Aug. 31, 1937. A. J. FISCHER ET AL 2,091,631

SEWAGE DIGESTION

Original Filed May 31, 1934 7 Sheets-Sheet 1

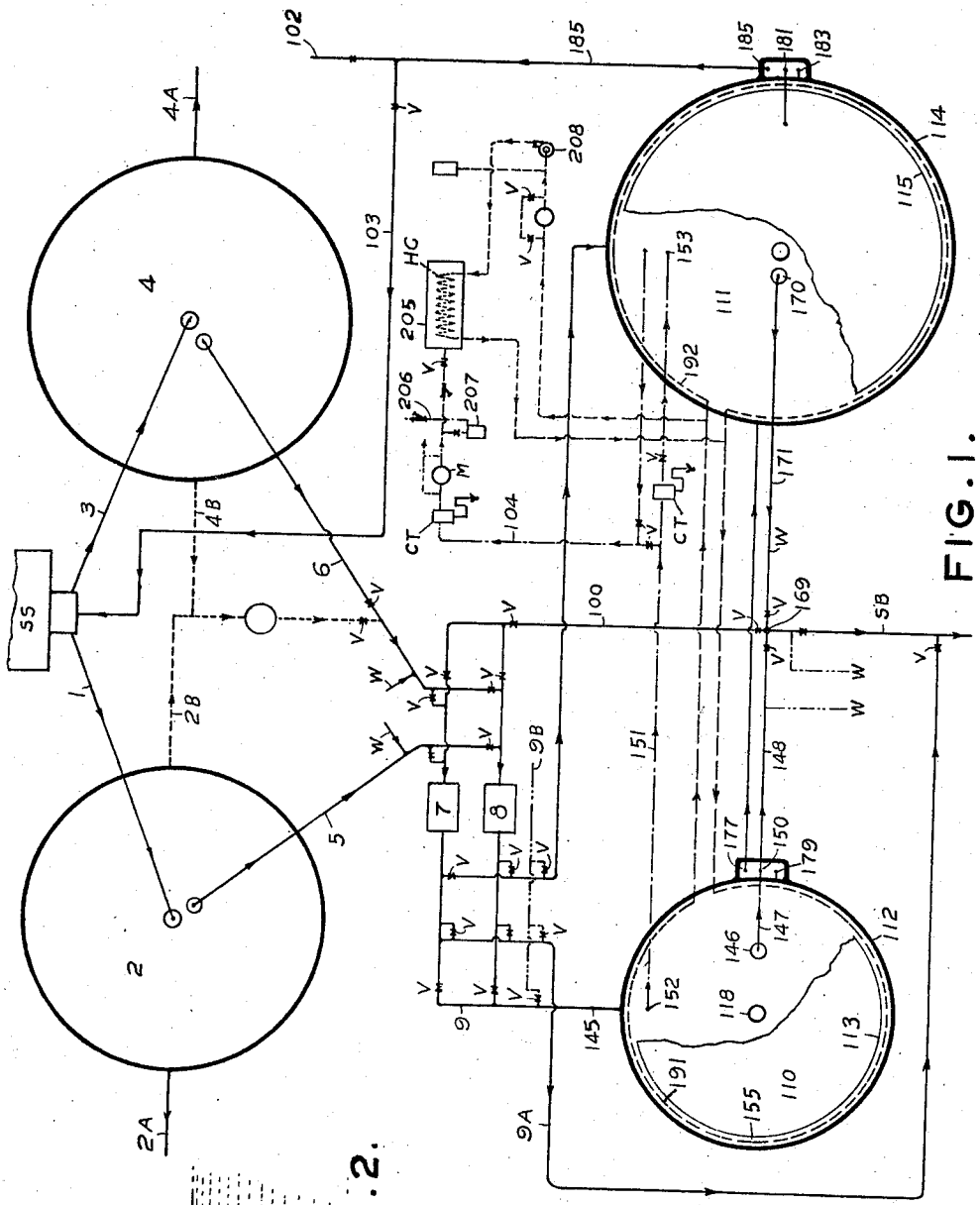


FIG. 1.

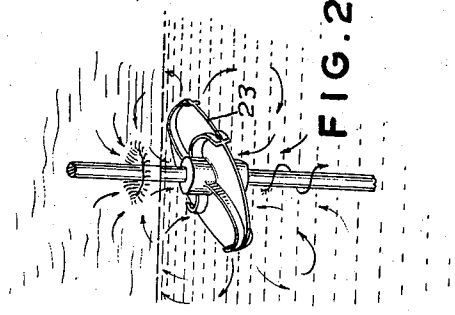


FIG. 2.

