United States Patent [19]

Farrell, Jr. et al.

[11] **3,904,131**

[45] **Sept. 9, 1975**

[54] **PRESSURE SEWER SYSTEM**

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[22] Filed: **Oct. 25, 1973**

[21] Appl. No.: **409,716**

[52] **U.S. Cl.** ..... **241/46.02**; 137/568; 241/185 A

[51] **Int. Cl.** **B02c 23/36**

[58] **Field of Search** ..... 241/46.02, 185 A; 137/568; 417/435, 540, 543; 418/49

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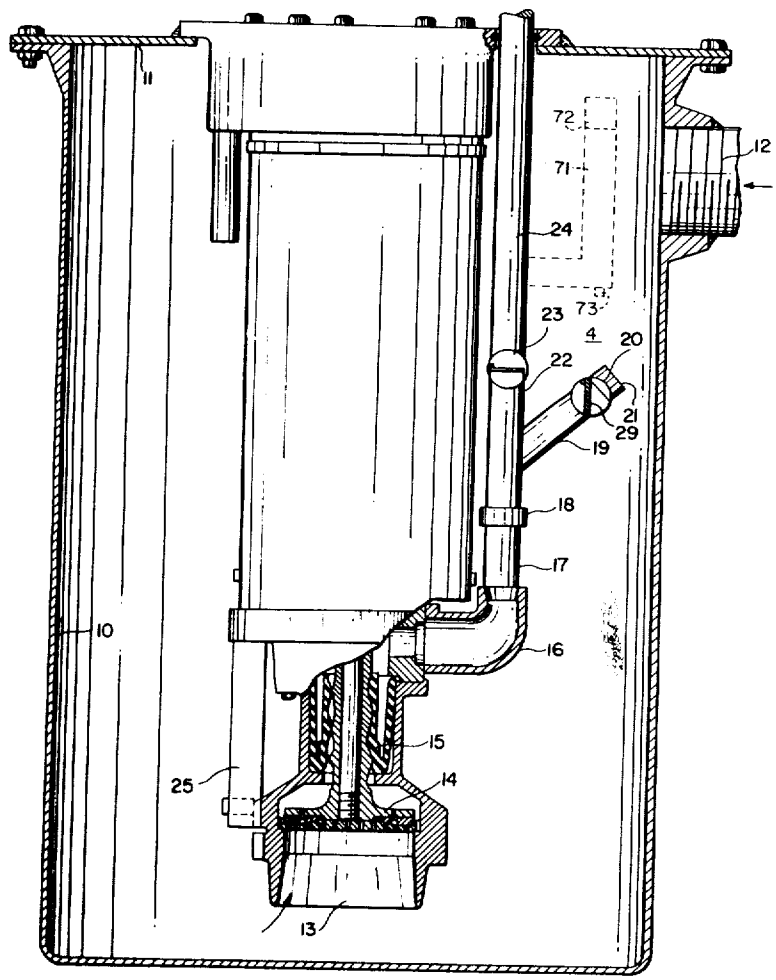
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Attorney, Agent, or Firm—Charles W. Helzer

[57] **ABSTRACT**

A low pressure sewer system is described which employs grinder pumps for a multiplicity of sewage generating sites and which have semi-positive displacement pumping characteristics whereby substantially constant flow (in gallons per minute) output can be produced regardless of the pressure head of the sewage piping distribution main into which the pump discharges. Each grinder pump unit includes its own anti-siphoning protection as well as self-priming characteristics and further includes a redundant check valve in the discharge piping to the low pressure sewage collection main. The low pressure collection main is comprised by small diameter, flexible, non-corroding pipes that need only be buried under the frost line and can follow the contour of the terrain of the community in which the system is installed.

33 Claims, 5 Drawing Figures



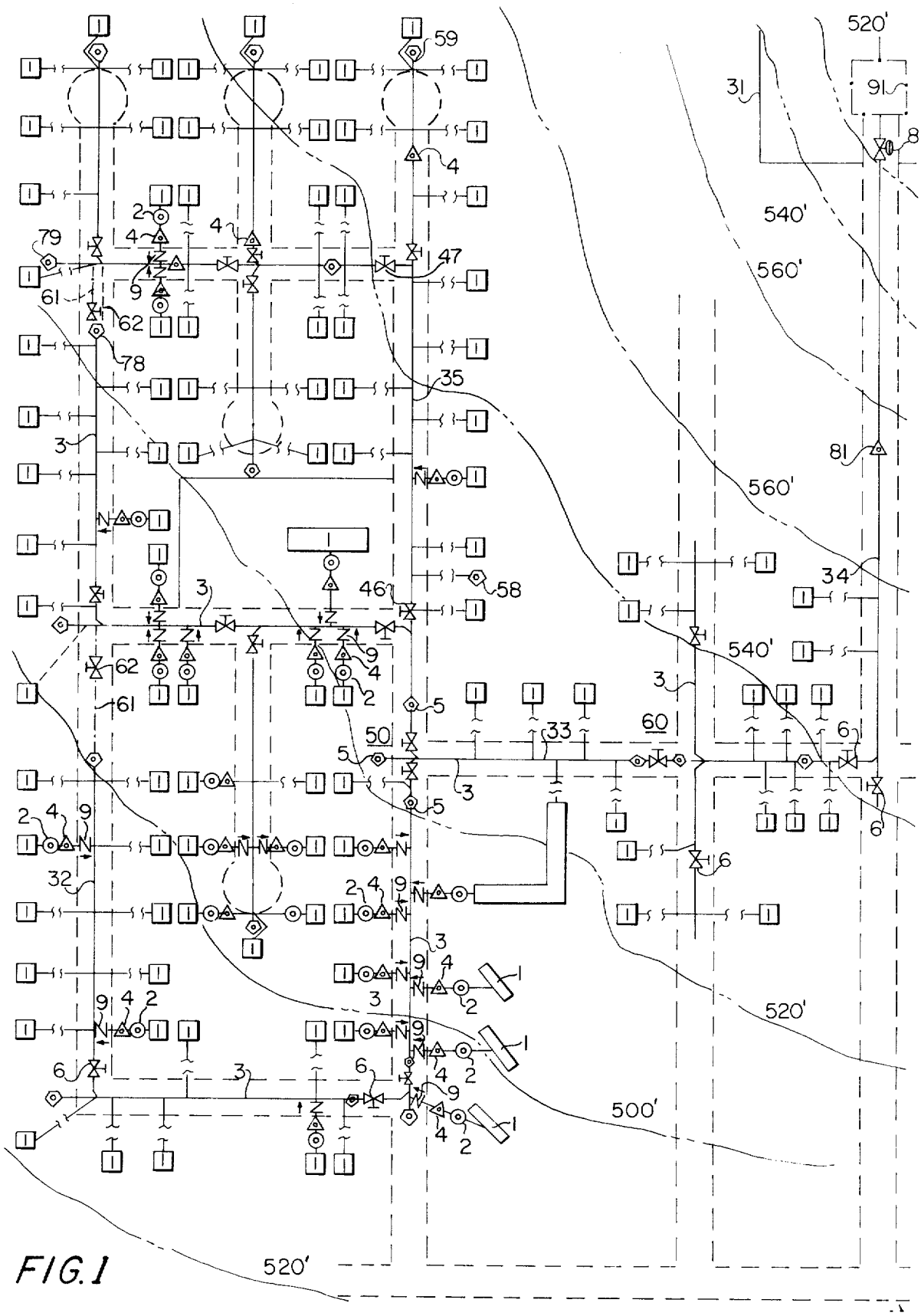

520'
91
31
8
540'
560'
59
4
2
4
4
79
47
9
61
62
78
35
3
81
560'
46
58
34
540'
3
62
61
2
5
50
33
60
6
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3
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6
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2
4
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32
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4
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520'
500'
520'

