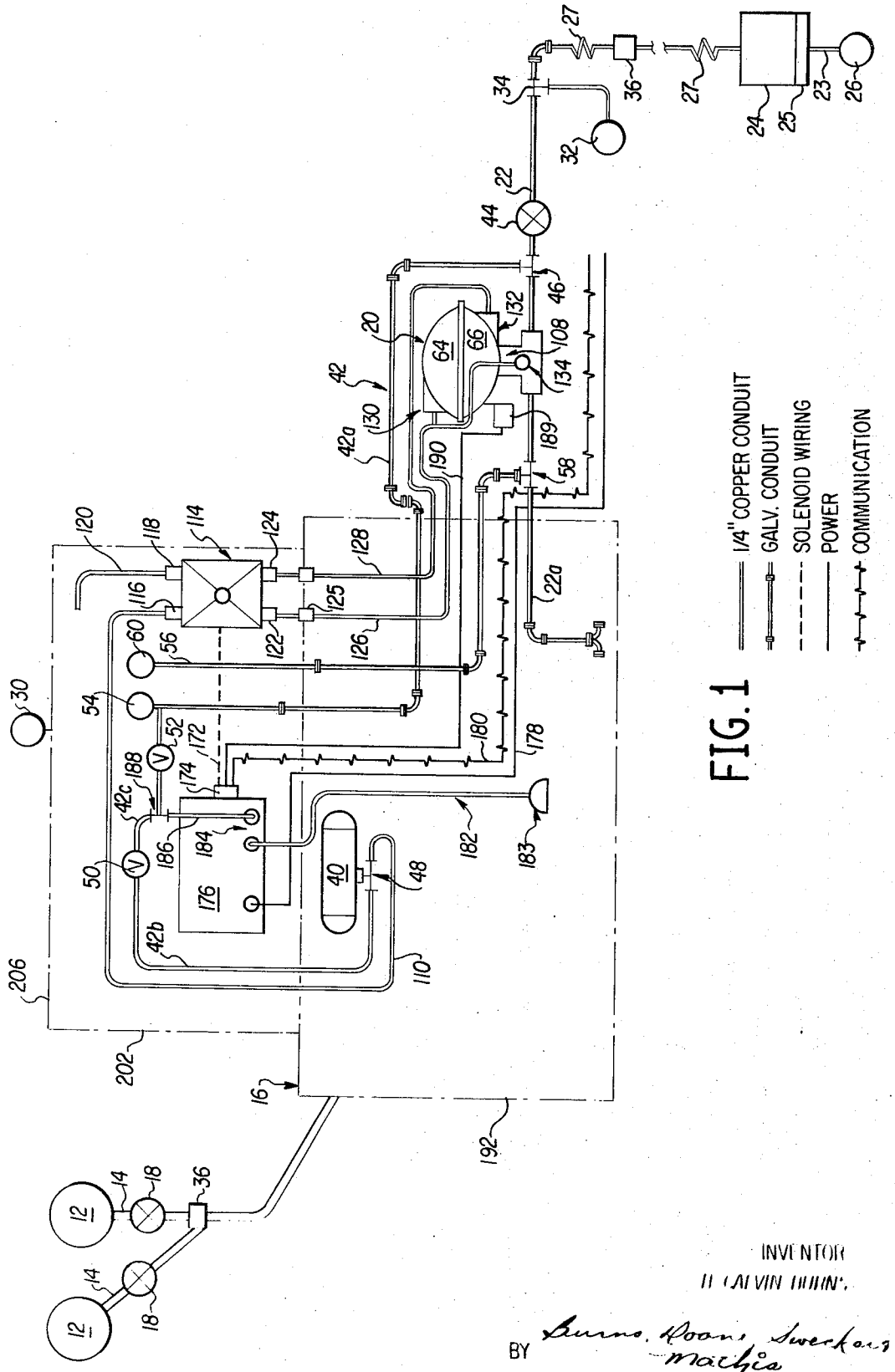
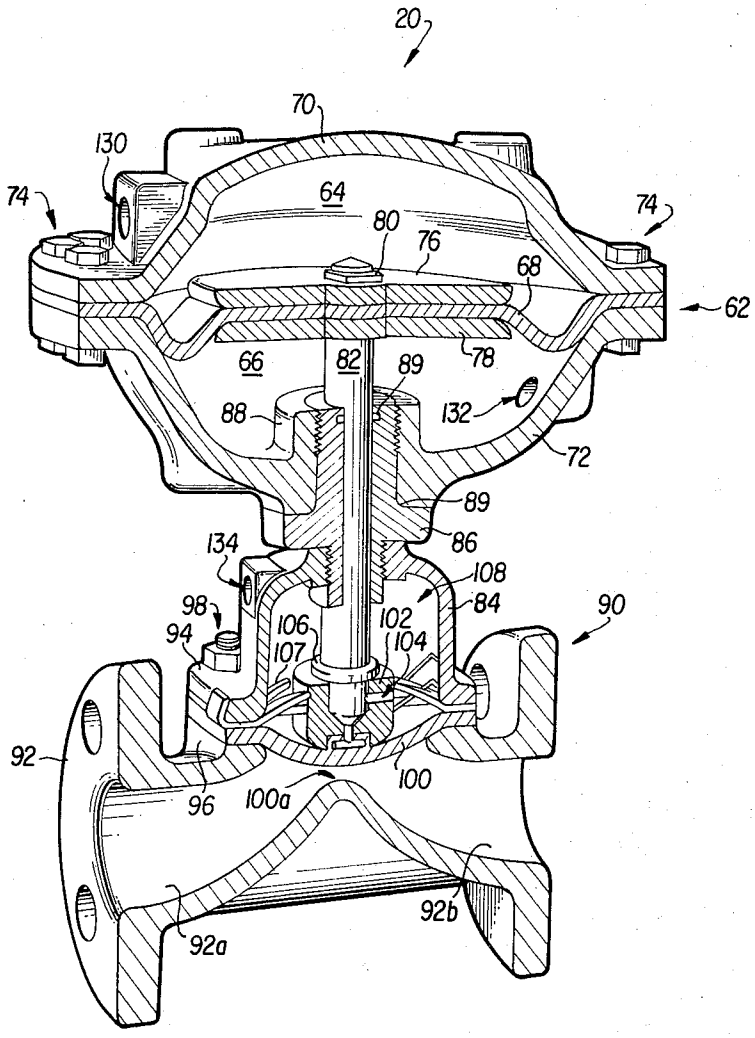


FIG. 1

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ATTORNEYS

FIG. 2


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104
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96
100a
100
92b
92a

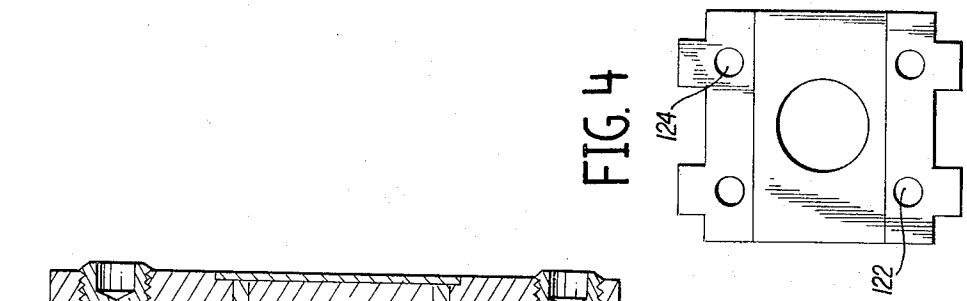
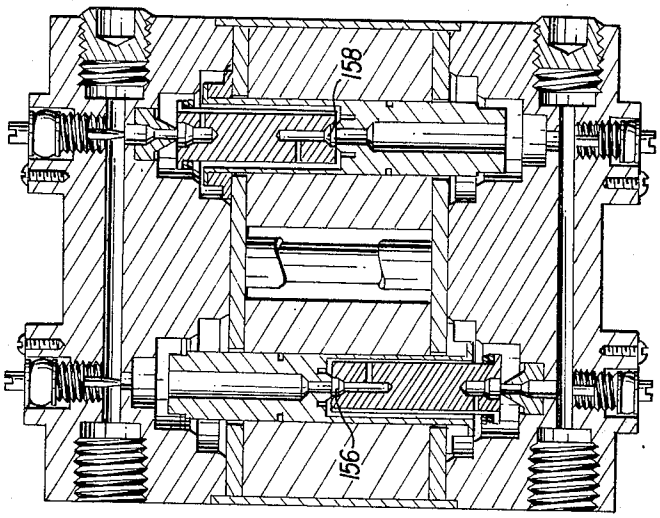
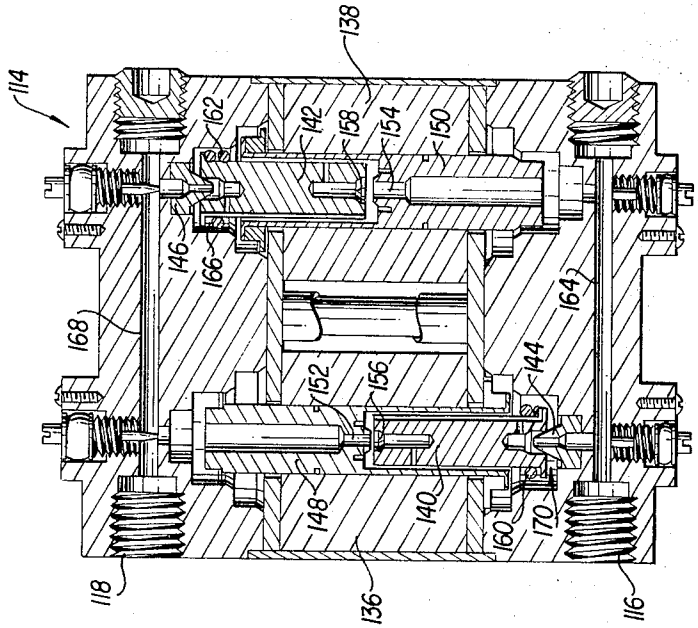