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SEWAGE DIGESTION

Original Filed May 31, 1934 7 Sheets-Sheet 2

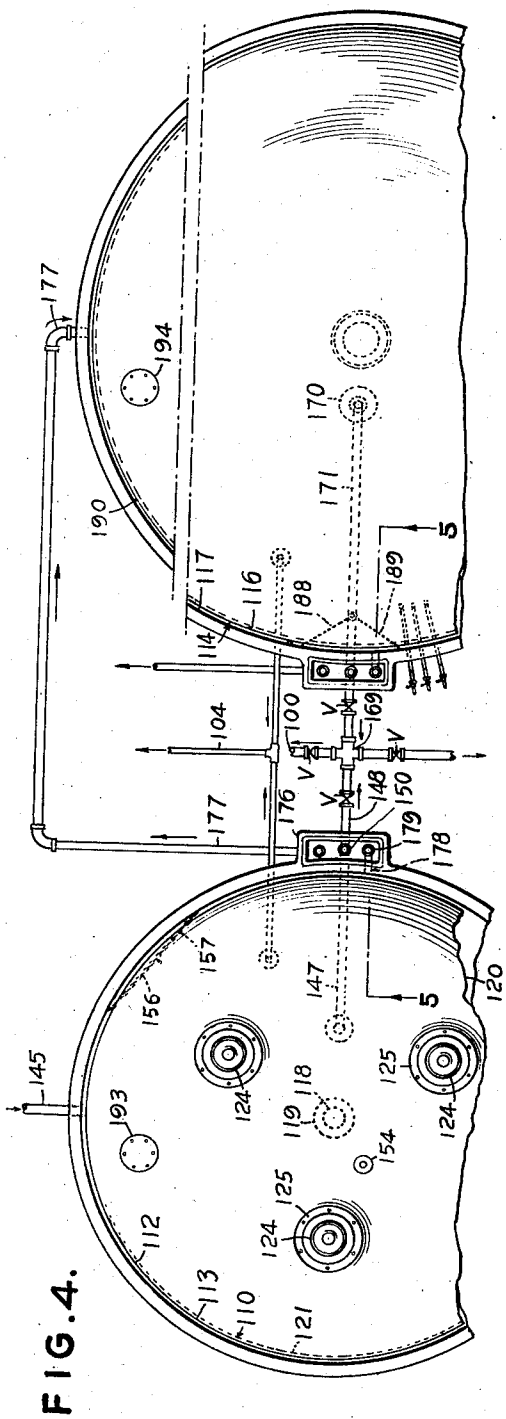


FIG. 4.

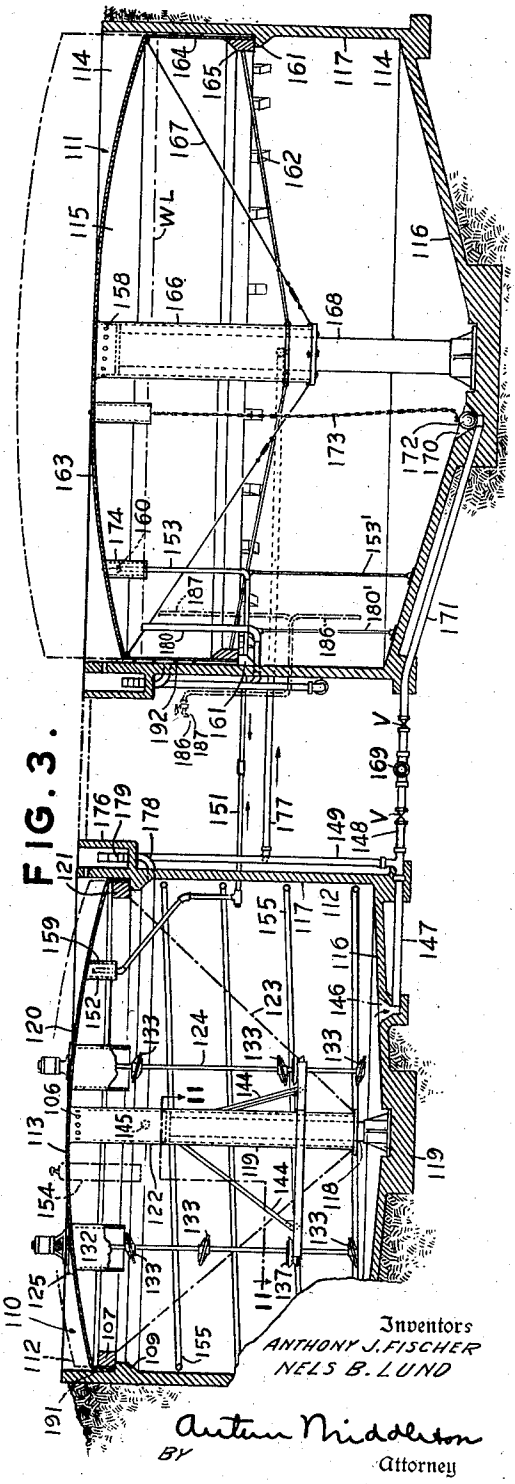


FIG. 3.

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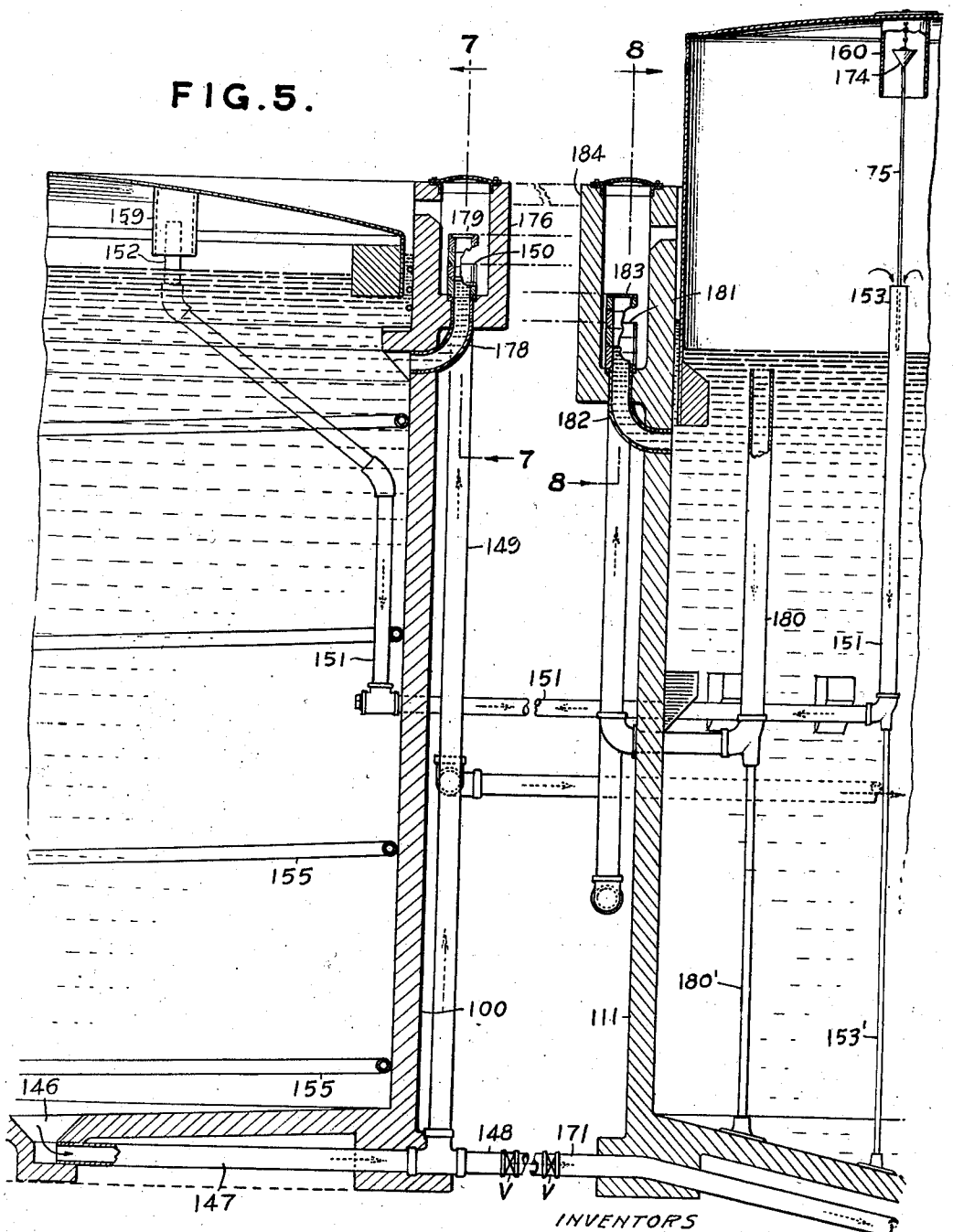
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SEWAGE DIGESTION