FIG. 1

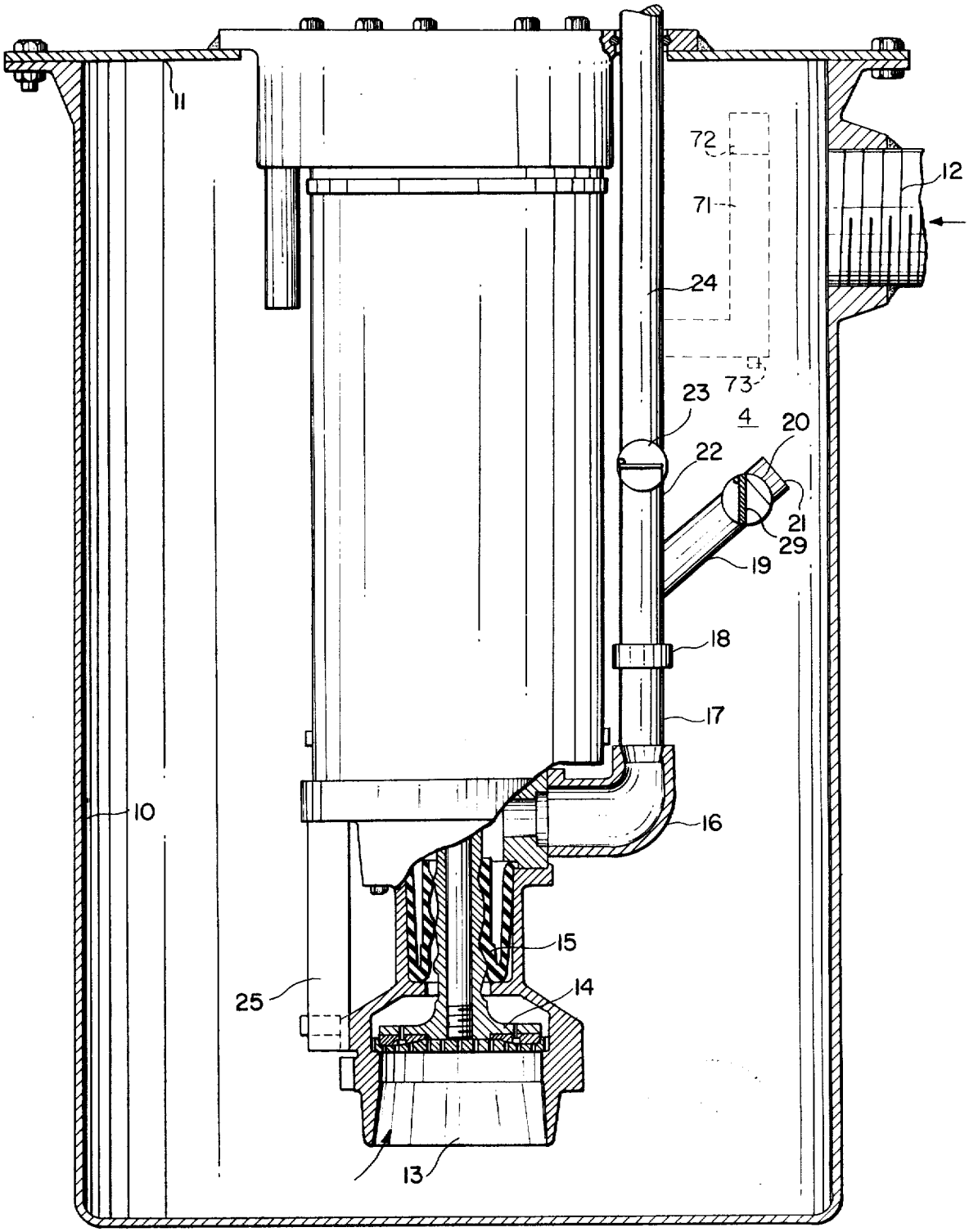


FIG. 2

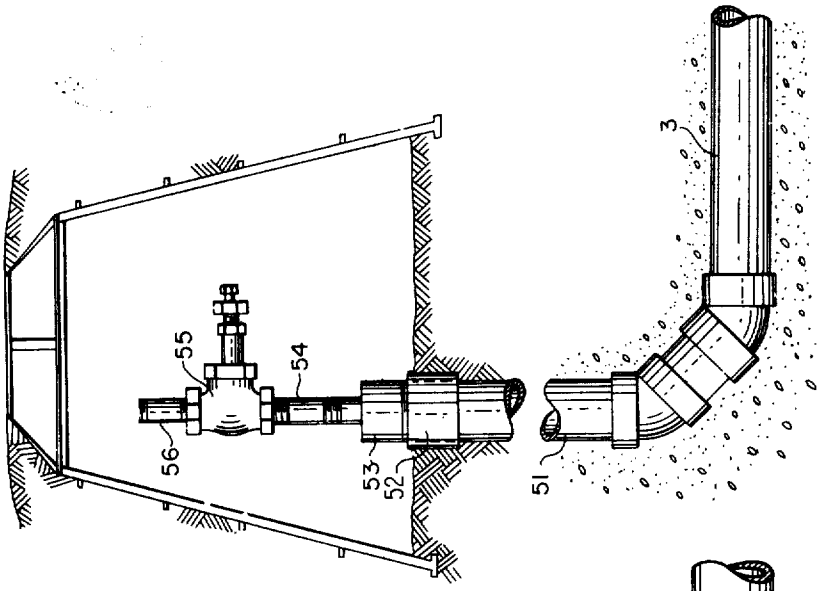


FIG. 5

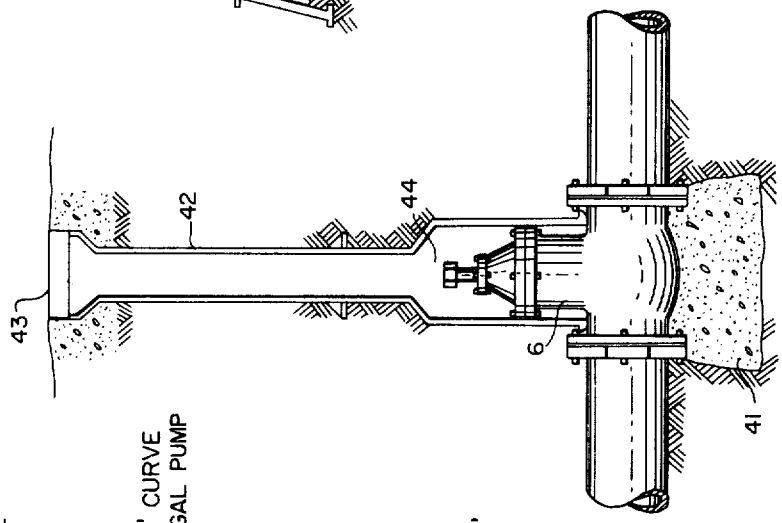


FIG. 4

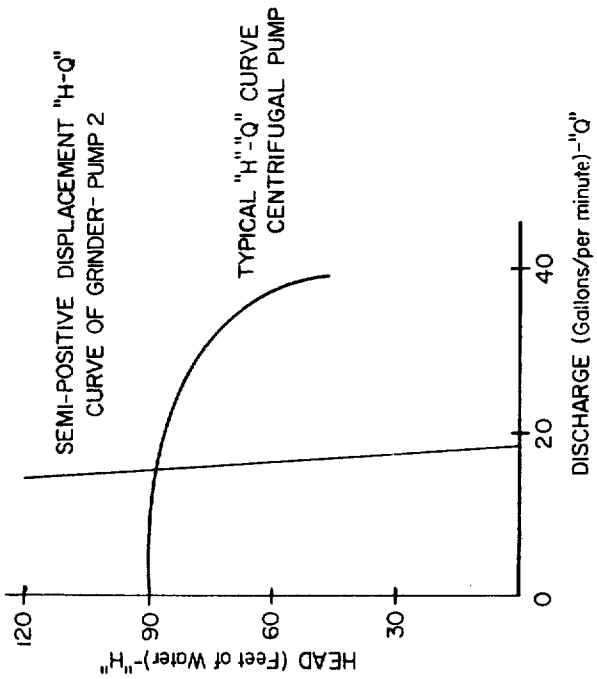


FIG. 3

PRESSURE SEWER SYSTEM

BACKGROUND OF INVENTION

1. Field of Invention

This invention relates to a new and improved low pressure sewer system.

More specifically, the invention relates to a new and improved low pressure sewage system which employs grinder pumps of the type having semi-positive displacement characteristics for each sewage generating site. The grinder pumps first grind and then pump the sewage under pressure through low pressure sewage distribution mains comprised by small diameter, flexible, non-corroding pipes that need only be buried under the frost line and can follow the contour of the terrain of the community in which the low pressure sewer system is installed.