FIG. 4



ENERGIZED

FIG. 3B



DE-ENERGIZED

FIG. 3A

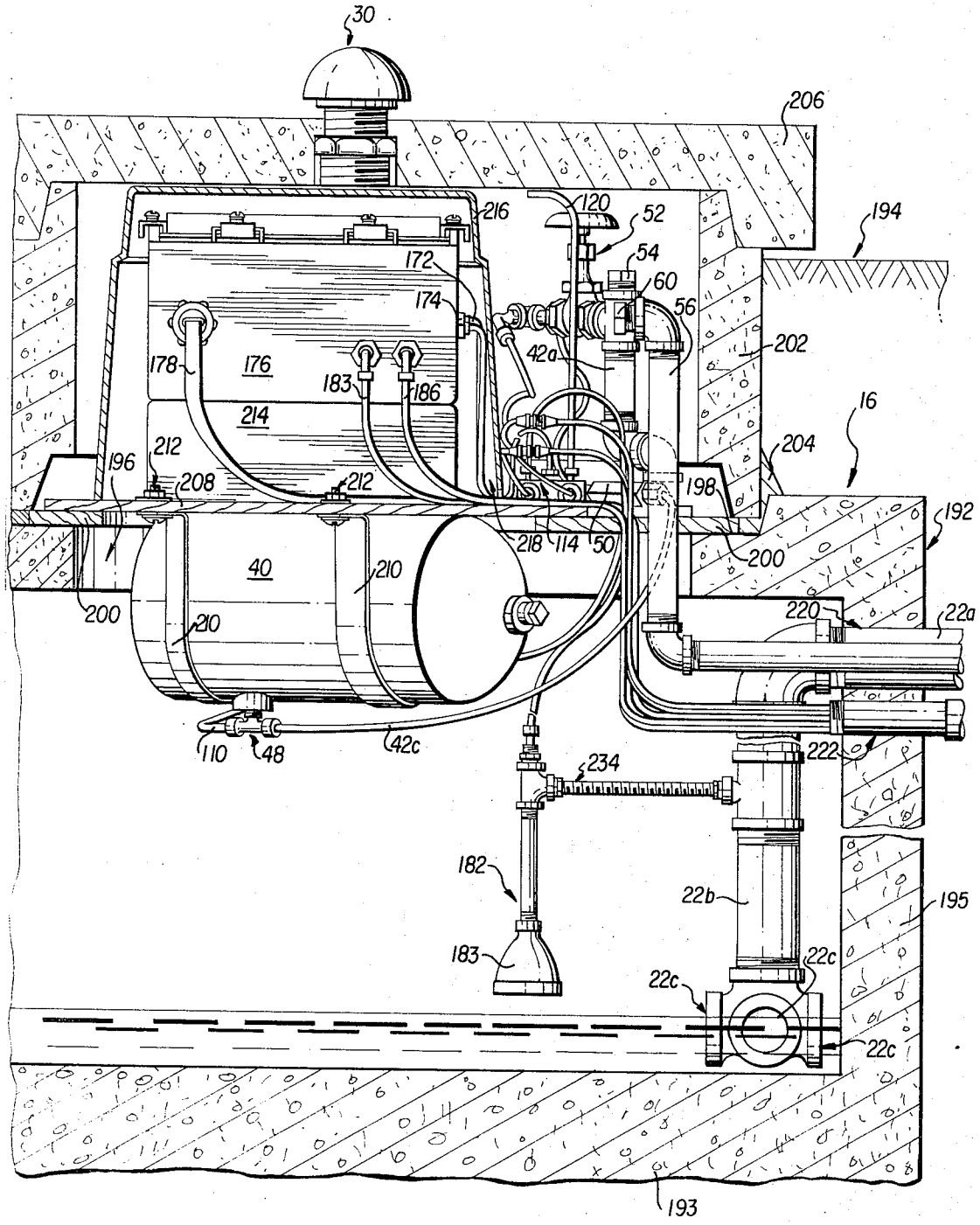

30
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216
120
52
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174
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42a
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16
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212
196
208
212
198
192
218
114
50
200
40
210
200
210
220
22a
110
48
42c
222
234
182
22b
195
183
22c
22c
22c
193

FIG. 5A

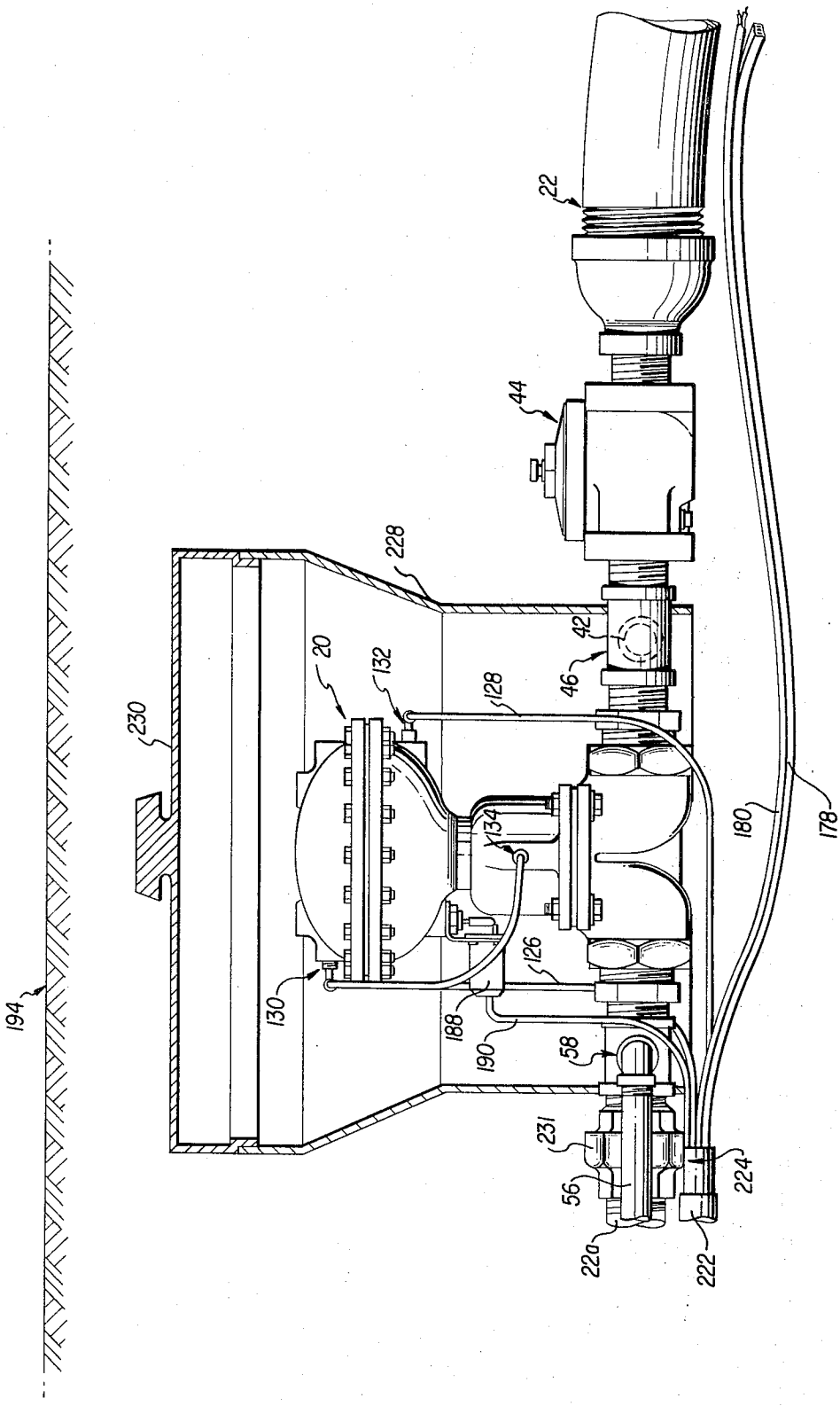

22
44
228
42
46
20
132
128
230
134
126
130
188
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56
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222
224
180
178
194

FIG. 5B

VACUUM SEWAGE CONVEYING WITH VACUUM OPERATED VALVE

BACKGROUND OF THE INVENTION

This invention relates to the conveying of sewage by vacuum induced flow. More particularly, this invention relates to such a method and apparatus which may be generally of the type for providing vacuum induced plug flow as disclosed in the copending application Ser. No. 130,791 [filed Apr. 2, 1971, by B. Calvin Burns et al. for *Method and Apparatus for Conveying Sewage*, as a continuation of application Ser. No. 016,734 filed Mar. 5, 1970 now abandoned, as a continuation-in-part of application Ser. No. 767,626, filed Oct. 15, 1968 now abandoned], and specifically of the type wherein a vacuum valve, through which sewage is drawn from a collection region, is vacuum controlled.