Original Filed May 31, 1934 7 Sheets-Sheet 3

FIG. 5.



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SEWAGE DIGESTION

Original Filed May 31, 1934 7 Sheets-Sheet 4

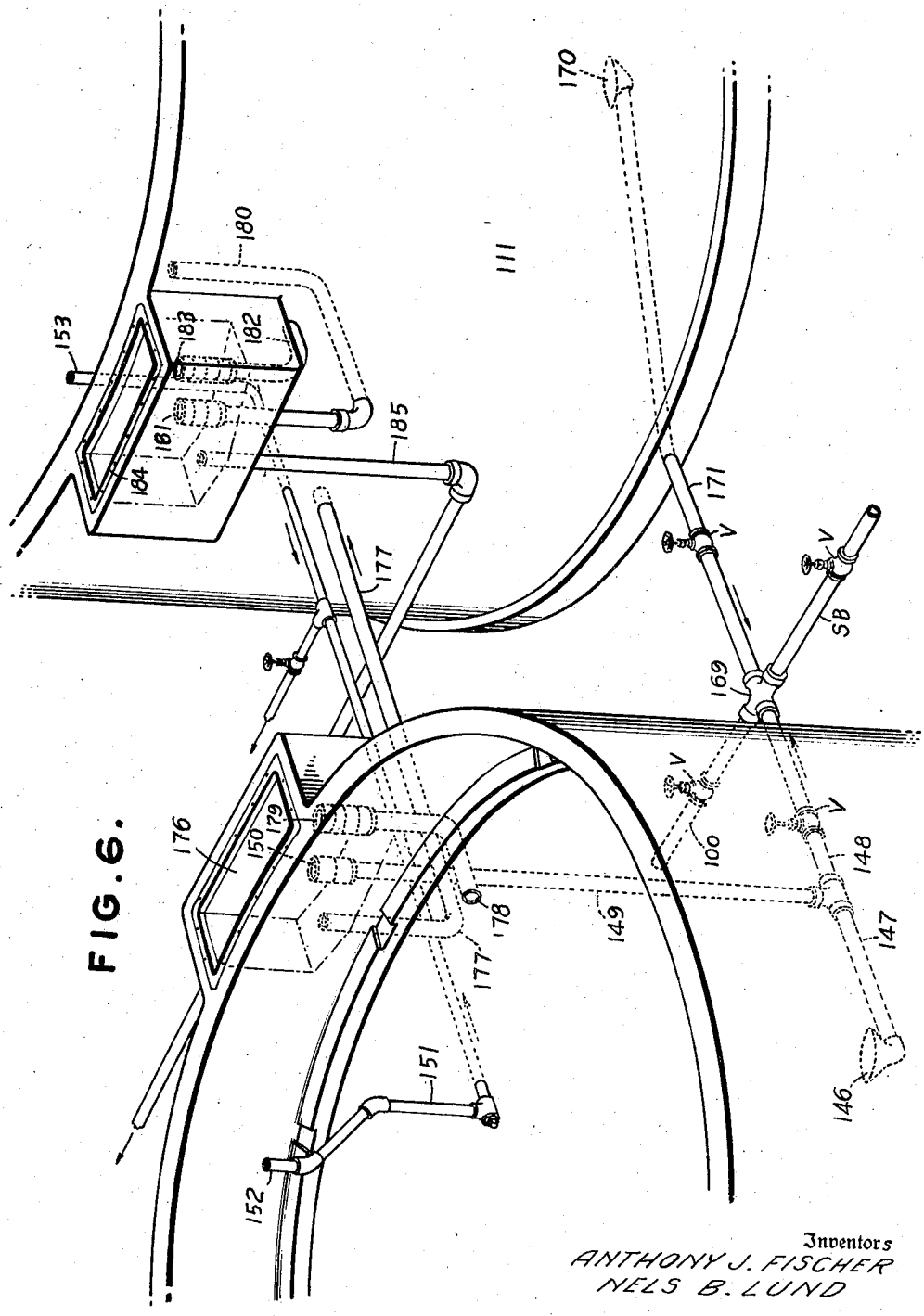


FIG. 6.

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SEWAGE DIGESTION

Original Filed May 31, 1934 7 Sheets-Sheet 5

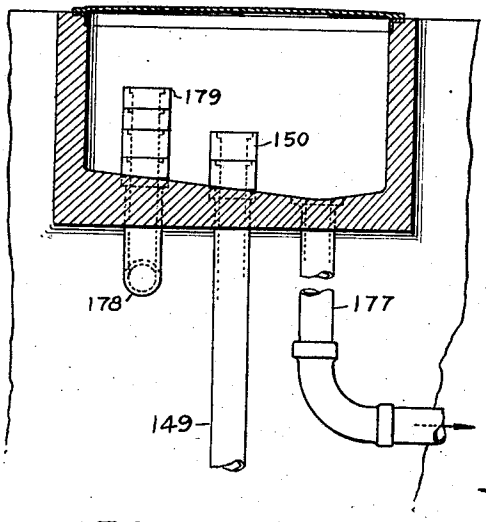


FIG. 7.