2. Background Problem

Any new home owner or builder who has suffered through the difficulties of voting in a sewer bond issue and subsequently installing and hooking up to the familiar gravity sewer system using known techniques and equipment such as gravity drain pipes, lift stations, ejectors, siphons or vacuum draw, is familiar with the considerable expense and problems which arise in the installation of such known sewer systems. Gravity sewer systems require the cutting of precise grades all leading to a collection point which is below the level of all the sewage generating sites, and where installed in hilly terrain, requires deep cuts that escalate costs. If required, the use of piling and dewatering techniques magnifies the costs and problems encountered. While there are commercially available lift stations, the known lift stations normally use solids handling pumps having flow rates which are unsuitable for servicing individual dwelling sewage sources. The use of ejectors requires external air sources for intermittently emptying the contents of collecting tanks and the use of a siphon requires an outside source of fluid at pressures which dilute the sewage in various amounts depending upon the fluid use and the flow rate. Vacuum systems normally involve all of the installation problems inherent with gravity and further require the use of an external vacuum source having extremely complex control/-monitoring/maintenance problems.

By far the largest number of known sewage systems constitute gravity systems. To possess satisfactory flow and fluid handling capabilities, a gravity system requires the use of large diameter pipe accurately placed and embedded in a continuous downwardly graded trench. This often requires digging of deep trenches in hilly terrain which results in high labor and equipment costs because of the earth removal problems. Safety shoring, piling and bracing, together with restoration of the property after installation, complicates the installation and escalates the cost of gravity sewer systems. Further, if high water tables or rocky terrain are encountered, the costs increase rapidly. Finally, in many systems or sections of systems expensive lift stations must be added to provide force lifting over extreme changes in grade, and the installation of deep manholes for maintenance and the oversizing of treatment facilities to accommodate infiltration of water that normally occurs into gravity systems often making the use of such systems prohibitive in otherwise suitable terrain for the development of residential communities.

Low pressure sewer systems according to the present invention, avoid all of the above complex and expensive installation problems in that such systems employ small diameter, contour-following, flexible, non-corroding piping which can be laid in shallow trenches dug just below the frost line and/or dug sufficiently deep to provide protection for the piping. The piping can be installed in sections having lengths of 40 feet or the like and should be sufficiently flexible so that upon being coupled together, it can follow the contour of the terrain in which the system is installed. Smaller, lighter construction equipment can be used in the installation thereby minimizing to the greatest possible extent the disturbance to natural features such as trees and top soil. Infiltration from high water tables is completely eliminated thus obviating the need for increasing hydraulic handling capacity for treatment facilities above and beyond that previously calculated for the sewage generating sites being serviced.

SUMMARY OF INVENTION

It is, therefore, a primary object of the present invention to provide a new and improved low pressure sewage system which employs grinder pumps of the type having semi-positive displacement characteristics for first grinding and then pumping ground liquid sewage slurry under pressure through low pressure sewage distribution mains comprised by small diameter, non-corroding piping that need only be buried under the frost line and/or buried sufficiently deep to provide protection against damage, and can follow the contour of the terrain of the community in which the low pressure sewage system is installed.

In practicing the invention, a new and improved low pressure sewer system having the above characteristics is provided which employs self-priming, self-scouring grinder pumps having semi-positive displacement characteristics as well as anti-siphoning protection and that automatically correct for any problems that might arise due to vagrant vacuum pockets that are produced or otherwise occur in the low pressure sewage system, and further includes the use of non-clogging redundant check valves installed in each of the sewage generating system branches served by a grinder pump unit for the reduction of start-up transient loads and water hammer.

BRIEF DESCRIPTION OF DRAWINGS

Other objects, features, and many attendant advantages of the present invention will become better understood from a reading of the following detailed description of a preferred embodiment of the invention wherein like parts in each of the several figures of the drawings are identified with the same reference character, and wherein:

FIG. 1 is a schematic, block diagram of a low pressure sewer system constructed in accordance with the teachings of the present invention and which is installed in hilly terrain having elevation characteristics illustrated by the elevation lines traversing the drawing;

FIG. 2 is a cross-sectional view of a preferred grinder pump unit used in the system and having semi-positive pump displacement characteristics for grinding and pumping ground liquid sewage slurry under pressure from each of the houses or sewage generating sites identified in FIG. 1;

FIG. 3 is a pump operating characteristic curve for the grinder pump units illustrated in FIG. 2 and shows a preferred straight-line semi-positive displacement "H-Q" flow versus discharge pressure head operating characteristic curve of such grinder pump units as compared to other types of pumps, for example, centrifugal pumps;

FIG. 4 is a functional sectional view of a suitable division isolation valve installation for use in the low pressure sewage system of FIG. 1; and

FIG. 5 is a schematic cross-sectional view of a combination clean-out, air accumulator, air purging, air relief and system excess pressure release station or installation suitable for use at points indicated in the schematic diagram of FIG. 1.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

FIG. 1 is a schematic block diagram illustrating the lay-out of a typical pressure sewer system in accordance with the invention in a mixed community of residential and commercial buildings located on terrain having the contour indicated by the elevation lines labelled —520'—500'—520'—540'—560'—560'—540'—520' and which represent the actual elevation of the land above sea level at the points indicated. In typical community fashion, the residences and commercial buildings are arrayed along each side of the thoroughfare or street providing access to the residences and buildings. The small squares labelled **1** are considered to be individual family homes while the larger rectangular or "L" shaped buildings are considered to be commercial offices, motels, light manufacturing facilities, schools and the like. Each residence and commercial building, school, etc., is considered to be a sewage generating site and, hence, all have been identified by a reference numeral **1**. Each of the sewage generating sites **1** have toilets, sinks, etc., installed therein in a conventional manner and which are drained through drainage piping by gravity to a grinder pump sewage unit (indicated by reference numeral **2** in FIG. **1** located in the basement of the building. Alternatively, the grinder pump may be located in a manhole outside the building in the event that the building has no basement and in order that the grinder pump unit **2** be at the lowest point of the sewage generating site to insure that all sewage generated in the building drains by gravity into the collection tank of the unit.

FIG. **2** of the drawings is a partial sectional view of a suitable grinder pump unit **2** for use with each of the sewage generating sites **1** and has been described more completely in U.S. Reissue Pat. No. Re28,104, issued Aug. 6, 1974, Richard C. Grace - Inventor; and in co-pending U.S. application Ser. No. 305,712, filed Nov. 13, 1972, Richard C. Grace and Frank Van Luik - Inventors, entitled: ANTI-SIPHON AND PUMP PRIMING FOR SEWAGE GRINDER PUMP, both of which are assigned to the same assignee as the present invention, the Environment/One Corporation of Schenectady, N.Y. For a more detailed description of the construction and operation of the grinder pump unit **2** reference is made to the above-mentioned reissue patent and co-pending U.S. application. However, for the purposes of the present disclosure, the following brief description of a preferred form of the grinder pump unit **2** is believed to be adequate.

The grinder pump unit **2** is comprised by an outer collection tank **10** which may be fiberglass, plastic, cement or some other similar, preferably non-corroding, non-rusting material having a tank top **11** of similar material. Sewage collected in each of the sewage generating sites is transmitted to the collection tank **10** through the inlet pipe **12** which in conventional fashion is vented through a vent pipe to atmosphere (not shown) for the plumbing system of each sewage generating site. Thus, gasses which might accumulate within the tank are vented to the atmosphere directly through the inlet piping connected to the collection tank **10** or through a separate vent. The tank top **11** has a central opening formed therein in which a grinder pump core unit, designated generally by reference numerals **13–29**, is suspended, as described more fully in above-referenced U.S. Reissue Pat. No. Re28,104.

The grinder pump core unit is comprised by a grinder **14** whose suction inlet **13** is designed to be located a short distance above the bottom of the collection tank **10** in a manner such that a swirling motion provided to liquid sewage collected in the tank causes scouring of the bottom of the tank thereby preventing build-up or accumulation of solids on the bottom of the tank. However, the suction inlet **13** is located a sufficient distance above the bottom of the tank to prevent blockage by solids entrained in the sewage collected in the tank. The ground liquid sewage slurry passing through grinder **14** is sucked up and pumped out under pressure by a semi-positive displacement pump shown generally at **15**. Pump **15** comprises a positive helical screw-type pump employing a flexible boot with an internal helical surface arrangement in cooperative working engagement with a rigid shaft having an external helical surface, but of different pitch. The discharge from the helical screw-type pump **15** is directly connected to a discharge passage shown generally at **16**. An outlet pipe shown at **22** is for connecting the discharge passage **16** through a suitable coupling **18** and interconnecting pipe **17** to a first check valve means **23** located at the discharge side of outlet pipe **22** for permitting fluid flow only in the direction from the outlet of the pump through a second outlet conduit **24** to a receiving point (not shown in FIG. **2**) and to prevent backflow of pressurized liquid slurry sewage into the grinder pump unit. A first venting conduit **19** is connected at one end to outlet pipe **22** intermediate the discharge outlet from the pump **15** and the first check valve means **23**. The remaining end of first conduit **19** is freely open to the interior of collection tank **10** which, of course, is vented to atmosphere through the inlet pipe **12**. It is also possible to vent separately the collecting tank **1** through a suitable vent pipe connection (not shown) in a manner well known in the art. A second differentially operable check valve means **29** is mounted within the first conduit for passing gaseous fluids through conduit **19** and for preventing the passage of liquid sewage slurry under pressure from said one end connected to outlet pipe **22** through the open end **21**. The differentially operable check valve means **29** operates to pass gaseous fluids in either direction through the first conduit **19** and hence constitutes both a pump self-priming device as well as an anti-siphoning device as explained more fully in the above-referenced U.S. patent application, Ser. No. 305,712.