The above referenced patent applications disclose a novel and advantageous technique and system for conveying sewage which involves the conveying, preferably by gravity, of sewage from a source thereof to a collection region, preferably in the form of a collecting tank. According to that technique and system, sewage is drawn from the collection region, through a vacuum valve, into a vacuum line conduit subjected to a low pressure by a source of vacuum. A volume of air is interposed behind sewage drawn into the vacuum line conduit to propel, by vacuum induced plug flow involving the interposition of volumes of air between plugs of sewage, the sewage toward the source of vacuum. This vacuum source is disclosed as preferably being provided by a vacuum receiver tank.

Interposition of air behind sewage drawn into the vacuum line conduit may be accomplished by intermittently maintaining the vacuum valve in an open position for a time sufficient to substantially empty the collecting tank of sewage and to admit a volume of air through the valve behind the sewage. Alternatively, but preferably additionally, air introduction means may be employed to admit air into the vacuum line conduit downstream of the vacuum valve.

Although the technique and system disclosed in the above referenced patent applications have constituted a significant advance in the sewage conveying art, it will be appreciated that amenability to improvement exists in certain respects. The present invention is particularly concerned with improvements relating to control of the vacuum valve. It will, however, be appreciated that the present invention has applicability to control of a vacuum valve in techniques other than those establishing vacuum induced plug flow.

Previously the vacuum valves employed in the technique and system of the foregoing applications have been operated and controlled pursuant to sensing of a predetermined amount of sewage in the collection region, as well as on a timed basis and/or on manually initiatable basis. The disclosures of the above referenced patent applications which generally contemplated hydraulic or pneumatically operated vacuum valves, dealt primarily with electric motor control of the vacuum valves.

One of the drawbacks of employing electric motor control is the requirement of the electrical power from the commercial power lines at the sewage collection region. Often the power requirements imposed for causing opening and closing of the valve by the electric motor have entailed the need for providing local transformers at the local collecting tanks. As will be appreciated, where a plurality of collecting tanks interspersed in a system were employed, direct supply of adequate power from a control station had been significantly impeded by the distances involved. Hence, the local transformers were employed. As will be apparent, the connection of power lines into the sewage collection region, together with the need for metering the amount of power used and possible extra transformers, constitute impediments to the efficient use of the system.

Further impediments to the provision for both economic and reliable valve control may be encountered where electric motor operation of the vacuum valve is undertaken. The normally closed vacuum valve in the vacuum line conduit is subjected to rather severe operating requirements. The valve, when closed, must provide an airtight seal sufficient to prevent loss of the vacuum. When open, it must be capable of normally passing all objects which find their way into the sewage line. Both economic and reliable vacuum valve control are not always compatible in the case of electric motor operation of a vacuum valve in a manner intended to facilitate performance within the operating requirements.

The present invention is also concerned with improvements relating to system maintenance. Another drawback of the prior system is that when the vacuum valve in the vacuum line conduit fails to operate properly such, for example, as when a blockage occurs or the electric motor operator fails to function, the repair or replacement of the valve may be an extremely unpleasant task because of the location of the valve at the low discharge point of the collecting tank. Unless the sewage collecting tank is completely empty, sewage cannot be kept out of the trench or excavation where the workmen must be.

Further in regard to blockages in the vacuum line conduit, the present invention envisions the novel provision for their removal either back toward the collection region or forwardly toward the source of vacuum.

OBJECTS AND SUMMARY OF A PREFERRED EMBODIMENT OF THE INVENTION

It is, therefore, a general object of the present invention to provide a novel method and apparatus for conveying sewage which obviates or minimizes problems of the sort previously noted.

It is a particular object of the invention to provide such a novel method and apparatus wherein a vacuum valve, employed in the conveying of sewage by vacuum induced flow, is efficiently controlled by vacuum in a manner so as to render vacuum valve operation both economical and reliable under the severe operating requirements encountered.

It is a related object of the present invention to provide such a novel method and apparatus for conveying sewage designed to result in maintenance of the vacuum valve in a closed position upon failure of power.

It is a further object of the present invention to provide such a novel method and apparatus wherein a low pressure reservoir communicable with a vacuum line conduit is employed so as to enable opening and closing of the vacuum valve independently of the pressure

condition existing in the vacuum line conduit through which sewage is conveyed.

Another major object of the invention is to provide a novel arrangement of components and parts that are located immediately adjacent the sewage collecting region. The vacuum valve in the underground vacuum line conduit is installed at an elevation sufficiently above the level of sewage in the collection region so as to enable the disconnection of pipes at the valve without causing the leakage of sewage at the location where workmen must stand.

Yet another object is to provide a novel piping arrangement whereby compressed air from a mobile unit may be injected into the piping arrangement on both sides of the vacuum valve to thereby remove blockages either back into the sewage collection region, or forwardly through the vacuum line conduit toward the vacuum source.

A related object of the invention is to employ such a novel piping arrangement in conjunction with the maintenance of the low pressure reservoir previously noted.

A preferred form of the invention intended to accomplish at least some of the foregoing objects partakes of many features disclosed in the above referenced applications, particularly insofar as the sewage is conveyed by vacuum induced plug flow involving the interposition of volumes of air between plugs of sewage. Sewage is passed from a source to a collection region or zone from which it is drawn into a vacuum line conduit. This conduit intermittently provides communication between the collection region and a source of vacuum through control of a vacuum valve means. A volume of air is interposed behind sewage drawn into the conduit through the vacuum valve to propel the sewage, by vacuum induced plug flow, toward the source of vacuum.

The present invention involves vacuum control of the vacuum valve means. To this end a control zone is provided in an operator portion of the vacuum valve means. This zone is controllable by a low pressure reservoir for opening the vacuum valve means. Vacuum tap conduit means communicable with the low pressure reservoir and the vacuum line conduit means is operable to provide low pressure in the reservoir. Selective communication between the reservoir and the control zone of the vacuum valve means is provided by negative pressure control conduit means. In response to a predetermined pressure condition in the control zone, the vacuum valve is opened or closed.

A portion of the vacuum tap conduit means may be isolated from the low pressure reservoir by isolating valve means to prevent increases in reservoir pressure. In this fashion, the reservoir is available to operate the vacuum valve means independently of the pressure condition in the vacuum line conduit.

Positive pressure control conduit means may be additionally employed to selectively provide communication between the vacuum valve control zone and a source of positive pressure.

With the control zone of the vacuum valve means comprised of first and second chambers separated by a diaphragm means, positive and negative pressure may be alternated between those chambers to effect opening and closing of the valve. Control valve means may control communication of the negative and positive pressure control conduit means with the control zone.

Preferably the control valve is a solenoid valve including a pair of inlet and outlet ports. The positive and negative pressure control conduit means include: outlet conduit means extending from the low pressure reservoir to one inlet port, positive pressure vent conduit means extending from a positive pressure zone to the other inlet port, and first and second control valve outlet conduit means extending from the outlet ports respectively to the first and second control zone chambers. The control valve is operative to continuously supply one chamber with vacuum while the other is supplied with positive pressure.

Preferably, in the deenergized condition of the control valve, the supply to the chambers results in a vacuum valve closed condition. Thus, the possibility of loss of vacuum in the vacuum line conduit upon a power failure is minimized.

An auxiliary control chamber may be provided to aid in opening and closing the vacuum valve.

The low pressure reservoir may be uncoupled from the vacuum line conduit by means of a manually operable valve means. Maintenance procedures are thereby enhanced. In this connection, the vacuum tap conduit means may be utilized as a cleanout conduit means, and additional cleanout conduit means may be communicated with the vacuum line conduit means upstream of the vacuum valve.

Piping inside the collection region extends from the bottom of a collecting tank defining the collection region vertically to the approximate elevation of the vacuum valve and through a side wall of the collecting tank. A pipe section extending from the vacuum valve is then coupled by a union to the outer end of the pipe section from the collecting tank. By providing a slight slope in the pipe section between the vacuum valve and the collecting tank, the union may be disconnected without the leakage of sewage in the region where work is being performed insofar as the sewage will slope back into the tank.

Other objects and advantages of the present invention will become apparent from the subsequent detailed description with reference to the accompanying drawings in which like numerals refer to like elements.

THE DRAWINGS

FIG. 1 is a diagrammatic illustration of a system for conveying sewage which embodies the present invention.

FIG. 2 is a generally centrally longitudinal cross-sectional view of a vacuum valve which may be advantageously used in practicing the present invention.

FIGS. 3A and 3B are front cross-sectional views of a solenoid operated control valve, respectively in the deenergized and energized condition, which may be advantageously used in practicing the present invention.

FIG. 4 is a front view of the valve of FIGS. 3A and 3B on a somewhat reduced scale.

FIGS. 5A and 5B are detailed views of portions of the system shown in FIG. 1, and together these views comprise an elevation in section of the system from the collection zone to immediately downstream of the vacuum valve.

DETAILED DESCRIPTION

General Summary

With reference to FIG. 1, illustrating schematically an overall sewerage system according to the present invention, the method and apparatus for conveying sewage according to the present invention may be understood.

As indicated in FIG. 1, one or more sources 12 of sewage are interconnected with collecting line conduits 14. These collecting line conduits 14 ultimately place the sources 12 of sewage in communication with a somewhat remotely positioned collecting tank or local receptacle 16.

Preferably, although not necessarily, the collecting line conduits 14 function as gravity conduits, i.e., means for conveying sewage from a sewage source 12 to the collecting tank 16 by gravity flow. If desired, conventional one-way check valves 18 may be positioned in the gravity conduits 14 to prevent the back flow of sewage toward the sewage source once the sewage has been conveyed in the gravity conduit 14 past the check valve 18.