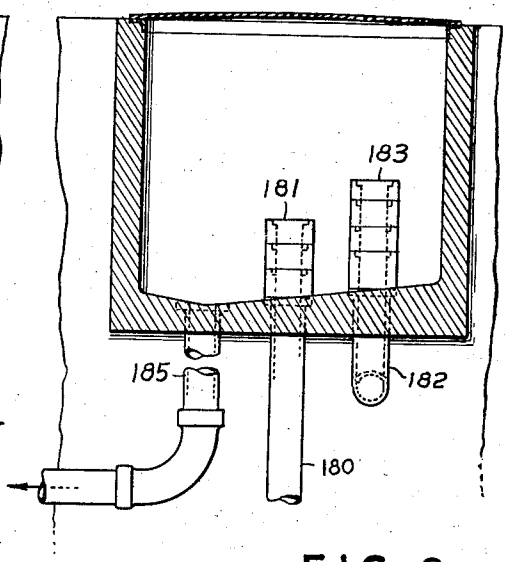


FIG. 8.

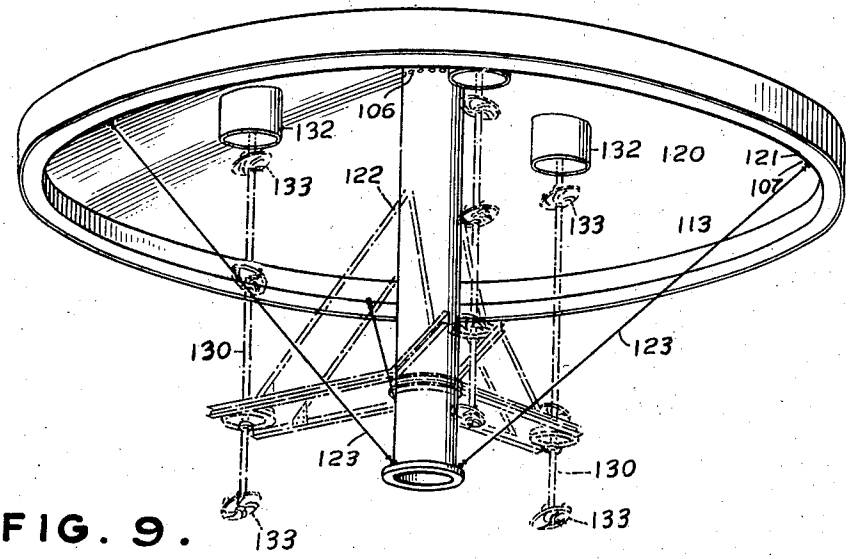


FIG. 9.

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SEWAGE DIGESTION

Original Filed May 31, 1934 7 Sheets-Sheet 6

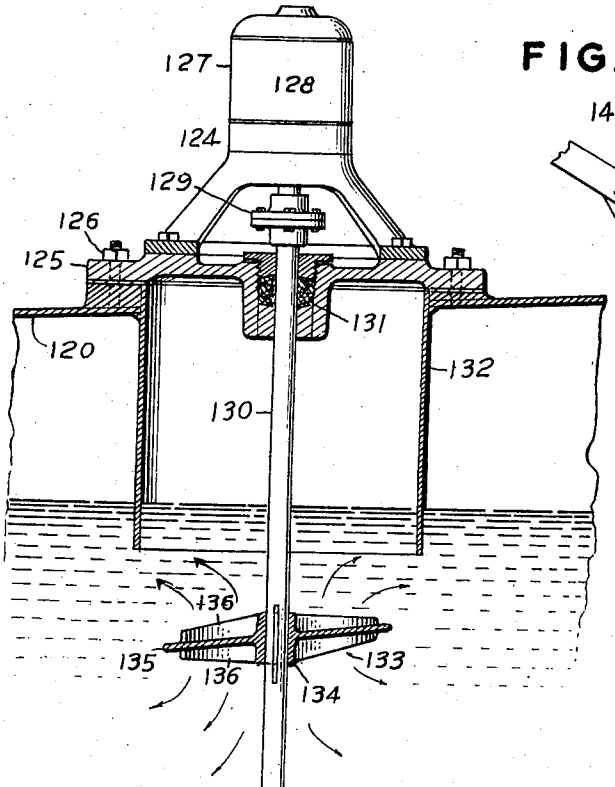


FIG. 10.

FIG. 11.

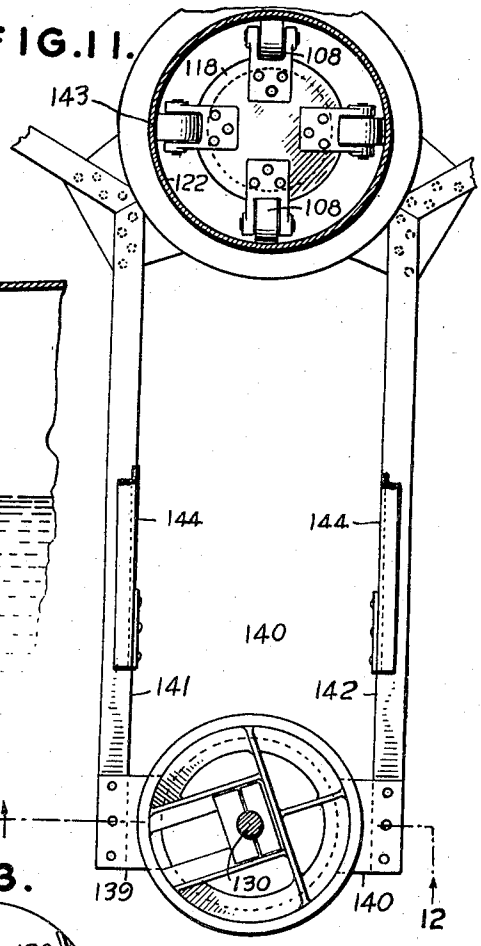
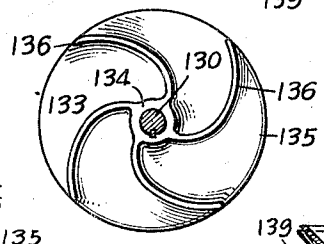


FIG. 13.