As noted above, the entire grinder pump core unit is suspended within coollection tank **10** by a suitable

mounting plate that overlaps a central opening in the tank top **11** and is secured therein by appropriate mounting bolts and nuts. The grinder pump core unit is suspended in a manner such that its suction inlet **13** is located a short distance above the bottom of the tank to provide scouring of the bottom of the tank as noted above. In the event that the grinder pump core unit requires servicing, all that the service man need do is to remove the mounting bolts and nuts and lift the entire core unit out to thereby withdraw it from the tank for ready access, cleaning, inspection and servicing.

In operation, liquid sewage supplied to the collection tank **10** through the inlet pipe **12** will rise to a certain critical level where a level sensing electrical switch operatively coupled to and actuated by a level sensing conduit **25** causes the electric motor which drives grinder **14** and pump **15** in common to be actuated. This results in grinding the liquid sewage and entrained solids into a fine slurry that is pumped out under pressure through the discharge outlet **16.** In normal operation, the differentially operable check valve **29** will be closed due to the pressure of the pumped liquid sewage slurry while the check valve **23** will be opened thereby discharging the liquid sewage under pressure into a collection main such as those illustrated at **3** in FIG. **1.**

Because gaseous fluids can flow in both directions past the differentially operable check valve **29,** liquid in the collection tank **10** will be allowed to rise to a level within the pump **15** to cause the pump to be primed before the motor which drives the pump and grinder in common is turned on by the level sensing arrangement **25.** The electrical controls and electric motor driving the pump and grinder all are contained within a tightly sealed enclosure housing which protects these portions of the grinder core unit from the adverse effect of any gasses in tank **10.**

In addition to the self-priming feature noted above and in the further event of vagrant vacuum pockets forming in the low pressure sewage system as can occur, for example, when there are long, down-hill runs, the differentially operable second check valve **29** will allow removal of liquid sewage in the discharge conduit **24** down to the point of connection of the second conduit **19.** Thereafter, the differentially operable check valve **29** opens to provide passage for venting air through the conduit open end **21** and into the discharge line thereby breaking the vacuum. For a more detailed description of these features, reference is made to the above-noted U.S. patent application, Ser. No. 305,712.

FIG. **3** illustrates the "H-Q" semi-positive displacement pumping characteristics of the grinder pump unit depicted in FIG. **2** of the drawings and used with each of the generating sites **1** of the system shown in FIG. **1.** In FIG. **3,** the discharge from the grinder pump tabulated in gallons per minute is plotted as the abcissa and the head (pressure of the collection main into which the pump must discharge) in feet of water, is plotted as the ordinate. From an examination of this curve, it will be appreciated that the "H-Q" curve of the grinder pump unit **2** employed in the system of FIG. **1** has as nearly vertical as possible discharge displacement characteristic with increases in pressure head. It is desirable that the H-Q curve be absolutely vertical, that is to say, it possesses a positive displacement characteristic, and such a characteristic is intended to be included in the more comprehensive term "semi-positive." However, it has been determined through experience that in order to provide a pump with solids handling capability which it must have for the use envisioned, some falling off of the H-Q curve from a strictly vertical characteristic, is experienced. For this reason the pump is defined as possessing a semi-positive H-Q displacement characteristic which, unlike conventional centrifugal pumps, for example, does not have a relatively low flow cut-off point and has the ability to pump significant amounts of liquid at two, three or even more times its normal design head. That is to say, a significant output flow will take place within reasonable limits as long as the driving source has power enough to operate the pump. It will be appreciated, therefore, that the semi-positive displacement characteristics of the grinder pump units **2** do not have a "shut-off" pressure head and provide a significant discharge flow (in gallons per minute) at an essentially constant rate regardless of the pressure head of the sewage mains into which they discharge. This is in contrast to the typical displacement operating characteristics of centrifugal pumps, for example, which, as indicated in FIG. **3,** allow the flow or discharge to drop off substantially in the range of pressure heads above approximately eighty feet of water.

In a system application such as depicted in FIG. **1** of the drawings, where any number of the individual grinder pump units **2** may be operating simultaneously, the pressure produced in the common collection main can range 40% or more above design pressure head up to quite high values of the order of 120 feet of water or higher, for example. Since there is no practical, economic way in which to control turn-on and turn-off of the separate, sewage level operated grinder pump units to thereby control within restricted ranges the pressure head of the common collection main, it is essential that the pumps employed in such a system possess the semi-positive displacement characteristic depicted in FIG. **3** so that they continue to discharge a significant flow even during those infrequent but inevitable conditions of operation when the overall sewage system is stressed beyond its normal design head. Otherwise, accumulative, multiple-"shut-off" of several pumps (assuming conventional centrifugal type pumps are employed) might be experienced under such circumstances. Even if centrifugal pumps are designed to possess the relatively "steep" displacement characteristic illustrated in FIG. **3,** it can be demonstrated that during peak flow periods many of such pumps attempting to operate in a system such as in FIG. **1,** could be "shut off". Repeated and prolonged periods of operation of centrifugal pumps in a flow shut-off condition can result in harmful vibration and generate excessive heat from continued recirculation of water in the pump possibly leading to failure or irreparable damage. Such a condition is avoided in the system of the present invention by the employment of grinder pump units **2** having semi-positive displacement characteristics such as are illustrated in FIG. **3.** It should be noted at this point in the description, that while applicants have disclosed a preferred form of semi-positive displacement pump, there are other known forms of semi-positive displacement pumps having solids handling capability which could be used in the system herein disclosed.

In FIG. **1** of the drawings, the various component parts of the overall low pressure sewage system are identified by the following symbols and associated reference numbers:

(1)	⊡	Sewage generating site
(2)	⊙	Grinder Pump
(3)	—	Small diameter, non-corroding, non-rusting, pipe of appropriate diameter to handle design flow and sufficiently flexible to follow contour of land
(4)	△	Anti-ciphon valve
(5)	◇	Combination clean-out, flushing station, air purging, manual air release and air accumulator
(6)	⋈	Sectional division valve
(8)	⋈	System control regulator valve
(9)	⋈	Redundant check valve

From a comparison of the above list of symbols to FIG. **1** of the drawings it will be appreciated that each sewage generating site **1** normally is connected to a low pressure sewage main **3** through its grinder pump unit **2**, an anti-siphoning valve assembly **4** (which corresponds to the differentially operable second check valve means **19, 20, 21,** and **29** in FIG. **2**), a second or redundant check valve means **9** and suitable piping of appropriate diameter together with required connectors, elbows, couplings, etc. The redundant check valve means **9** may be similar in construction to the first check valve means **23** shown in FIG. **2** of the drawings and may comprise a conventional, commercially available flapper-type check valve or as described in U.S. Pat. No. 3,664,775. The redundant check valve means **9** preferably is inserted in the piping connection **24** to the low pressure main **3** at a point between the discharge of the grinder pump **2** on the output side of its associated outlet discharge check valve **23** and the intersection of the connecting pipe with low pressure sewage main **3.** Preferably the redundant check valve **9** is located substantially at the intersection of the connection to the low pressure main **3** for reasons to be discussed hereafter. It will be noted in FIG. **1** of the drawings, that not all of the associated grinder pump units, anti-siphoning valve assemblies and redundant check valves have been illustrated for each of the sewage generating sites **1.** This omission was for the pupose of simplification of the drawings and in view of the belief that the number indicated are sufficient to illustrate the concept to a reader of the disclosure.