At an appropriate time, sewage may be drawn from the collecting tank 16 through a vacuum valve 20 and into a vacuum line conduit 22. It will be appreciated that according to a preferred technique of the present invention, normal system operation, to so draw the sewage, involves the emptying of the collecting tank 16.

At such time as the emptying is accomplished, a volume of air is permitted to pass from the collecting tank and through the vacuum valve 20 behind the sewage drawn from the collecting tank, in a manner hereinafter more fully described. However, the conveying of sewage by vacuum induced plug flow, as accomplished in practicing the present invention, may involve the interposition of a volume of air behind sewage drawn through the vacuum valve 20 in a manner other than through flow of such air from the collecting tank 16, or for that matter through the vacuum valve 20.

Practice of the present invention is not however, restricted to vacuum induced plug flow operation as will be readily apparent to those skilled in the art.

It will also be apparent that the drawing of sewage from the local receptacle or collecting tank 16 may be initiated upon the sensing of a predetermined volume or level of sewage collected therein. Additionally or alternatively, discharge of sewage from the collecting tank may be initiated on a timed basis or pursuant to an operator controlled signal.

At any rate, upon opening of the vacuum valve 20, sewage in the collecting tank 16 is drawn through the vacuum valve 20 insofar as the vacuum line conduit 22 is subjected to a vacuum by means of a source of low pressure. Through the interposition of a volume of air behind sewage drawn through the vacuum valve 20, the sewage may be conveyed, by vacuum induced plug flow, toward the source of low pressure.

In the preferred embodiment, the source of low pressure is constituted by a vacuum receiver tank 24 into which the sewage is conveyed. This vacuum receiver tank 24 may be a portion of a tranfer station which may include an ejector 25 preferably of the positive pressure type.

If desired, the sewage may be conveyed from the transfer station to a sewage treatment plant 26 through further vacuum line conduits 23.

The vacuum line conduit 22 may be provided with one or more plug reformers 27 spaced therealong. Advantageously, these plug reformers 27 may be of the type which are helical along the axis of the vacuum line conduit 22 so as to impart rotation to sewage plug as they are propelled from the plug reformers 27.

As noted above, the sewage may be conveyed to the vacuum receiver tank by vacuum induced plug flow; and such plug flow involves the interposition of a volume of air between plugs of sewage. This volume of air may be provided from the collecting tank 16. For this purpose, a vent valve 30 is provided at the collecting tank.

With further reference to FIG. 1, it will be seen that air introduction means in the form of a valve 32 is in communication with the vacuum line conduit 22. One or more of such introduction means may be provided. Preferably air admitted through the valve 32 enters the vacuum line conduit 22, which interconnects the collecting tank 16 and the vacuum receiver tank 24, at a zone 34 intermediate the vacuum valve 20 and at least one of the plug reformers 27.

One or more pressure clean-out valve 36 may be strategically placed in the vacuum line conduit 22 at a free end thereof or at a position such as that illustrated in FIG. 1. Similarly, such pressure clean-out valves 36 may be interposed in the collecting line conduit means 14 between the sewage source 12 and the collecting tank 16.

As illustrated, one of the pressure clean-out valves 36 may be conveniently located upstream of at least one of the plug reformers 27. This facilitates unclogging of the vacuum line conduit 22 at the zone of the plug reformer.

Desirably, some or all of the pressure clean-out valves 36 in the vacuum line conduit may additionally function as air introduction means in a manner similar to the previously noted air introduction means provided by the collecting tank vent valve 30 and the air inlet valve 32.

The system and method so far described is more fully elaborated upon in the earlier referenced United States patent applications of B. Calvin Burns and Hans C. Albertsen. The disclosures of those applications are hereby incorporated by reference.

As pointed out in the applications, the overall system may include a plurality of interconnected collecting regions, such as the collecting tank 16 illustrated, and/or a plurality of sources of vacuum such as the vacuum receiver tank 24 illustrated.

In each case, sewage is drawn from the collecting region 16 through the vacuum valve 20 and is conveyed by vacuum induced plug flow toward the vacuum source 24. Implicit in the disclosures of the foregoing patent applications is the fact that the interposition of a volume of air behind sewage drawn into the vacuum line conduit 22 creates a pressure differential suitable for conveying the plugs of sewage; this interposition of air may be accomplished through the agency of air introduction means such as the vent valve 30 of the collecting tank 16 when employed, the air inlet valve 32 and/or 36, or all of these.

Of course, it will be recognized that the introduction of air into the vacuum line conduit 22 through the

agency of the vent valve **30** may be accomplished not only during emptying of sewage from a collecting tank **16** which has collected sufficient sewage, but also through the opening of a vacuum valve **20** associated with an interconnected collecting tank **16** that may or may not have sewage therein. Such air introduction is a consequence of the interconnection of a plurality of collecting tanks **16** with suitably interconnected vacuum line conduits **22,** and may conveniently be accomplished by opening the vacuum valves **20** associated with each collecting tank **16** on a predetermined time basis and/or manually, if desired, as pointed out in the disclosures of the foregoing applications.

In any event, the opening of the vacuum valves **20,** according to the present invention, is through vacuum control.

Detailed Structure and Method

According to a preferred form of the present invention, the vacuum valve **20** is vacuum operated both for the purpose of opening and closing that valve.

For this purpose, a low pressure reservoir, preferably in the form of a vacuum storage tank **40,** is provided. This vacuum storage tank **40** is advantageously located in the collecting tank **16,** in a manner hereinafter more fully described, as schematically depicted in FIG. **1.**

Presently it is sufficient to note that the vacuum storage tank **40** is maintained in its low pressure state by means of the vacuum existing in the vacuum line conduit **22.** For this purpose, a vacuum tap conduit means **42** is situated so as to be communicable with both the low pressure reservoir **40** and the vacuum line conduit means **22.**

The vacuum tap conduit means **42** may, in its preferred form, be considered to be divided into three sections. The first section **42***a* is in continuous communication with the vacuum line conduit **22** downstream of the vacuum valve **20,** and preferably upstream of a check valve **44** interposed in the vacuum line conduit **22.** The zone of continuous communication is indicated at **46.**

A second section **42***b* of the vacuum tap conduit means is in continuous communication with the low pressure reservoir **40.** The zone of continuous communication is indicated at **48.**

The first and second sections **42***a* and **42***b* of the vacuum tap conduit means **42** are interconnected by a third section **42***c*. This latter section **42**c may include a check valve **50** and a gate valve **52.**

It will be appreciated that the check valve **50** functions to automatically uncouple the vacuum storage tank **40** from the vacuum line conduit **22** whenever the pressure in the vacuum line conduit **22** exceeds that in the storage tank **40.** In this fashion, the vacuum storage tank **40** functions as a low pressure reservoir independently of a loss of vacuum, or partial loss of vacuum, in the vacuum line conduit **22.**

The gate valve **52** also included in the intermediate section **42***c* of the vacuum tap conduit means **42** is normally maintained in an open position. This permits communication between the vacuum line conduit **22** and the vacuum storage tank **40** through the check valve **50.**

However, in instances where it becomes desirable to clean out the vacuum line conduit **22** downstream of its zone **46** of communication with the vacuum tap conduit means **42,** the gate valve **52** may be closed. Thereafter, pressurized air from a suitable source may be introduced into the initial section **42***a* of the vacuum tap conduit means. As this air is forced through the vacuum line conduit means **22,** the cleanout operation is performed.

To facilitate the introduction of cleanout air, a removable closure **54** is provided in the section **42***a* of the vacuum tap conduit means adjacent the gate valve **52.**

It may be here noted that provision is also made for internal cleaning of a connecting conduit portion **22***a* extending from the collecting tank **16** to the vacuum valve **20.** As will be apparent, the connecting conduit portion **22***a* is, through opening of the vacuum valve **20,** placed in communication with the remainder of the vacuum line conduit **22** that is continuously subjected to a low pressure.

Such a cleanout operation may be accomplished through the provision of a cleanout line conduit **56.** One end of this conduit **56** is in continuous communication with the lead portion **22***a* of the vacuum line conduit at a zone indicated at **58.** The other end of the cleanout line conduit **56** is capped by a suitable removable closure **60.**

Removal of the closure **60** and interjection of compressed air or the like through the cleanout line conduit **56** will, if the vacuum valve **20** is closed, be operative to direct any sewage clogged in the upstream portion of the vacuum line conduit section **22***a* back into the collecting tank **16.** Of course, if the vacuum valve **20** is open, the same introduction of air will ultimately (since the collecting tank **16** is generally airtight, i.e., it prevents air from exiting) function to unclog the section of the vacuum line downstream of the cleanout line communication zone **58.**

As will become apparent, the vacuum storage tank **40** functions to place the vacuum valve **20** in an open or closed position. With reference to FIG. **2,** a preferred form of the vacuum operated vacuum valve **20,** that may advantageously be employed in practicing the present invention, may be seen. This valve is comprised of a double acting air motor of the type commercially available from the Grinnell Company, Inc., Providence, R.I. The specific basic structure of the illustrated valve **20** forms no part of the invention per se and structural variations may be employed.