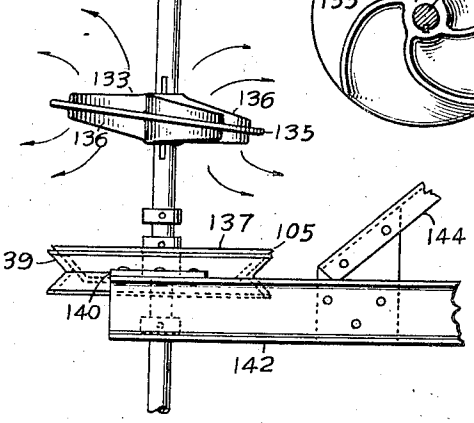
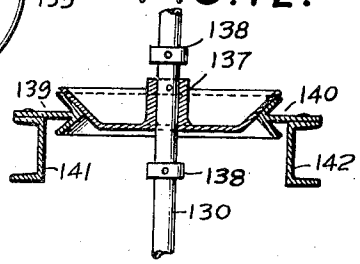


FIG. 12.



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SEWAGE DIGESTION

Original Filed May 31, 1934 7 Sheets-Sheet 7

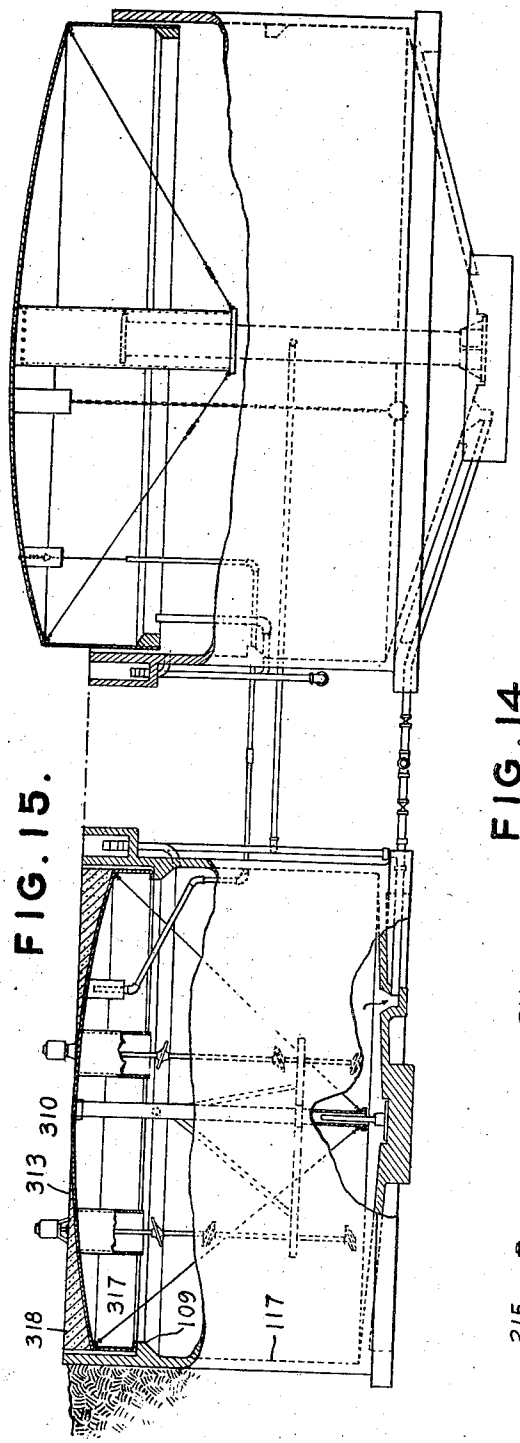


FIG. 15.

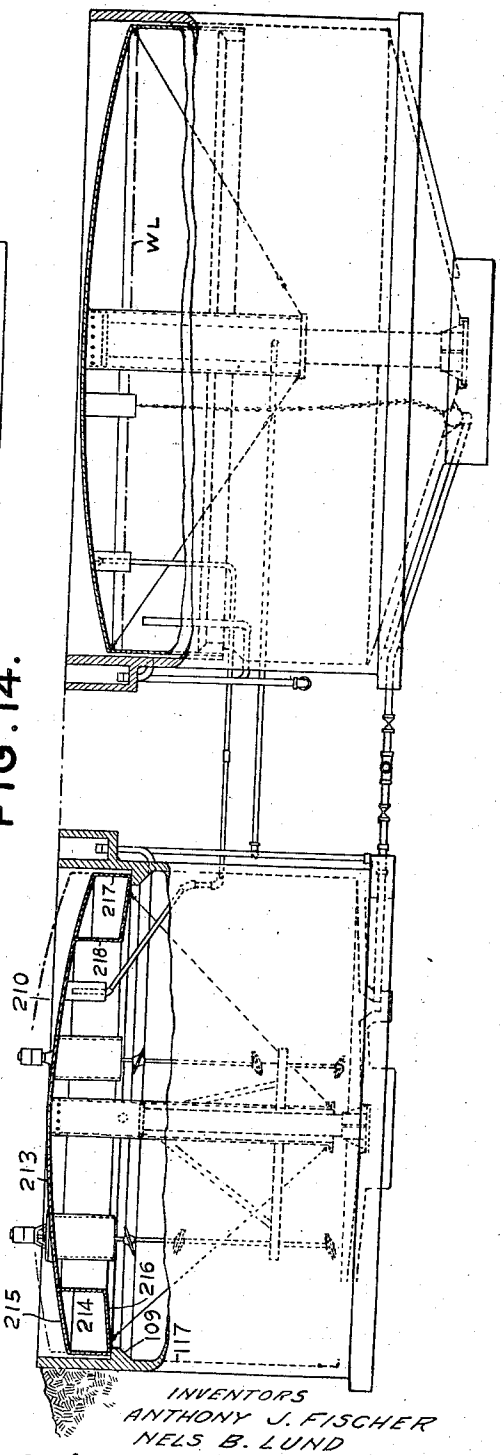


FIG. 14.