As described above, redundant check valves (**9**) may comprise any conventional, commerical check valve, but preferably are fabricated from a suitable, non-rusting, non-corroding plastic such as polyethylene or polyvinylchloride (P.V.C.). A flapper-type check valve construction is preferred and may, for example, be similar to the flapper-type valve construction described in U.S. Pat. No. 3,664,775 issued May 23, 1972. The redundant check valve **9** is in addition to the discharge outlet **23** which normally is included as an integral part of the grinder pump core unit, and can be removed along with the core unit for servicing. Under such conditions, it will be appreciated that the redundant check valve **9** will serve as a means for withholding pressurized sewage in the low pressure sewage main **3** from flowing back into and flooding the collection tank **10** unless a manually operated cut-off valve also is included. Where the additional expense can be tolerated, it is preferred that each sewage generating site be provided with a manual shut-off valve similar in construction and operation (but of smaller size) to the division or section cut-off valves **6** to be described hereinafter with reference to FIG. **4.** Such manual shut-off valves, if used, would be placed in the piping connection between the first check valve **23** on the grinder pump unit **2** and the point of connection to the common low pressure sewage main **3** and may be located on either side of the redundant check valve **9** but preferebly on the main side. By the inclusion of the redundant check valve **9** only a minimum amount of backflow of pressurized sewage contained in the interconnecting pipe from the grinder pump unit out to the low pressure sewage main, can take place whether or not an additional, manually operated cut-off valve is provided (or not used if provided). Normally, this amount of sewage readily can be accommodated in the collection tank **10** while servicing of the grinder pump core unit is to be carried out. Hence, it will be appreciated that inclusion of the redundant check valve **9** also facilitates maintenance and servicing of the grinder pump core unit.

Another advantage obtained by the use of the redundant check valve **9** from a systems point of view occurs in the original installation of the sewage main. Consider the case of a land developer who does not want to build homes in a development all at the same time and connect their respective grinder pump units to a low pressure sewage main being installed to serve the homes. The low pressure sewage main **3** can be run at relatively low cost and at locations along the main where lots for homes are located, inlets to the main can be installed with redundant check valves and capped. Thereafter, as a home is built on a particular lot, its grinder pump unit can be installed and connected through suitable outlet piping to the appropriate preinstalled inlet to the main, the cap removed, and the home placed in service all without disruption of service to other homes served by the same main.

However, in addition to the above-discussed desirable features, the inclusion of the redundant check valve **9** serves to reduce or minimize the transient load placed on the grinder pump unit motors during each start-up of the grinder pump unit when its sewage level sensor actuates the motor. This rather unexpected advantage is obtained by reason of the fact that the redundant check valve serves for some definite time interval (determined at least in part by the length of piping connection between the redundant check valve **9** and the grinder pump unit **2** and the amount of air (compressible fluid trapped therein) to withhold the instantaneous pressure head of the low pressure sewage main **3** from being imposed as a load on the grinder pump during start-up intervals while the pump is starting and building up a sufficient pressure head to cause the first outlet and redundant check valves to open and allow a discharge flow of liquid sewage slurry into the common main **3.** This characteristic will be appreciated better from the following discussion.

Assume, for example, that at a point in time when start-up of an individual grinder pump unit is called for by its sewage level sensor (which may be any random time), it is a time when a large number of residences on the same main are using their facilities and a considerable number of grinder pump units are discharging into the common low pressure sewage main **3.** Under such conditions, the low pressure sewage main **3** will be operating above its normal design pressure head, for example, to a value of 120 feet of water, where its normal design head is 81 feet of water. Under these circumstances, the redundant check valve **9** will withhold the

120 feet of water head as a load on the grinder pump upon its initial start-up. Assume further that just prior to the pump-out period the low pressure sewage main had been operating at the normal, design 81 feet of water pressure head. Under these conditions, the fluid including liquid sewage entrained in the interconnecting pipe **24** between the redundant check valve **9** and the first discharge outlet check valve **23** will be at the normal 81 feet of water design pressure head. Finally, it should be noted that it is a characteristic operating phenomenon observed with pressure sewer systems that some air (a compressible fluid) gets entrained in the connecting pipe (second conduit **24** between the first discharge outlet check valve **23** and the redundant check valve **9.** Some of this trapped air is due to air trapped in the length of the outlet pipe **22** between first discharge outlet check valvee **23** and the point of connection of the venting first conduit **19** following each operation of the grinder pump. Upon the next start-up of the grinder pump, some of this trapped column of air is compressed by the slug of water discharged from pump **15** and upon opening of the first check valve **23,** is introduced into the fluid column in second conduit **24** between the first check valve **23** and the redundant check valve **9.** Thereafter, following initial start-up, the grinder pump will be allowed to discharge into the second conduit **24** at the relatively lower design pressure head of 81 feet of water while it is coming up to speed and for the interval of time required for the pump to build up sufficient pressure in the fluid (including the quantity of air mentioned above) in the interconnecting pipe **24** from the grinder pump discharge to the low pressure main **3** to cause the redundant check valve **9** to open against the instantaneous full back pressure of main **3** and to start discharging liquid sewage at the higher pressure head into the common sewage main. It will be appreciated therefore, that this characteristic of the system, made possible by the inclusion of the redundant check valve, tends to reduce or minimize to the greatest possible extent the transient starting load on the grinder pump, thereby providing additional protection against undesired stressing or overloading of the grinder pump. It further minimizes or cushions mechanical shocks due to water hammer in the system.

A further considerable advantage made possible by the inclusion of the redundant check valves **9** in the low pressure sewage system is that they allow the individual grinder pump units to see (i.e., have imposed on them) the lowest pressure head which occurred in the common main **3** during the intervening period of time between each operating interval of the grinder pump. To illustrate this characteristic, consider again the example described in the preceeding paragraph. After the grinder pump empties its collection tank, it will cease pumping and the high 120 feet of water head pressure in the common main will cause the redundant and first check valves to snap shut upon the discharge presssure from the pump dropping to a value less than 120 feet of water head. Thereafter, during the night, for example, should the pressure in the common main drop to a lower value, such as the design head of 81 feet of water or even lower, perhaps to 45 feet of water, the redundant check valve **9** will open and allow the liquid slurry sewage trapped in the interconnecting pipe **24** to discharge into the now lower pressure common main. Thus, at the time of the next start-up, the grinder pump will see the lowest pressure head assumed by the common main **3** during the intervening time period between its last operation and the time of start-up.

In order to assure that some air will be trapped in the second conduit **24** (although this phenomenon occurs despite efforts to keep it out), it is possible to modify the grinder pump structure in the manner shown in dotted outline form in FIG. **2.** In this proposed alternative construction, an air accumulator in the form of a vertically extending stand pipe **71** is connected to the second conduit **24** at a point on the outlet side of the first discharge check valve **23** but is located within the container **10.** The air accumulator stand pipe **71** is capped at **72** and may include a clean-out plug **73** for cleaning the stand pipe should it tend to clog. With this alternative arrangement, it will be assured that some air always will be trapped in the vertically extending stand pipe **71** thereby assuring the presence of a compressible fluid in the length of interconnecting pipe **24** between the first outlet discharge check valve **23** and the redundant check valve **9.** As a consequence, all of the above-noted advantageous operating features of minimizing the initial or transient starting load on the grinder pump as well as minimizing mechanical shock in the form of water hammer, are attained.

As an alternate to the stand pipe construction shown in dotted outline form in FIG. **2,** the air accumulator **71** could be provided in the form of a small tank connected to the second conduit **24** at some point intermediate the first outlet check valve **23** and the redundant check valve **9.** In such an arrangement the air accumulator tank would be provided with an expandable diaphragm dividing the tank into two parts and having air trapped in back of the diaphragm. During pump-out operation of the grinder pump or other high pressure conditions arising in the second conduit **24,** the expandable diaphragm would compress the trapped air and provide assurance that the fluid column extending between the discharge outlet check valve **23** and the redundant check valve **9** would have some compressibility.

Still a third alternative arrangement would be to include a small controlled orifice leak at the point indicated by the clean-out plug **73** of the dotted outline construction shown in FIG. **2.** It will be noted that any such leak would be contained within the collection tank **10** so that liquid seeping through the leak would be returned to the interior of tank **10.** Because of the pressures at which the system is designed to operate, the leak would tend to be self-cleaning and would further assure the entrapment of air in the stand pipe **72.** As a matter of fact, it is possible to eliminate the stand pipe **72** and use only the leak in its place provided some means is included for returning leakage through the leak to the interior of the tank **10.** The leak would provide a controlled orifice through which air would be siphoned into the second outlet conduit **24** to thereby assure the presence of a compressible fluid in the length of pipe between the two check valves during operation of the grinder pump. During the static holding condition between each operating period of the grinder pump, the controlled orifice would allow some of the entrapped liquid sewage in the column to leak back into the collection tank **10,** again for the purpose of assuring the presence of a small amount of air (compressible fluid) in the liquid column between the two check valves.