As may be seen in FIG. **2,** the illustrated valve **20** is of the diaphragm type and includes basically three sections. The upper, or air motor section **62,** provides an operator section including an internal control zone made up of first and second primary control chambers **64** and **66.** These control chambers are separated by an air motor diaphragm **68.**

To define the chambers **64** and **66,** the outer circumferential periphery of the diaphragm **68** is sandwiched between upper and lower air motor covers, or housing portions **70** and **72.** These covers are provided with flanged circumferentially extending peripheries suitably connected together, for example by bolts and nuts indicated generally at **74.**

The central portion of the diaphragm **68** is generally sandwiched between upper and lower air motor plates **76** and **78.** A nut **80** may be employed to interconnect the motor plate and control diaphragm assembly with a control spindle **82** which extends generally centrally along the longitudinal axis of the valve **20.**

As may be seen, the control spindle **82,** at its lower end, extends into an adapter bonnet, or housing, com-

prising the intermediate section of the valve **20.** An adapter bushing **86,** along with an adapter bushing nut **88,** serves to interconnect the air motor section **62** and the intermediate adapter section of the valve. To further insure isolation of a control atmosphere in the lower control section **66** of the air motor section **62,** suitable O-ring seals **89** may be provided.

A third, or body section **90** of the valve provides a conduit indicated generally at **92.** The valve body section **90** is suitably interconnected with the adapter bonnet **84.**

This may be accomplished, as illustrated, through the provision of a flanged, circumferentially extending bottom periphery **94** of the adapter bonnet. This flanged periphery **94** may be interconnected with a complimentary section **96** of the valve body **90** such as by means of bolts and nuts indicated generally at **98.**

Sandwiched between the interconnected sections **94** and **96** about its outer circumferential periphery is a valve diaphragm **100** which functions as the valve proper. The valve spindle or stem **82** is connected to the valve diaphragm **100** in any suitable manner. It will be appreciated that reciprocable movement of the valve stem **82,** controlled by the air motor diaphragm **68,** results in opening and/or closing movement of the diaphragm valve **100.**

In its lower or closed position, the diaphragm valve **100** is seated, at a zone indicated at **100***a*, and blocks communication between upstream and downstream sections, **92***a* and **92***b*, of the valve body conduit **92.** Upward movement of the valve stem **82** raises the diaphragm **100** and permits the sections **92***a* and **92***b* of the valve body conduit **92** to communicate.

Of course, the valve body **90** is interposed in the vacuum line conduit **22** so that one section **92***a* of the valve body conduit functions as an extension of the lead section **22***a* of the vacuum line conduit **22.** The other section **92***b* of the valve body conduit functions as a lead section of the remainder of the vacuum line conduit **22.**

At this point, it may be noted that the lower end of the sliding stem **82** projecting into the adapter bonnet **84** is coupled to a compressor element **102.** This compressor element is pinned to the stem as indicated at **104.** A stop collar **106** adjacent the compressor **102** serves to limit upward movement of the valve diaphragm **100.** At the same time, a finger plate **107** overlies the diaphragm **100.**

In a manner hereinafter more fully described, a chamber **108** defined by the adapter bonnet housing **84** and the diaphragm **100** may function as an auxiliary control chamber according to the present invention.

It will be appreciated by those skilled in the art that gas pressure differential valves other than the type previously described may be incorporated as the vacuum operated valve employed according to the present invention. In any case, however, the present invention envisions vacuum control of the vacuum valve **20.**

To this end, the control zone of the vacuum valve **20** is controllable by the low pressure reservoir **40** for opening the vacuum valve. This is accomplished through the provision of a negative pressure control conduit means as viewed schematically in FIG. **1.** This negative pressure control conduit means includes an outlet circuit **110** from the low pressure reservoir **40.**

Through a control valve **114,** hereinafter more fully described, the low pressure reservoir outlet conduit **110** selectively communicates with either the upper chamber **64** or the lower chamber **66** constituting the control zone of the vacuum valve **20.** It will be appreciated that the control valve **114** is provided with two inlets **116** and **118.**

One of these inlets **116** is in continuous communication with the low pressure reservoir outlet conduit **110,** whereby a constant source of vacuum is available at that control valve inlet **116.**

The other control valve inlet **118** is in continuous communication with a positive pressure vent conduit **120,** whereby a continuous source of positive pressure is available at that control valve inlet **118.** In the preferred embodiment, the positive pressure vent conduit **120** is constituted by a continuous vent to the atmosphere within the local receptacle.

By means of the previously identified vent valve **30,** this atmosphere is at least at a pressure equal to the ambient pressure surrounding the collecting tank **16.** However, when sewage enters the collecting tank **16,** an increased pressure may be provided in the vent conduit **120** insofar as the entering sewage compresses existing air in the collecting tank **16** by reason of the one way nature of the vent valve **30.**

The control valve **114** is also provided with two outlet openings **122** and **124.** Respectively connected to these outlet openings **122** and **124,** such as by means of suitable bulk head unions **125,** are first and second control valve outlet conduit means **126** and **128.** As indicated at **130,** the first of these outlet conduit means **126** is in continuous communication with the upper control chamber **64** of the vacuum valve **20.** Similarly, the other outlet conduit means **128** is in continuous communication with the lower control chamber **66** as indicated at **132.** (See also FIG. **2.**)

If desired, a branch of the first control valve outlet conduit means **126** may be also placed in continuous communication with the previously identified auxiliary control chamber **108** within the valve bonnet. This communication is indicated generally at **134.** (See also FIG. **2.**) As will be appreciated, in this fashion the auxiliary control chamber **108** is subjected to a substantially identical pressure as that to which the upper control chamber **64** is subjected.

In the illustrated system, one of the control chambers **64** and **66** is always subjected to a negative pressure. The other of the control chambers is subjected to a positive pressure. In other words, positive and negative pressure alternate between the control chambers **64** and **66.** With a negative pressure existing in the upper chamber **64** (and thus with a positive pressure existing in the lower chamber **66**), the air motor diaphragm **68** (FIG. **2**) is raised thereby causing the valve diaphragm **100** to move to a valve open position. Conversely, with a negative pressure existing in the lower control chamber **66** and a positive pressure in the upper chamber **64,** the valve diaphragm **100** is maintained in a valve closed position. The pressure in the auxiliary chamber **108** aids in the maintenance of the valve diaphragm **100** in either the open or closed position.

The control valve **114** may be considered to be a cross-over valve insofar as it establishes alternatively communication between the inlet openings **116** and **118** and the outlet openings **122** and **124,** depending upon the presence of an electrical control signal. Ad-

vantageously, the valve has no neutral position so that the inlet opening **116** always is in communication with one or the other of the outlet openings **122** and **124.**

From the foregoing it will be appreciated that a vacuum will always be present in either the upper or lower control chamber **64** and **66.** At the same time, the positive pressure inlet opening **118** is always in communication with the one of the outlet openings **122** and **124** not subjected to vacuum pressure existing at the other inlet opening **116.** Thus, positive pressure always exists in the other of the control chambers **64** and **66.**

With reference to FIGS. **3** and **4,** one preferred form of a control valve **114** that may be employed according to the present invention may be understood. The illustrated valve is of the type commercially available from the Skinner Electric Valve Division of Skinner Precision Industries, Incorporated at New Britain, Conn. as a "4-way normally closed - normally open no neutral position valve, type V-935." It will, however, be appreciated that other valves will suffice.

The illustrated valve **114** is solenoid operated. In FIG. **3A** the valve components are illustrated in their de-energized positions. For convenience, the numerical designations utilized in connection with the schmatic illustration of the valves **114** in FIG. **1,** have been employed in FIGS. **3A** and **3B** and **4.**

For example, the valve vacuum inlet opening is shown at **116** and the valve positive pressure inlet opening is shown at **118.** Similarly, the valve outlet openings are indicated at **122** and **124.**

Each of the valve outlet openings **122** and **124** constitutes a cylinder port. Functionally, valve operation in the system according to the present invention may be summarized as follows. In the illustrated de-energized position of FIG. **3A,** the one cylinder port **122** is closed to the vacuum existing at the valve inlet opening **116.** However, it is open to positive pressure existing at the valve inlet opening **118.** Conversely, the other cylinder port **124** is open to the vacuum existing at the inlet port **116,** while it is closed to the positive pressure existing at the inlet port **118.** In this fashion the vacuum valve **20** is maintained in a closed position as previously described.

In the energized position, the reverse of the previously established communication network is established. In other words, the vacuum inlet port **116** communicates with the cylinder port **122** while the positive inlet port **118** communicates with the other cylinder port **124,** to maintain the valve in an open position.

It may be here mentioned that since the de-energized condition of the solenoid operated control valve **114** establishes a closed position of the vacuum valve **20,** the vacuum valve **20** may be considered to be a normally closed valve not withstanding the fact that the control valve **114** has no neutral position. As will be appreciated, even if vacuum were lost from the vacuum storage tank, or for some reason insufficient vacuum existed in the vacuum storage tank, the vacuum valve **20** would not open since, at a minimum, positive pressure would exist in the upper control chambers **64** (as well as in the auxiliary control chamber **108** if employed).

The control valve **114** includes two coils **136** and **138.** These coils respectively surround plungers **140** and **142.**

Each of the plungers **140** and **142** cooperates with an orifice seat **144** and **146,** at one end, and with a stop member **148** and **150** at the other end. The stop members **148** and **150** are provided with orifices **152** and **154** which in turn may be sealed by soft synthetic inserts **156** and **158** in the adjacent ends of the plungers. Springs **160** and **162** normally bias, together with fluid pressure, the plungers **140** and **142** into sealed relationship with the orifice seats **144** and **146** when the valve is de-energized.