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Patented Aug. 31, 1937

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UNITED STATES PATENT OFFICE

2,091,631

SEWAGE DIGESTION

Anthony J. Fischer, Jackson Heights, and Nels E. Lund, Seaford, N. Y., assignors to The Dorr Company, Inc., New York, N. Y., a corporation of Delaware

Original application May 31, 1934, Serial No. 728,376. Divided and this application January 28, 1935, Serial No. 3,726

9 Claims. (Cl. 210—2)

In the treatment of sewage and analogous polluted waters, according to modern practice, it is quite common to effect an early separating as by settling and withdrawal of the suspended solids of the sewage in the form of a sludge and to subject the withdrawn sewage sludge to what is known as sewage sludge digestion. Sometimes in this class of work the sewage sludge is obtained in a condition which is known as raw or untreated sludge. According to other procedures either the sewage is chemically treated or the sludge may be treated whereby there may be obtained what may be termed a chemically treated sludge. The chemical treatment may have been provided to facilitate the precipitation for the ultimate obtaining of the solids as sewage sludge. Also according to certain procedures the sewage or the sewage sludge is subjected to aeration which is employed as for example to facilitate the precipitation of the sludge solids called activated sludge or in order to obtain a sewage sludge having certain characteristics which facilitate the process as a whole.

Raw or untreated sludge often has acid characteristics. Where the sewage is aerated the sewage sludge obtained may have an acid characteristic particularly where the sludge is stored prior to digestion.

When sewage sludge is digested the acid characteristic has to be overcome and the sludge takes on an alkaline characteristic which is desirable throughout the entire digesting period. This alkaline characteristic may be the result of anaerobic bacterial action which results in digestion which is duly initiated and which is maintained. This digestion is the conversion by virtue of bacterial activity of certain of the sewage solids into some other physical form such as a liquid or a gas. Some sewage solids are digestible while others are not. Digestible sewage solids are largely putrescible, so their conversion by digestion thus eliminates their odoriferous nuisance from digested sewage sludge.

The present invention is concerned with apparatus useful in connection with the digesting of sewage sludges or mixtures thereof no matter how obtained, for example, in sludge digesters in which the sludge treatment carried out therein is by a method in which there is an anaerobic digestion of the sewage sludge as the result of biological or bacteriological activity during which certain bothersome sewage solids undergo decomposition and distintegration, such digestion is accompanied with the production of a combustible gas containing methane as a substantial constituent thereof.

The present invention primarily relates to apparatus or instrumentalities usable for or in connection with the biological digestion of sewage sludge and its analogues and one of the objects thereof is to construct in commercial practical form an apparatus or instrumentality useful in the treating of the sludge and so that during said treatment the gas developed and given off as the process progresses can be collected and handled.

The apparatus which is the subject of the present invention embodies agitating or mixing devices which will aid mixing conducive to the seeding action referred to herein and which hastens the production of the methane gas due to the bacterial action which takes place as the sludge digestion process goes on.

The invention according to one aspect thereof relates to the providing for use in connection with a sewage sludge digester tank, of a vertically yieldable or vertically movable structure or unitary top assembly comprising (*a*) a sheet metal gas holding type of top with depending marginal flange or peripheral wall; (*b*) a bracing and guiding means providing a centrally located vertically extending strut rigidly connected and depending from the sheet metal top and serving if desired as a vertically movable center guide element, and tie rods or connecting members extending from the marginal portion of the sheet metal top downwardly and inwardly to the lower end portion of the center strut; (*c*) one or more off-center sludge stirring devices each extending downwardly into and through an intermediate opening provided in a section of the sheet metal top member between the center strut and the marginal flange, and essentially comprising a vertically extending driven rotatable shaft carrying one or more sludge impelling or stirring elements, a base member normally seated on the sheet metal top and having a gas-tight seal through which the shaft extends and serving as a closure cap for the corresponding intermediate opening; (*d*) a steady bearing construction at and for the lower end of each shaft; and (*e*) an arm construction providing an arm for a corresponding sludge stirring device, each said arm extending outwardly, that is, horizontally from the lower end portion of the central strut, carrying at the outer end thereof a fixed member of the steady bearing construction, deriving support from the strut because of being directly connected to the lower end portion of the latter, and preferably supported against downward deflection of the outer end thereof by a connecting brace extending upwardly and inwardly from the outer end

portion of the arm to an upper portion of the central strut.

The unitary top assembly is preferably made so as to permit ready removal and ready replacement of a sludge stirring device and therefore a sheet metal top is employed which is preferably provided with a depending intermediate flange along the marginal defines of an opening intermediate the central and marginal wall portion of the top. The base member or cap referred to is constructed so as to provide a suitable gas seal realized as by a gas sealing packing through which the stirring device shaft extends and this base or cap member preferably carries the shaft operating parts and is detachably secured to the sheet metal top thus permitting the sludge stirring device to be lifted as a whole from its normal position in respect to the sheet metal top. In furtherance of a practical construction wherein the feature of ready removal and replacement may be realized together with the attainment of suitable guiding for the lower end of the stirring device shaft, the steady bearing construction has been deliberately made so as to comprise a liftable member for, at and on the lower end portion of the shaft and liftable therewith and also a relatively fixed member which remains in place on its corresponding arm. In such a construction as that just referred to either the liftable member or the relatively fixed member of the steady bearing construction is provided with an inverted cone shaped or a cone shaped section for directing and for aiding in the proper seating of the one member on the other as the sludge stirring device is lowered into operative position.

Further aspects relate to the simplifying of the construction of the digester; to the reducing of the cost of its operation; and to the devising of means for preventing troublesome scum formation therein.