All of the above-discussed alternative arrangements ordinarily need not be included in a grinder pump installation, except where a particular installation has exhibited a tendency to produce water rattle and its associated mechanical shock to the system during the initial start-up of the grinder pump and while it is coming up to pressure. Under such circumstances, any of the above-discussed alternative arrangements could be employed to further assure the presence of a cushioning, compressible fluid in the output fluid column extending between the discharge outlet check valve **23** and the redundant check valve **9.**

In cases where the water rattle problem is not too severe, it would be possible to overcome any tendency to produce water rattle by locating the first discharge outlet check valve **23** at a point further along the discharge outlet piping system from the interconnection of the first air venting conduit **19** so as to maximize the length of the pipe column extending between the first outlet discharge check valve **23** and the point of interconnection of the air venting conduit **19.** By constructing the anti-siphon/air venting assembly in this manner a maximum cushioning column of air (compressible fluid) will be introduced into the piping system which will tend to cushion the impact effect of the discharge column of wastewater liquid sewage as it is discharged from the grinder pump **15.**

While this last described feature of construction is more simple and requires fewer parts, the inclusion of an air accumulator such as shown in dotted outline form at **71** and **72** in FIG. **2,** in addition to providing the desired presence of a compressible fluid (air) in the outlet piping between the two check valves, would further serve to protect the grinder pump unit from backwardly traveling mechanical shock waves that are produced in the low pressure sewage piping systems by other components of the system. While the grinder pumps are operating, externally produced mechanical shock waves, perhaps produced by other grinder pumps coming on the line at the same time, might be transmitted back through the piping system to impact the flexible stator of an already operating grinder pump unit. Such an impact, if sufficiently severe, could be the cause of a stator failure due to blow-out. By including an air accumulator as shown in dotted outline form in FIG. **2,** or one which employs a flexible diaphragm, controlled orifice leak, etc., protection for the grinder pump stator is provided since the air accumulator would absorb and dampen any such reverse mechanical shocks traveling through the piping system.

The low pressure sewage mains **3** are sized in accordance with the number and capacity of the sewage generating sites which a particular section or division of the main must serve. Thus, in FIG. **1,** assuming that the final sewage disposal or collecting site is shown at **31,** then the section of the low pressure sewage main **3** depicted by the reference numeral **32** can employ a smaller diameter pipe than, say, a section **33** or **34** which must accommodate not only the flow from section **32** but from additional sections or divisions of the system. Thus, the sizing of the low pressure sewage main is determined by the number and capacity of the sewage generating sites, the design pressure head and desired scouring velocity at which it is desired that the system normally operate, the strength of the piping or the conduit from which the mains are formed, its ability to withstand negative pressure, a design margin for insurance protection against over pressures, along with considerations for maintaining sufficient flexibility to allow the main to follow the contour of the land in which it is installed. For the most part, all of these considerations are used in determining the sizing of particular sections of the low pressure sewage mains **3.** For the most part, polyvinylchloride (PVC) plastic piping of appropriate diameter to to satisfy the above requirements, can be used in installing the main **3** and interconnecting piping **24** to each grinder pump. The piping can be installed in sections of 40 feet length or more just below the frost line or sufficiently deep to protect it from the likelihood of damage. While PVC plastic piping is preferred, other comparable materials having the physical characteristics noted can be used satisfactorily in fabricating the piping, couplings, joints, valves, etc., used in the system.

In a preferred system as shown in FIG. **1** of the drawings, it is desirable that each section or division of the overall system which are readily identified by reason of the planned layout or community plot, be subject to cut-off and isolation for servicing through the medium of installed sectional division cutoff valves. FIG. **4** is a partially cut-away view of a preferred form of construction and installation of a divisional cutoff valve. The valve itself is shown schematically at **6** and may comprise any commercially available manually operated gate valve or comparable device with a smooth invert or bottom. The valve body **6** preferably is secured in place on a concrete thrust block **41** and is disposed within a cylindrically shaped pipe that extends vertically upward over the valve **6** to the surface and is closed by a suitably heavy but removable top **43.** The gate valve **6** has an actuating member **44** which is accessible through the removable top **43** by means of an elongated wrench (not shown) that can be secured to the actuating member **44** and manually turned so as to open or close the sectional divisional valve from the surface. Thus, it will be appreciated that where by reason of servicing or other requirements, it is necessary to shut off (or open) particular sections of the overall system, all that is required is that the service man open the top **43** and, using an elongated gripping wrench (not shown), selectively close or open the sectional divisional valve **6.**

In addition to the sectional divisional valves, it is desirable that substantially each of the sections of the system include a combination clean out, flushing station, air purging, air accumulator and manual air release facility or installation to facilitate maintenance and servicing. Each of these facilities or stations are depicted by the pentagonal shaped symbols **5** and preferably are installed at the ends of cul-de-sacs, the ends of each block or section being serviced by the system, on one or both sides of the sectional divisional valves **6,** etc. FIG. **5** of the drawings illustrates a preferred construction for such combination clean-out, flushing, air purging stations or installations. As shown in FIG. **5,** the low pressure sewage main **3** is connected through suitable couplings and elbow sections to a riser section **51,** adapter **52,** reducer **53** and nipple **54** to a manually operated gate valve **55** which may have a second nipple **56** threaded to its outlet side. The arrangement is installed in a sufficiently large access pit formed in the surface of the ground and closed by a removable cover lid of adequate strength to protect the installation. With this arrangement, it will be appreciated that any

air trapped in the system will tend to rise into the upright portion of the piping where it can be bled off at periodic servicing intervals merely by opening the manually operated gate valve **55.** Further, by connection of the nipple **56** to a source of high pressure air, it is possible to use the installation for air purging. If it is desired to clean out the system by flushing with water, routing, etc., the reducer **53** together with other parts connected to it above the adapter **52** may be removed allowing connection of a hose or pipe or insertion of a router or other cleaning equipment for cleaning purposes. At certain locations in the system it may be desirable to install two clean-out stations, one on each side of a sectional divisional valve in order to service the piping system in either direction from the divisional valve in the manner depicted at **50** and **60** in FIG. **1** of the drawings. the provision of such combination clean-out stations at strategic points throughout the low pressure sewer system greatly facilitates maintenance and servicing of the sewer system.

In reviewing FIG. **1,** it should be noted that the amount of installed piping is reduced to a minimum. This is for the purpose of reducing installation costs by minimizing the amount of trenching and damage to the ground surface as well as reducing the labor content required in installing the system. If desired, the low pressure sewage system readily could be modified to include closed loops to facilitate bypassing of particular sections or divisions of a section while still maintaining service to other sections. In FIG. **1,** for example, this could be achieved by installing dotted line interconnections such as shown at **61** in the upper left hand portion of FIG. **1,** including the additional sectional divisional valves **62.** With such an arrangement, for example, it would be possible to service any one of the residences connected to the low pressure sewage main **35** by closing the sectional divisional valves **46** and **47** and servicing through the combination clean-out stations **58** and **59.** Low pressure sewer service would be maintained to the other sections otherwise served through main **35** by opening the bypass connection sectional valve **62.** Extreme caution should be observed while operating the system in this mode, however, and any prolonged period of operation while the bypass connection is in the system should be avoided. The arrangement is included only to accommodate emergency repair and servicing problems and should not be used for extended periods of operation.

A similar result preferably is obtained with the system of FIG. **1** without requiring the permanent installation of the bypass connection **61** and associated sectional divisional valves **62.** This can be achieved through the combination clean out installations or stations **78** and **79** by connecting a portable hose or pipe between these two combination clean out stations. When used in this manner, a service man can make a jumper connection between the two combination clean out stations **78** and **79** thereby maintaining sewer service through the sections not requiring maintenance without the need for a permanent installation or interconnection in the manner depicted in dotted outline form. By thus designing the system to provide for portable jumper interconnections of reasonable length between the various combination clean out installations or stationss **5,** it is possible to achieve a considerable savings in installed piping not to mention the savings in labor for installation, disturbance to the ground surface and otherwise unnecessary piping. This can be a considerable savings factor particularly where a community is located in rocky terrain and trenching costs are significant.

In addition to the above-discussed features, a well-designed low pressure sewer system may include at particular high points in the system such as depicted at **81,** suitable air relief valves and/or air and vacuum relief valves such as the commercially available line of "APCO" valves manufactured and sold by the Valve and Primer Corporation of Chicago, Illinois. It will be noted that the air and/or vacuum release valve **81** is located at the crest of a hill in the community between elevation lines of 560 feet and from this crest there is a downward slope for the low pressure sewage main **34** on either side of the appurtenance. By the inclusion of an air and/or vacuum release valve **81** at this point where it is not unlikely and, if fact, quite predictable that vagrant air and/or vacuum pockets will be formed, the device automatically will vent any such air and/or vacuum pockets to the atmosphere upon their occurrence thereby minimizing disturbances to the system.