Thus, in the de-energized valve posture of FIG. **3A,** the vacuum existing at the inlet port **116** is blocked from the valve outlet port **122** by reason of the seal at the valve orifice seat **144.** Similarly, the positive pressure at the inlet port **118** is blocked from the valve outlet port **124** by reason of the seal at the orifice seat **146.**

At the same time, vacuum is transmitted to the outlet port **124** through a vacuum passageway **164,** the stop member orifice **154,** and around the plunger **142** to a zone **166** communicating with the outlet port. This zone **166,** is, of course, sealed from the positive pressure at the inlet port **118** by reason of the seal at the orifice seat **146** blocking the positive pressure passageway **168.**

However, positive pressure in the passageway **168** is at the same time, transmitted to the other outlet port **122,** through the stop member orifice **152,** around the plunger **140,** to zone **170** communicating with the outlet port **122.** That zone **170** is, of course, sealed from the vacuum at the inlet port **116** by reason of the seal at the orifice seat **144.**

Upon energization of the coils **136** and **138,** the orifice seats **144** become unsealed by "lifting" of the plungers **140** and **142.** Similarly, the stop member orifices **152** and **154** become sealed by the synthetic inserts **156** and **158.** Thus, the vacuum passageway **164** communicates, through the orifice seat **144,** with the zone **170** while being blocked from the zone **166;** but the positive pressure passageway communicates, through the orifice seat **146** with the zone **166** while being blocked from the zone **170.** In this manner, the vacuum valve **20** is opened.

It will be appreciated that the current supply to the coils **136** and **138,** which cause movement of the plungers **140** and **142,** may be supplied through solenoid wiring indicated at **172** in FIG. **1.**

The solenoid wiring in turn extends from a connector **174** at a control panel **176.** Also extending from the control panel connector **176** is a power cable **178** and a communication cable **180** as indicated schematically in FIG. **1.**

The power cable supplies the basic power utilizable for energizing, through the solenoid wiring **172,** the control valve **114** in order to establish opening of the vacuum valve **20.** As previously noted, in the de-energized position of the control valve **114,** the vacuum valve **20** will be maintained in a closed position. Thus, even if power fails, automatic closing of the vacuum valve results thereby maintaining the possibility of a loss of vacuum.

Moreover, since the vacuum valve **20** is vacuum operated through the control of the solenoid actuated control valve **114,** comparatively minimal power requirements are established for opening of the vacuum valve. Therefore, it is possible to eliminate a requirement of a previous system that a local transformer be employed to provide power for opening of the vacuum valve **20** associated with the local receptacles **16.**

The present invention envisions running the power cable **178** from each control panel **176** at each local receptacle or collecting tank **16** to a common control station (not shown). Considerable lengths of power cable **178** may be economically employed insofar as comparatively minimal power is required for operating the control valve **114.**

At the same time, related advantages may be realized according to the present invention. For example, the communication or signal cable **180,** which may also run from each of the local control panels **176** to a common station (not shown) in a common trench with the power cable **178,** is subject to induction interference. Such interference is minimized through using a low voltage, direct current power source at the common station. For example, the electrical power used at the control panels **176** may be 24 volts d.c. and supplied by the power cable **178.** Such a power source would suffice for the minimal power required for operation of the control valve **114,** so that the power cable **178** may supply the total power requirements for energizing the solenoids in the control valve **114** in order to establish opening of the vacuum valve **20;** at the same time, any problem of the power cable **178** interfering with the communication cable **180,** through induction, is substantially obviated.

The signal cable **180** laid in the same trench which runs from the local control panels **176** to a common control station (not shown) may be employed to transmit a signal to cause opening of the vacuum valve **20** as a result of a switch actuation at the central station. This transmission may also be accomplished through using a low voltage, direct current power source at the common station. Additionally, signals from the local control panels **176** indicating whether or not the associated vacuum valve **20** is fully closed, are desirably sent to the common central station. These signals are similarly of a low voltage, direct current type.

When the types of low voltage, direct current signals noted above are employed, elimination of interference problems caused by alternating voltage is accomplished particularly at voltage and current levels which would be necessary if amounts of electrical power adequate to operate the vacuum valve **20** through an electric motor were transmitted through the required length of power cable **178.**

As earlier noted, the vacuum valve **20** may be opened in several ways, i.e., upon sensing of a predetermined volume collected in the local receptable **16,** on a time basis, and/or on an operator initiated basis. Suitable circuitry for accomplishing opening of the vacuum valve according to these techniques is more fully set forth in the previously identified patent applications. Since the control panels **176** may be of the type illustrated and described therein, they need only be briefly described herein. At this juncture it need only be noted that a suitable volume sensing means **182** including a level sensing device **138** is provided in the local receptacle **16** for the purpose of initiating opening of the vacuum valve **20** on the basis of the level of collected sewage.

The control signal to actuate the control valve **114** and thus open the vacuum valve **20** can be generated in response to the level of sewage in collecting zone tank **16,** as detected by the level sensing device **183** or by signals derived by manually or clock operated switches through the communication cable **180.**

It should also be noted that a vacuum sensing means **184** may be provided at the control panel **176** for the purpose of sensing pressure in the vacuum line conduit **22.** The general function of the vacuum sensor means **184** is also more fully described in the aforementioned patent applications. In this connection, according to the present invention, a conduit **186** extends from the vacuum sensor **184** into communication with the intermediate section **42***c* of the vacuum tap conduit means **42,** as indicated generally at **188.** The zone **188** of communication is, of course, downstream of the isolating check valve **50** whereby the vacuum sensor means **184** communicates with the vacuum line conduit **22,** through the vacuum tap conduit means **42,** at the previously identified zone **46.** Thus, as will be appreciated, the vacuum tap conduit means **42** performs the dual functions of providing a low pressure in the reservoir **40** and at the same time forming a portion of the vacuum sensing system.

Upon sensing of a predetermined pressure in the vacuum line conduit **22,** representative of a substantial loss of vacuum which makes it undesirable to initiate withdrawal of sewage from the receptacle **16** by opening the vacuum valve **20,** the vacuum sensor **184,** through the connector **174,** inhibits the generation of the signal which would otherwise cause energization of the solenoid of the control valve **114.**

A limit switch **189** located adjacent the vacuum valve **20** may be employed to sense the fully closed condition of the vacuum valve **20.** If the vacuum valve **20** is not fully closed, a signal is caused to be sent through the communication cable **180** to the central control station thereby producing an indication that the valve **20** is not closed.

With reference to FIGS. **5A** and **5B,** a somewhat more detailed view of portions of a preferred system according to the present invention may be seen.

The local receptacle **16** may include a concrete collecting tank **192** buried beneath the ground, the grade of which is indicated at **194.** The concrete tank **192** has a bottom wall **193,** upstanding side walls **195,** and is preferably provided with a generally circular access indicated at **196.** Adjacent this access opening, the tank **192** is provided with a generally circumferentially extending recessed surface **198** defining a support surface.

Resting on the support surface **198** and extending generally radially inwardly of the axis opening **196** at generally diametrically opposed positions are two shoulder supports **200** which may be two pieces of plywood, each having a generally sector-like configuration with generally circular outer edges and the inner facing edges spaced apart sufficiently to allow a person to enter tank **192.** A generally cylindrical concrete access ring **202** is located on top of the support shoulder supports **200.** This access ring **202** functions to maintain or anchor the shoulder supports **200** in position and is itself fixed in place on the top wall of the concrete tank **192** by fitting in the recess at the support surface **198.** Also, the ring **202** is surrounded by a concrete grout seal **204** around the lower end of the access ring **200.** The upper end of the access ring is closed by a removable concrete cover **206** which may be provided with the previously noted vent valve **30.**

Resting on and freely supported by the support shoulders **200** is a generally circular base support member **208** of a material such as a plywood. The previously

identified vacuum reservoir tank **40** is suitably supported on the underside of the base support member **208** such as by means of straps **210** bolted to the base **208**, as indicated at **212**.

With continued reference to FIGS. **5A**, it may be seen that the electrical control panel **176** is supported on the upper side of the base support **208**. This electrical control panel or box contains the relays and other electrical circuitry that is provided at the sewage collection region. The control panel is mounted on an elevated support composed of generally parallel wooden members **214** secured to the base **208**. The supported control panel **176** may be surrounded by an open bottomed plastic housing **216** resting on the support base **208** to provide added protection against the elements to the electrical circuit components. The upper surface of the plastic housing **216** is immediately adjacent the lower surface of the cover **206**. In the event of an overflow in the tank, the housing **216** serves as a diving bell in preventing the liquid from rising inside the housing sufficiently to damage the electrical circuit and vacuum components in the control panel **176**.

A suitable opening **218** may be provided around the bottom of the housing **216** for allowing passage of the various conduits and cables connected to the control panel **176**. It will also be appreciated that suitable openings are provided in the plywood base **208** to permit passage of the various conduits and cables from the interior of the tank **192** into the upper dome area which contains the valves and other control elements which may require repair or replacement from time to time.

All conduits and cables extend from the local receptacle **16** through the side wall of concrete tank **192**. At the same time, elements to which access may be desired for maintenance purposes are all located in the upper dome area surrounded by the concrete access ring **202**. Access to that area is through removal of the cover **206**, which is above grade.