This application is a division of a parent application Serial No. 728,376 filed May 31, 1934, and which eventuated into Patent No. 1,989,589 granted January 29, 1935. In the parent application it was pointed out that digester liquor can be depended upon for seeding or inoculating fresh sewage sludge with anaerobic bacteria to initiate and to stimulate the bacteriological digestion thereof to a greater degree than can digester solids, when considered on a dry solids-content basis. Formerly it was believed that the ratio of digested sludge solids to the raw sludge solids was the determining factor in calculating the volume of seeding material required. With the aforementioned discovery in mind one aspect of the apparatus of this invention is to effect only such movements within the body of digesting sludge as will permit the heavier sludge solids to exist within a limited horizontal zone while otherwise the movement of the liquor is relatively unrestricted and is circulated throughout the entire mass in the digester of which the apparatus of this invention constitutes an important mechanical element. By the apparatus of this invention one is able to realize the selective and differential circulation of digester liquor and digester solids.

According to one and in certain respects preferred arrangement (or arrangements) of apparatus for realizing the basic aspects of the invention there is employed a primary digester (or primary digesters) having a vertically yieldable or vertically movable top or gas holder construction. In any event in realizing certain aspects of the invention there are employed with the gas holder or top member or cover of the primary digester agitating mechanisms known as turbomixers, to wit, mixing elements which are carried by and supported from the top member or cover of the primary digester.

In the arrangements shown herein, mixing devices are carried by the top of the primary digester and these mixing devices are relied upon for effecting a more or less constant mixing of incoming sludge with the sludge undergoing digestion and certain aspects of the present invention revolve about this construction of the gas holder and particularly about the construction of the yieldable top of the primary digester so that it will have the required movement. When the alkaline condition essential for the carrying out of the sewage digestion by anaerobic bacteria has been once established that condition will not be upset by incoming fresh sludge, even though the incoming fresh sludge may have an acid characteristic, because the immediate intimate mixing of the incoming sludge through the alkaline body of digesting sludge ensures the preponderance and prevalence of the alkaline characteristic and anaerobic bacterial activity.

The invention possesses other objects and features of advantage, some of which with the foregoing will be set forth in the following description.

In the following description and in the claims parts will be identified by specific names for convenience but they are intended to be as generic in their application to similar parts as the art will permit. In the accompanying drawings which constitute a part of this specification there have been illustrated the best and most characteristic embodiments of the invention known to the undersigned but such embodiments are to be regarded as typical only of many possible embodiments and the invention is not to be limited thereto.

In said drawings Fig. 1 is a diagrammatic view illustrative of a sewage system embodying two sedimentation tanks either or both of which can be relied upon to receive a stream of sewage and from either or both of which at will sewage sludge derived as a result of a settling operation carried out therein can be passed to a primary digester as operative conditions permit and wherein the major portion of a sewage sludge digesting operation is carried out and from which primary digester sewage sludge that has undergone the digestion operation carried out therein is passed to the secondary digester in an amount corresponding to incoming sewage sludge as and when the latter is passed to and into the primary digester.

This figure embodies the arrangement of the yieldable top primary digester and of the vertically movable top secondary digester as connected up and disclosed in relation to the primary and secondary digesters of Figs. 3 to 15 inclusive.

Fig. 2 illustrates razzle-dazzle or circumnutatory current movements which are set up or established when a wobdless tilted-type of impeller element in submergence is rotated about an upwardly extending axis of a vertical shaft carrying the same.

Figures 3 and 4 are respectively vertically sectional and plan views of a multiple digester.

Fig. 5 is a vertical sectional view partially broken away showing the relative arrangement and position of certain parts of the primary digester in respect to certain other parts of the secondary digester and more particularly the relative position of certain overflow constructions provided for the primary digester in respect to

certain overflow constructions provided for the secondary digester.

Fig. 6 is a perspective view illustrative of the overflow arrangements of Fig. 5. In Figs. 3 to 6 inclusive the overflow arrangements for the secondary digester are shown functioning in a horizonal path 180 degrees from the position which the same parts occupy in Fig. 1.

Fig. 7 is a vertical sectional view taken as on the plane indicated by the line 7—7 of Fig. 5 looking in the direction of the arrows, this Fig. 7 being a vertical sectional view showing the overflow arrangement for the primary digester in respect to the inlet end of a pipe or conduit leading to the secondary digester.

Fig. 8 is a vertical sectional view taken as on the plane indicated by the line 8—8 of Fig. 5 looking in the direction of the arrows, this Fig. 8 being a vertical sectional view showing certain overflow arrangements for the secondary digester in respect to the inlet end of a pipe or conduit for conducting the relatively clear effluent liquid to a place for the disposition of the same.

Fig. 9 is a perspective view of the vertically movable top member or gas holder used in the primary digester but it will be understood that the main features of this gas holder as embodied therein may also be embodied in the gas holder employed in the secondary digester. There is not included in Fig. 9 the mixing devices carried by the gas holder.

Fig. 10 is a view partially in section showing the mixing device and the manner in which it is applied to the gas holder of Fig. 9.

Fig. 11 is a partial sectional view taken as on the plane indicated by the broken lines 11—11 of Fig. 3 looking in the direction of the arrows.

Fig. 12 is a vertical sectional view taken as on the plane indicated by the line 12—12 of Fig. 11 looking in the direction of the arrows.

Fig. 13 is a plan view of an impeller element used in the mixing device of Fig. 10.

Figs. 5 to 13 inclusive are shown at a much larger scale than the same parts are shown in Figs. 3 and 4 and it will also be noted that Fig. 1 is at a smaller scale than any of the other figures.

Fig. 14 shows a primary and secondary digester construction that functions practically the same as the digesters shown in Fig. 3 except that in Fig. 14 the gas holder of the primary digester is shown as a floating cover arrangement that is provided with a pontoon construction that defines the peripheral wall thereof. In Fig. 3 each of the gas holders is shown as resting on stops—to wit, a position below that which they occupy in normal operation.