It is further desirable that any well-designed low pressure sewage system such as that shown in FIG. **1** also include a pressure regulating device shown at **8** at some point in the system. Preferably, the pressure regulating device **8** may comprise any conventional, commercially available pressure regulator valve such as those manufactured and sold by the Kennedy Valve Manufacturing Co., Inc. or the BP 130 Bypass Control Valve manufactured and sold by the Watts Regulator Co. These or other comparable pressure regulator valves desirably would be inserted in at least that common low pressure sewer main **34** which is connected to and feeds sewage under pressure to the disposal site **31,** and, if desired, could be located in others of the sectional divisional mains where it is desired to maintain sewage in the line particularly at the end of downhill runs.

In addition to the above considerations, it may be necessary (because of particularly abrupt or severe changes in terrain of a community in which a system is being installed) to include as part of the system a lift station such as depicted at **91.** Normally, lift stations are designed to handle large quantities of sewage and, hence, must be installed at some point in the system where there is a considerable accumulation of sewage under pressure to justify its expense and use in the system. In the situation depicted by FIG. **1,** it will be assumed, for example, that in place of an elevation line of say 520 feet, the elevation rises to, say, a level of 600 feet at the disposal site **31.** For such substantial increases in elevation, which would overload the system above the design operating heads of the grinder pump units employed in the system, it would be necessary to include the addition of a lift station such as is depicted in dotted outline form at **91** to lift the sewage under pressure to the higher level sewage disposal site and further processing.

From the foregoing description it will be appreciated that the invention provides a new and improved pressure sewage system which employs a multiplicity of separate, individually operating grinder pumps of the type having semi-positive displacement characteristics for first grinding and then pumping sewage under pressure through low pressure sewage distribution mains to a disposal site. The low pressure sewage distribution mains may be comprised by small diameter, flexible,

non-corroding pipes that need only be buried under the frost line and can follow the contour of the terrain of the community in which the system is installed. By reason of the use of self-priming, self-scouring grinder pumps having semi-positive displacement characteristics, it is assured that positive outflow of sewage will always take place under substantially all operating conditions that reasonably can be expected to be encountered and irrespective of wide variations in pressure head of the sewage main into which the individual grinder pumps must discharge. In addition, the system provides automatic anti-siphoning protection that corrects for any problems that could arise due to vagrant vacuum pockets that are produced or otherwise might occur in a low pressure sewage system and additionally includes the provision of a non-clogging redundant check valve for minimizing transient overloads on the grinder pump motors during start-up as well as minimizing or relieving water hammer and mechanical shock otherwise produced in the system by the grinder pumps at start-up.

Having described several embodiments of a preferred low pressure sewage system constructed in accordance with the invention, it is believed obvious that other modifications, variations and changes may be made in the system by those skilled in the art in the light of the above teachings. It is, therefore, to be understood that changes may be made in the particular embodiments of the invention disclosed which are within the full intended scope of the invention as defined by the appended claims.

What is claimed is:

1. A pressure sewage transport system including in combination a plurality of sewage generating sites with each of said sewage generating sites including in combination at least one collection tank; grinder means having its inlet taking suction on the liquid sewage contents of the tank and discharging ground liquid slurry sewage from its outlet; pump means having its inlet connected to the outlet from said grinder means and providing a significant discharge flow of ground liquid slurry sewage under pressure from its outlet, a discharge passage connected to the outlet from said pump means for discharging ground liquid slurry sewage from said tank under pressure to one or more receiving points; outlet check valve means within said discharge passage permitting liquid sewage flow only in the direction from the outlet of said pump means to the receiving point and preventing backflow of pressurized liquid sewage; first conduit means connected at one end to said discharge passage and freely open at its other end to a source of venting gas; anti-siphon check valve means within said first conduit means for passing gaseous fluids through said first conduit means at least in a direction from said open end to said discharge passage and for preventing the passage of liquid sewage from said one end to said open end of said first conduit means; at least one common pressure sewage main for connecting to at least one other sewage generating site and to at least one pressure sewage collection point; second conduit means connecting the outlet from said first check valve means to said common pressure sewage main and redundant check valve means connected in said second conduit means.

2. A pressure sewage system according to claim 1 wherein said anti-siphon check valve means passes gaseous fluids through said first conduit means in either direction and said pump means is self-priming.

3. A pressure sewage system according to claim 2 wherein said pump means comprises semi-positive displacement pump means for providing a significant discharge flow of ground liquid sewage slurry under pressure from its outlet substantially independently of the pressure head into which the discharge is directed.

4. A pressure sewage system according to claim 3 wherein said semi-positive displacement pump means comprises a positive helical screw-type pump employing a flexible boot with an internal helical surface in cooperative working engagement with a rigid shaft having an external helical surface, but of a different pitch, the discharge from said helical screw-type pump being directly connected to said discharge passage, said first conduit means and said anti-siphon check valve means also comprise pump priming means for relieving build-up of gaseous fluids in the pump means, and allow liquid sewage to rise through the suction inlet into the flexible boot of the pump means as liquid sewage accumulates within the collection tank to some predetermined maximum level and actuates the pump means.

5. A pressure sewage system according to claim 4 wherein said first conduit means and said anti-siphon check valve means comprise anti-siphon means for preventing the removal of the pump liquid prime and liquid from said collection tank upon a vacuum being produced in said discharge line due to siphoning, said anti-siphoning means allowing removal of liquid sewage in said discharge line down to the point of connection of said first conduit means or below and thereafter providing passage of venting gas through the open end of said first conduit means and through said anti-siphon check valve means into said discharge line and allowing the liquid in the discharge line to seek the level of the liquid in the collection tank.

6. A pressure sewage system according to claim 5 wherein said discharge passage is permanently sealed with respect to the interior of said collection tank between said outlet from said pump and said first conduit means, the interior of said collection tank is vented to the atmosphere, said first conduit means is connected at said one end to said discharge passage intermediate the outlet from said pump means and said outlet check valve means and is sealed and uninterrupted between its one end connected to the discharge passage and its open end save for the anti-siphon check valve means, the open end of said first conduit means opens directly into said collection tank at a level substantially above the maximum predetermined level of sewage collected in the tank, and said redundant check valve means is connected in said second conduit means substantially at the intersection of said common pressure sewage main.

7. A pressure sewage system according to claim 6 further including a combination clean-out, flushing station, air accumulator, system air purging and system excess pressure release mechanism located at strategic points along the common pressure sewage main generally at the terminus of each section of the low pressure sewage main.

8. A pressure sewage system according to claim 7, further including air relief valve means installed in the common pressure sewage main at respective high points in the main intermediate the sewage generating sites and the pressure sewage collection point.

9. A pressure sewage system according to claim 8 further including sectional division stop valves included in the pressure sewage main at strategic points in each section of the main for isolating desired sections of the main from other sections, and means for providing bypass pressure sewage conduits interconnecting particular sections of the common pressure sewage main for isolating a desired section through the medium of said sectional division valves without interrupting service to other sections or portions of a section.

10. A pressure sewage system according to claim 9 further including system pressure control regulator means included in the common pressure sewage main at a point substantially at the point of connection to the pressure sewage receiving point.

11. A pressure sewage system according to claim 3 wherein said semi-positive displacement pump means comprises a positive helical screw-type pump employing a flexible boot with an internal helical surface in cooperative working engagement with a rigid shaft having an external helical surface, but of a different pitch, the discharge from said helical screw-type pump being directly connected to said discharge passage, said first conduit means and said second anti-siphon check valve means comprise pump priming means for relieving build-up of gaseous fluids in the pump means and allow liquid sewage to rise through the suction inlet into the flexible boot of the pump means as liquid sewage accumulates within the collection tank to some predetermined maximum level and actuates the pump means; said first conduit means and said anti-siphon check valve means comprise anti-siphon means for preventing the removal of the pump liquid prime and liquid from said collection tank upon a vacuum being produced in said discharge line due to siphoning, said anti-siphoning means allowing removal of liquid sewage in said discharge line down to the point of connection of said first conduit means or below and thereafter providing passage of venting gas through said first conduit means open end and through said anti-siphon check valve means into said discharge line and allowing the liquid in the discharge line to seek the level of the liquid in the collection tank; said discharge passage being permanently sealed with respect to the interior of said collection tank between said outlet from said pump and said first conduit means, the interior of said collection tank being vented to the atmosphere; said first conduit means being connected at said one end to said discharge passage intermediate the outlet from said pump means and said outlet check valve means and sealed and uninterrupted between its one end connected to the discharge passage and its open end save for the anti-siphon check valve means and the open end of said first conduit means opens directly into said collection tank at a level substantially above the maximum predetermined level of sewage collected in the tank, said redundant check valve means is connected in said second conduit means substantially at the intersection of said common pressure sewage main, and the pressure sewage main comprises a small diameter, non-corroding pipe laid just below the frost line and to afford protection for the pipe while following substantially the contour of the land where the pressure sewage system is installed.