With reference also to FIG. **1**, wherein the numerical designations associated with FIG. **5A** are employed in connection with the schematic depictions of the corresponding elements, it will be seen that the access zone provides access to the control valve **114**, the control panel **176**, the gate valve **52**, and the check valve **50** in the intermediate section **42c** of the vacuum tap conduit means, as well as the removable closures **54** and **60** respectively associated with the vacuum tap conduit means **42** and the clean-out line **56**.

As best shown in FIG. **5A**, a plurality of pipes and conduits pass through the side wall just below the upper wall of the tank **192**. A section of 2 inch pipe **22*a*** serving as an extension of the vacuum line conduit **22** passes through the side wall and is connected to a vertically extending pipe **22*b*** which may be up to about 5 feet long. A separate section of ½ inch pipe, which is part of the clean-out line **56**, also passes through the side wall of tank **192** at approximately the same elevation. A section of ½ inch pipe (not shown), which is part of the vacuum tap conduit means **42**, passes through the tank wall at the same elevation as the pipe **56** and on the other side of pipe **22*a***. A further 1 inch pipe **222** is provided at a slightly lower elevation for passing the electrical wires and vacuum tubing through the side wall of tank **192**. A jacket **224** of plastic materials on the outer end of pipe **222** is heat shrunk to provide a moisture seal. The 1 inch pipe **222** provides a passageway for the power cable **178**, the communications cable **180**, the limit switch signal cable **190**, which goes to limit switch **189** on the vacuum valve **20** (see FIG. **1**), and the control conduits **126** and **128** leading from the control valve **114** to the chambers **64** and **66** in the vacuum valve **20**.

Referring now also to FIG. **5B**, a detailed view of valve **20** and that part of the system in the region of the sewage collecting zone **16** but which is physically separate from tank **192**, is illustrated. The principal component is the vacuum valve **20** which is normally closed to provide the vacuum tight seal which is essential in order that a vacuum can be maintained in the vacuum line conduit **22**. Failure of this seal compels that the valve be repaired or replaced in order that the proper vacuum can be maintained at the vacuum receiver tank **24**.

As may be seen in FIG. **5B**, the vacuum valve **20** is located beneath the ground **194** sufficiently far to avoid freezing and preferably is encased in a suitable protective enclosure **228**, such as a bottomless plastic container. The enclosure is provided with a suitable access cover **230** that can be removed when the soil on the cover has been taken away.

Also within the enclosure are the zones **46** and **58** of communication of the vacuum line conduit means **22** to the vacuum tap conduit means **42** and the clean-out conduit **56**, respectively.

The vacuum valve **20** is supported at an elevation relative to the elevation of tank **192** that is determined by the substantially horizontal, rigid pipe section **22*a***. The fitting at the zone **58** which extends from the upstream side of the vacuum valve **20** is provided with a nipple which extends into one side of union coupling **231**. The threaded end of the pipe **22*a*** extends into the other side of union coupling **231**. When providing a support beneath the vacuum valve **20**, it is advantageous to maintain the valve at a sufficiently high elevation so that pipe **22*a*** will drain back into tank **192** to thereby avoid leakage of sewage when the union coupling **231** is taken apart. Pipe sections **22*a*** and **22*b*** together serve as a drainable section of the vacuum line conduit means **22**. Similarly, the substantially horizontal pipe section of the vacuum line **22** extending from the fitting at the zone **46**, which is at the downstream side of the vacuum valve **20**, toward the check valve **44**, may be sloped so as to drain away from the vacuum valve **20**.

At the bottom of pipe section **22b**, which is near the bottom **193** of the tank **192**, a plurality of inlet openings **22*c*** are provided in an elbow type fitting. The inlet openings **22*c*** are circumferentially spaced from one another. The elbow fitting provides a 90° bend so as to prevent the introduction of long, ridid objects unable to negotiate the bend into the pipe section leading to vacuum valve **20**, where they may lodge. Several openings **22*c*** are preferred so that in the event one inlet opening **22*c*** becomes clogged, the remaining inlet openings will permit the removal of sewage from the tank **192**.

The generally vertical pipe section **22*b*** supports in any suitable manner, such as by means of a threaded stud **234**, the liquid level sensing device **182** including the sensing bell **183**. The level sensing device **182** is located near the bottom of the tank **192** to service as a means for determining when the valve **20** should open and close. Also, it is important in connection with preventing false indications that sensing bell **183** be laterally spaced from inlets **22*b*** by a distance sufficient to

avoid the effects of flow velocity on the sensing device.

With renewed reference to FIG. 5B, it may be seen that the cross-sectional area of the vacuum tap conduit means **42** is less than that of the portion of the vacuum line conduit **22** at the communication zone **46.** Thus, even though a low pressure exists in both the vacuum tap conduit means **42** and the vacuum line conduit **22,** after the vacuum valve **20** is opened, the possibility of sewage being diverted into the vacuum tap conduit means **42** is minimized by means of the small cross-sectional area.

At any rate, any increases in the pressure in the vacuum tap conduit means **42** are isolated from the low pressure reservoir **40** by the isolating check valve **50** as earlier noted. In this fashion, the reservoir **40** provides a source of low pressure continuously available to cause opening of the vacuum valve upon energization of the solenoid valve **14.**

It will, of course, be appreciated that the reservoir volume is sufficiently large relative to the volume of control chambers in the vacuum valve to effect alternate opening and closing of the vacuum several times even if the low pressure of the reservoir cannot be replenished by reason of an increased pressure condition in the vacuum tap conduit means, and that the vacuum valve is maintained open for the required time period during which sewage is drawn from the collecting region.

Although the invention has been described with reference to particular preferred forms thereof, it will be appreciated by those skilled in the art that additions, substitutions, modifications and deletions may be made without departing from the spirit and scope of the invention as defined in the appended claims.

What is claimed is:

1. In a system for conveying sewage by vacuum induced flow and including: a sewage collection zone; a source of vacuum remote from the collection zone for conveying the sewage; vacuum line conduit means for intermittently providing communication between said collection zone and the source of vacuum; and vacuum valve means intermittently maintainable in an open position to permit passage of sewage from the collection zone into the vacuum line conduit means, in a downstream direction toward the source of vacuum; the improvement comprising:

a low pressure reservoir;

a central zone in said vacuum valve means controllable by low pressure for opening said vacuum valve means;

vacuum tap conduit means communicable with said vacuum line conduit means at a vacuum line conduit means location downstream of said vacuum valve means and communicable with said low pressure reservoir;

pressure control conduit means, selectively providing essentially closed fluid circuit communication between at least said low pressure reservoir and at least a portion of said control zones to open said vacuum valve means; and

low pressure control means for maintaining said low pressure reservoir in a low pressure condition in the presence of increased pressure in said vacuum line conduit means.

2. The improvement according to claim **1** wherein said low pressure control means comprises:

isolating valve means for responsively isolating said low pressure reservoir from a portion of said vacuum tap conduit means to prevent increases in pressure of said reservoir.

3. The improvement according to claim **2** wherein:

said pressure control conduit means selectively provides communication between a positive pressure zone and at least a portion of said control zone in said vacuum valve means.

4. The improvement according to claim **3** and further including:

control valve means for controlling alternate communication of said low pressure reservoir and said positive pressure zone with alternate portions of said control zone in said vacuum valve means through said pressure control conduit means.

5. The improvement according to claim **4** wherein:

said control valve means includes:

first and second inlet ports, and

first and second outlet ports,

said pressure control conduit means including:

low pressure reservoir outlet conduit means extending from said low pressure reservoir to said first inlet port,

first control valve outlet conduit means extending from said first outlet port to said control zone,

positive pressure vent conduit means extending from a positive pressure zone to said second inlet port, and

second control valve outlet conduit means extending from said second outlet port to said control zone.

6. The improvement according to claim **5** wherein:

said vacuum valve means comprises a differential area diaphragm means and housing means establishing first and second chambers comprising said control zone;

said first chamber being in direct continuous communication with said first control valve outlet conduit means; and

said second chamber being in direct continuous communication with said second control valve outlet conduit means.

7. The improvement according to claim **6** wherein:

said control zone further comprises a third chamber defined by further diaphragm means and housing means;

said third chamber being in direct continuous communication with said second control valve outlet conduit means.

8. The improvement according to claim **7** wherein:

said isolating valve means comprises a pressure responsive movable isolating valve member in said vacuum tap conduit means for maintaining said low pressure zone at a low pressure.

9. The improvement according to claim **8** and further including:

manually operable valve means for uncoupling said low pressure reservoir from said vacuum line conduit means.

10. The improvement according to claim **9** and further including:

vacuum sensor means, communicating with said vacuum tap conduit means, for effecting an overriding control valve means condition to prevent opening of said vacuum valve means upon sensing of a pre-

determined abnormal pressure in said vacuum line conduit means.

11. The improvement according to claim **10** and further including:

cleanout conduit means communicable with said vacuum line conduit means through said vacuum valve means.

12. The improvement according to claim **10** wherein:

said vacuum tap conduit means is provided with normally closed inlet means interposed between said isolating valve means and the zone of communication with said vacuum line conduit means.

13. The improvement according to claim **2** wherein:

said isolating valve means comprises a pressure responsive valve means in said vacuum tap conduit means and providing for evacuation of said low pressure reservoir means and for isolation of said low pressure reservoir means against pressure increases in said vacuum tap conduit means.

14. The improvement according to claim **1** and further including:

vacuum sensor means communicating with said vacuum tap conduit means for monitoring said control valve means to selectively prevent opening of said vacuum valve means.

15. The improvement according to claim **1** wherein said vacuum valve comprises

a diaphragm establishing first and second chambers defining said control zone; and

an auxiliary chamber communicating with one of said first and second chambers.

16. The improvement according to claim **1** including:

cleanout conduit means communicable with said vacuum line conduit means through said vacuum valve means.

17. The improvement according to claim **2** wherein:

said vacuum tap conduit means is provided with normally closed inlet means interposed between said isolating valve means and the zone of communication with said vacuum line conduit means.

18. In a system for conveying sewage and including: a sewage collection region, having a volume large relative to the rate of production of sewage at a source thereof for accumulating sewage therein over a period of time; collecting line conduit means for conveying sewage from the source to the collection region; a vacuum receiver tank located in a position remote from the collection region; and means for conveying sewage from the collection region to the vacuum receiver tank by vacuum induced flow, said means for conveying comprising: vacuum line conduit means for intermittently providing communication between the collection region and the vacuum receiver tank, and vacuum valve means intermittently maintainable in an open position for a period of time sufficient to permit the drawing of sewage from the collection region through the vacuum line conduit means in a downstream direction toward the vacuum receiver tank; the improvement comprising:

a control zone portion of said vacuum valve means controllable by negative and positive pressure for respectively placing said vacuum valve means in open and closed positions;

a vacuum storage tank;

vacuum tap conduit means, communicable said vacuum line conduit means downstream of said vacuum valve means and communicable with said vacuum storage tank, for providing a low pressure zone in said vacuum storage tank;

isolating valve means for responsively isolating said vacuum storage tank from a portion of said vacuum tap conduit means to prevent increases in the pressure of said storage tank;

first pressure control conduit means, selectively providing essentially closed fluid circuit communication between said vacuum storage tank and at least a part of said control zone portion of said vacuum valve means, for maintaining said vacuum valve means in said open position;

second pressure control conduit means, selectively providing communication between a positive pressure zone and said control zone portion of said vacuum valve means, for maintaining said vacuum valve means in said closed position; and

control valve means for selectively placing said first pressure control conduit means and said second pressure control conduit means in communication with said control zone portion of said vacuum valve means.

19. In a method for conveying sewage by vacuum induced flow and including the step of: collecting sewage at a sewage collection zone and conveying collected sewage through a vacuum line conduit means toward a source of vacuum remote from the collecting zone by intermittently providing communication between the collection zone and the source of vacuum through intermittently maintaining a vacuum valve means in an open position to permit passage of sewage from the collection zone in a downstream direction into the vacuum line conduit means; the improvement comprising:

creating a low pressure reservoir by vacuum tap conduit means communicable with the vacuum line conduit means downstream of said vacuum valve means;

maintaining said low pressure reservoir in a low pressure condition in the presence of increased pressure in the vacuum line conduit means; and

selectively providing essentially closed fluid circuit communication between said low pressure reservoir and a control zone in the vacuum valve means to open said vacuum valve means.

20. In a system for conveying sewage by vacuum induced flow and including: a sewage collection range; a source of vacuum remote from the collection zone for conveying the sewage; vacuum line conduit means for intermittently providing communication between said collection zone and the source of vacuum; and vacuum valve means intermittently maintainable in an open position to permit passage of sewage from the collection zone into the vacuum line conduit means, toward the source of vacuum; the improvement comprising:

a low pressure reservoir;

a control zone in said vacuum valve means controllable by low pressure for opening said vacuum valve means;

vacuum tap conduit means communicable with said low pressure reservoir and said vacuum line conduit means;

pressure control conduit means, selectively providing communication between at least said low pressure reservoir and said control zone to open said vacuum valve means;

isolating valve means for responsively isolating said low pressure reservoir from a portion of said vac-

uum tap conduit means to prevent increases in pressure of said reservoir; and

manually operable valve means for uncoupling said low pressure reservoir from said vacuum line conduit means.

21. In a system for conveying sewage by vacuum induced flow and including: a sewage collection zone; a source of vacuum remote from the collection zone for conveying the sewage; vacuum line conduit means for imtermittently providing communication between said collection zone and the source of vacuum; and vacuum valve means intermittently maintainable in an open position to permit passage of sewage from the collection zone into the vacuum line conduit means, toward the source of vacuum; the improvement comprising:

a low pressure reservoir;

a control zone in said vacuum valve means controllable by low pressure for opening said vacuum valve means;

vacuum tap conduit means communicable with said low pressure reservoir and said vacuum line conduit means;

pressure control conduit means, selectively providing communication between at least said low pressure reservoir and said control zone to open said vacuum valve means; and

vacuum sensor means communicating with said vacuum tap conduit means for monitoring control valve means to selectively prevent opening of said vacuum valve means.

22. In a system for conveying sewage by vacuum induced flow and including: a sewage collection zone; a source of vacuum remote from the collection zone for conveying the sewage; vacuum line conduit means for intermittently providing communication between said collection zone and the source of vacuum; and vacuum valve means intermittently maintainable in an open position to permit passage of sewage from the collection zone into the vacuum line conduit means, toward the source of vacuum, the improvement comprising:

a low pressure reservoir;

a control zone in said vacuum valve means controllable by low pressure for opening said vacuum valve means;

vacuum tap conduit means communicable with said low pressure reservoir and said vacuum line conduit means;

pressure control conduit means, selectively providing communication between at least said low pressure reservoir and said control zone to open said vacuum valve means;

said sewage collection zone constituting an underground tank having a bottom, side, and top walls and said tank having an opening in the top wall of a size sufficient to permit access by a person to the interior of said tank;

cover means for said opening including a cylindrical access ring having its lower end supported by said top wall and a liftable cover on the upper end of said access ring;

support means extending across said top wall opening at the lower end of said access ring; and

means attaching said reservoir to said support means.

23. The improvement as defined in claim **22** wherein said support means comprises a pair of members each having a generally circular outer edge which extends between the top tank wall and the lower end of said access ring and facing edges which are spaced apart sufficiently far to permit access of a person through said space, and base support sheet freely mounted on the upper surfaces of said pair of members, and wherein said attaching means is secured to the under surface of said base support sheet to thereby hold said reservoir in the space inside said tank.

24. The improvement as defined in claim **23** further comprising an electrical control housing including electrical conductor cables connected thereto for controlling the opening and closing of said vacuum valve means, said electrical control housing being supported by the upper surface of said base support sheet, and an inverted gas tight container mounted on said base support sheet to enclose said electrical control housing, said container having an upper surface adapted to engage the undersurface of the liftable cover to thus be maintained in a position to serve as a diving bell to prevent flooding of said control housing which would otherwise result from an overflow condition in said sewage collection zone tank.

25. In a system for conveying sewage by vacuum induced flow and including: a sewage collection zone; a source of vacuum remote from the collection zone for conveying the sewage; vacuum line conduit means for intermittently providing communication between said collection zone and the source of vacuum; and vacuum valve means intermittently maintainable in an open position to permit passage of sewage from the collection zone into the vacuum line conduit means, toward the source of vacuum; the improvement comprising:

a low pressure reservoir;

a control zone in said vacuum valve means controllable by low pressure for opening said vacuum valve means;

vacuum tap conduit means communicable with said low pressure reservoir and said vacuum line conduit means;

pressure control conduit means, selectively providing communication between at least said low pressure reservoir and said control zone to open said vacuum valve means; and

isolating valve means for responsively isolating said low pressure reservoir from a portion of said vacuum tap conduit means to prevent increases in pressure of said reservoir;

said vacuum tap conduit means being provided with normally closed inlet means interposed between said isolating valve means and the zone of communication with said vacuum line conduit means.

26. The improvement according to claim **25** including:

vacuum sensor means responsive to a pressure condition in said vacuum line conduit means for inhibiting actuation of said control valve means.

27. In a system for conveying sewage and including: a sewage collection region, having a volume large relative to the rate of production of sewage at a source thereof for accumulating sewage therein over a period of time; collecting line conduit means for conveying sewage from the source to the collection region; a vacuum receiver tank located in a position remote from the collection region; and means for conveying sewage from the collection region to the vacuum receiver tank by vacuum induced flow, said means for conveying comprising: vacuum line conduit means for intermittently providing communication between the collection

region and the vacuum receiver tank, and vacuum valve means intermittently maintainable in an open position for a period of time sufficient to permit the drawing of sewage from the collection region through the vacuum line conduit means in a downstream direction toward the vacuum receiver tank; the improvement comprising:

a control zone portion of said vacuum means controllable by negative and positive pressure for respectively placing said vacuum valve means in open and closed positions;

a vacuum storage tank;

vacuum tap conduit means, communicable said vacuum line conduit means downstream of said vacuum valve means and communicable with said vacuum storage tank, for providing a low pressure zone in said vacuum storage tank;

isolating valve means for responsively isolating said vacuum storage tank from a portion of said vacuum tap conduit means to prevent increases in the pressure of said storage tank;

first pressure control conduit means, selectively providing communication between said vacuum storage tank and said control zone portion of said vacuum valve means, for maintaining said vacuum valve means in said open position;

second pressure control conduit means, selectively providing communication between a positive pressure zone and said control zone portion of said vacuum valve means, for maintaining said vacuum valve means in said closed position;

control valve means for selectively placing said first pressure control conduit means and said second pressure control conduit means in communication with said control zone portion of said vacuum valve means; and

said control valve means being actuatable in response to at least one signal derived independently of the pressure condition in said vacuum line conduit means.

28. The improvement according to claim **1** wherein:

said sewage is conveyed by vacuum induced plug flow.

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