12. A pressure sewage system according to claim 11 further including relief valve means installed in the common pressure sewage main at respective high points in the main intermediate the sewage generating sites and the pressure sewage collection point, and system pressure control regulator means included in the common pressure sewage main at a point substantially at the point of connection to the pressure sewage receiving point.

13. A pressure sewage system according to claim 12 further including lift station means installed in the common pressure sewage main at particular points where the main must traverse substantial increases in grade intermediate the sewage generating sites and the low pressure sewage collection point.

14. A pressure sewage system according to claim 1 further including system pressure control regulator means included in the common pressure sewage main at a point substantially at the connection to the receiving point.

15. A pressure sewage system according to claim 1 wherein the pressure sewage main is comprised by a small diameter, non-corroding plastic pipe installed just below the frost line and/or sufficiently deep for protection while following the contour of the land where the pressure sewage system is located, and further including relief valve means installed in the pressure sewage main at respective high points in the main intermediate the sewage generating sites and the pressure sewage collection point.

16. A pressure sewage system according to claim 1 further including air accumulator means connected to the second conduit means intermediate the outlet check valve means and the redundant check valve means.

17. A pressure sewage system according to claim 16 wherein said air accumulator means comprises a vertically extending stand pipe.

18. A pressure sewage system according to claim 17 wherein said vertically extending stand pipe has at least a portion extending within said sewage collection tank and further includes controlled orifice leak means formed in said stand pipe portion for assuring air charging of the air accumulator means, said controlled orifice leak means being located within said sewage collection tank for returning any liquid sewage emanating through the leak means to the tank.

19. A pressure sewage system according to claim 15 further including air accumulator means connected to the second conduit means intermediate the first outlet check valve means and the redundant check valve means, said air accumulator means comprising a vertically extending stand pipe having at least a portion extending within said sewage collection tank and further including controlled orifice leak means formed in the stand pipe portion for assuring air charging of the air accumulator means, said controlled orifice leak means being located within said sewage collection tank for returning any liquid sewage emanating through the leak means to the tank.

20. A pressure sanitary wastewater including sewage transport system including in combination a plurality of sanitary wastewater including sewage generating sites, a number of said wastewater including generating sites including in combination at least one wastewater collection tank; grinder pump means having solids handling capability with its inlet taking suction on the contents of the wastewater collection tank and providing a significant discharge flow of liquid wastewater under pressure from its outlet substantially independently of

the pressure head into which the discharge is directed, discharge passage means connected to the outlet from said pump means for discharging liquid wastewater from said tank under pressure to a pressure sewage main; first outlet check valve means within said discharge passage means permitting liquid sewage flow only in the direction from the outlet of said pump means to the pressure sewage main and preventing backflow of pressurized liquid sewage; venting conduit means connected at one end to said discharge passage means and open at its other end to a source of venting gas; check valve means within said venting conduit means for passing gaseous fluids through said venting conduit means at least from its open end toward said discharge passage and for preventing the passage of liquid sewage from said one end to said open end of said venting conduit means; at least one common pressure liquid wastewater main for connection to at least one other liquid wastewater including sewage generating site and to at least one low pressure liquid wastewater including sewage collection point; second conduit means connecting the outlet from said first outlet check valve means to said common low pressure liquid wastewater main and redundant check valve means connected in said second conduit means.

21. A pressure sanitary wastewater transport system according to claim **20** wherein said check valve means within the venting conduit means passes gaseous fluids through said venting conduit means in either direction and said pump means is self-priming.

22. A pressure sanitary wastewater transport system according to claim **21** further including air accumulator means connected to the second conduit means intermediate the first outlet check valve means and the redundant check valve means.

23. A pressure sanitary wastewater transport system according to claim **22** wherein said air accumulator means comprises a vertically extending stand pipe.

24. A pressure sanitary wastewater transport system according to claim **23** wherein said vertically extending stand pipe has at least a portion extending within said wastewater collection tank and further includes controlled orifice leak means for assuring air charging of the air accumulator means, said controlled orifice leak means being located within said sewage collection tank for returning any liquid sewage emanating through the leak means to the tank.

25. A pressure sanitary wastewater transport system according to claim **21** wherein said discharge passage is permanently sealed with respect to the interior of said collection tank between said outlet from said pump and said venting conduit means, the interior of said collection tank is vented to the atmosphere, said venting conduit means is sealed and uninterrupted between its one end connected to the discharge passage and its open end save for the check valve means secured therein and the open end of said first venting conduit means opens directly into said collection tank at a level substantially above the maximum predetermined level of liquid wastewater collected in the tank.

26. A pressure sanitary wastewater transport system according to claim **25** further including air accumulator means connected to the second conduit means and the redundant check valve means, said air accumulator means comprising a vertically extending stand pipe having at least a portion extending within said wastewater collection tank and further including controlled orifice leak means formed in the stand pipe portion for assuring air charging of the air accumulator means, said controlled orifice leak means being located within said sewage collection tank for returning any liquid sewage emanating through the leak means to the tank.

27. A pressure sanitary wastewater transport system according to claim **25** further including a combination clean-out, flushing station, air accumulator, system air purging and system excess pressure release mechanism located at strategic points along the common pressure wastewater main generally at the terminus of each section of the low pressure wastewater main, and air relief valve means installed in the common pressure sewage main at respective high points in the main intermediate the sewage generating sites and the pressure sewage collection point.

28. A pressure sanitary wastewater transport system according to claim **27** further including sectional division stop valves included in the pressure wastewater main at strategic points in each section of the main for isolating desired sections of the main from other sections, and means for providing bypass pressure wastewater conduits interconnecting particular sections of the common pressure wastewater main for isolating a desired section through the medium of said sectional division valves without interrupting service to other sections or portions of a section.

29. A pressure sanitary wastewater transport system according to claim **28** further including system pressure control regulator means included in the common pressure wastewater main at a point substantially at the point of connection to the pressure wastewater receiving point.

30. A pressure sanitary wastewater transport system according to claim **29** wherein said semi-positive displacement pump means comprises a positive helical screw-type pump employing a flexible boot with an internal helical surface in cooperative working engagement with a rigid shaft having an external helical surface, but of a different pitch, said check valve means within the venting conduit means comprising pump priming means for relieving build-up of gaseous fluids in the pump means and allowing liquid sewage to rise through the suction inlet into the flexible boot of the pump means as liquid wastewater accumulates within the collection tank to some predetermined maximum level and actuates the pump means; said venting conduit means and said check valve means within the venting conduit means also comprising anti-siphon means for preventing the removal of the pump liquid prime and liquid from said collection tank upon a vacuum being produced in said discharge line due to siphoning, said anti-siphon means allowing removal of liquid wastewater in said discharge line down to the point of connection of said venting conduit means or below and thereafter providing passage of venting gas through said venting conduit means open end and through said check valve means within said venting conduit means and into said discharge line and allowing the liquid in the discharge line to seek the level of the liquid in the collection tank; and the pressure sewage main comprises a small diameter, non-corroding pipe laid just below the frost line and following substantially the contour of the land where the pressure wastewater transport system is installed.

31. A pressure sewage system according to claim **1** further including a combination clean-out, flushing sta-

tion, air accumulator, system air purging and system excess pressure release mechanism located at strategic points along the common pressure sewage main generally at the terminus of each section of the low pressure sewage main.

32. A pressure sewage system according to claim **31** further including air relief valve means installed in the common pressure sewage main at respective high points in the main intermediate the sewage generating sites and the pressure sewage collection point.

33. A pressure sewage system according to claim **1** further including sectional division stop valves included in the pressure sewage main at strategic points in each section of the main for isolating desired sections of the main from other sections, and means for providing bypass pressure sewage conduits interconnecting particular sections of the common pressure sewage main for isolating a desired section through the medium of said sectional division valves without interrupting service to other sections or portions of a section.

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