Fig. 15 shows a construction wherein primary and secondary digesters are employed that function much the same as the digesters in the arrangement of Figs. 3 and 14 but in the primary digester of Fig. 15 the normal position for the yieldable top is that which it occupies when resting upon the stops. In other words the yieldable top of the primary digester of this figure leaves the stops only due to a decidedly abnormal condition existing within the digester and in which instance it is free to yield or move upwardly.

Reference will now be made to the drawings in detail.

Like reference characters indicate parts functioning the same or substantially alike wherever they appear.

In the arrangement indicated in Fig. 1 the incoming sewage supply is designated by SS. The sewage from this supply is passed at will as along the path 1 to the clarifier, sedimentation tank, or sedimentation basin 2 or as along the path 3 to the clarifier 4. Settled sludge is withdrawn at will from one or both clarifiers as along the path 5 or the path 6 as the case may be and is delivered intermittently by means of sludge pumps 7 and/or 8 ultimately along the path 9 that terminates in feed pipe 145 to and into the primary digester 110 constituting part of a multiple digestion system that also comprises the secondary digester tank 111 arranged to receive intermittently from the primary digester sludge which is undergoing digestion and in an amount which is equal to the amount as and when fed into the primary digester for treatment. This tank 111 and its equivalents, while herein are referred to as secondary digesters, are primarily for carrying out sedimentation and secondarily for carrying out digestion.

Each of these digesters comprises a digester tank and an associated gas holder or gas collector. The tank of the primary digester is designated by 112 and its associated gas holder or collector by 113. The tank for the secondary digester is designated by 114 while its associated gas holder or collector is designated by 115.

As previously indicated piping or other passage is provided whereby partially digested sludge can pass from the primary digester to the secondary digester as is required incident to the supplying of the incoming sludge to the primary digester. Piping is also provided whereby the gas receiving spaces within the two digesters are in communication with each other during all normal periods of operation. These piping arrangements will later be described more in detail.

Also as previously indicated the digester arrangement of the system of Fig. 1, to wit, the arrangement of the primary and secondary digesters thereof as constructed and connected, is essentially that of the arrangements of Figs. 3 to 15 inclusive. The early work in connection with the actual carrying out of certain basic aspects of sewage digestion and which led to the development of the present invention is illustrated in Figs. 2 to 5 inclusive of said already issued Patent 1,989,589.

On that early work there was employed sludge agitating mechanism which may be operated intermittently or continuously as desired. Such early mechanism comprised a rotatable vertical shaft preferably mounted off center in respect to the digester tank, in which it functioned. The shaft was rotated from the motor through speed reducing gearing, and carried a plurality of impellers or propellers constituting sludge agitating elements arranged at different elevations. One of the impellers was mounted on the shaft near to but below the normally maintained minimum liquid level in the tank in a tilted relationship to said shaft, that is, the plane of rotation of the impeller was such that it effected a non-horizontal flow or current movement, to wit, movements which are not at right angles nor in a plane normal to the axis of the vertical shaft. The other impellers spaced along the shaft were located in a horizontal position and effect flow or current movements in planes normal to the axis of rotation of the vertical shaft. The function of the impellers that were horizontally mounted, was to agitate the particles of the sludge in the tank in horizontal zones, while that of the top tilted impeller was to discourage if not to prevent the formation of scum in the zone of

the liquid level in the digester by razzle-dazzle or circumnutatory flow or current movements which convectively carry scum particles rising to and which would otherwise tend to float and collect at the top of the body of digesting sludge to submergence within the sludge whereby the scum particles ultimately become digested. In this way the collecting and formation of scum was eliminated and avoided. The effect of this agitation with its consequent hindering of the formation of a floating scum layer and a deposited sludge layer or blanket was to ensure that the entire sludge mass in the primary digester was brought into a relatively homogeneous condition by virtue of which portions of said sludge mass withdrawn from the said digester for further or dewatering treatment have on the average substantially the same proportion of liquid and solid constituents as said sludge mass.

In the apparatus of the early work primary and secondary sludge digesters were employed and partially digested sludge from the primary digester was suitably conveyed to the secondary digester or digestion zone or tank. This secondary tank was of the sedimentation type since the function of this tank was primarily to thicken the sludge and to obtain a clarified supernatant therefrom and secondarily to finish the biological digestion of the sludge from the primary digester. The tank 27 was therefore sometimes referred to as a sedimentation tank or basin for in it there was maintained predominant essentially quiescent conditions as required for sedimentation without concurrent predominating conditions conducive to digestion. Accordingly, digesting sludge from the primary digester was fed to the secondary digester through suitable piping.

In the early demonstration plant as to which the showing of Figs. 2 to 5 of said Patent 1,989,589 is illustrative the primary tank was 29 ft. in diameter and 15 ft. deep. The impellers were of the weedless type and 20 inches in diameter. They were run at a speed of 120 R. P. M. although speeds up to 600 R. P. M. may be used.

In the primary digester, the lower impellers caused horizontal rotation or agitation of the sludge mass to produce thorough mixing thereof in and throughout the horizontal section or stratum affected thereby. The resulting turbulence causes an evolution of gas, which in rising to the top of the digester, tends to form scum adjacent the liquid level thereof. This tendency to form scum is particularly discouraged, if not overcome, by the action of a tilted impeller (typified by impeller 23 of Fig. 2) which set up a razzle-dazzle action or circumnutatory flow current in the digesting sludge as indicated in Fig. 2, and serves to beat back or diffuse the scum particles and any liquor which may rise to the top of the digester into the digesting and horizontally agitated mass or sludge.

Reference will now be made in detail to the later or other developments wherein the novel yieldable and movable top constructions embodying the present invention in association with digester tanks are employed. It will be understood that for an amplification of any part or description which has been eliminated, foreshortened or amended that reference may be made to the disclosure in the specification of Patent 1,989,589 since the disclosure in the application of this patent is the same as the disclosure of the application Serial No. 728,376 from which said patent eventuated.

The construction of the associated digesters of Figs. 3 and 4 will now be described and more particularly in conjunction with reference to Figs. 5 to 11 inclusive. The tank 112 of primary digester 110 is made of concrete. It comprises a floor or bottom portion 116 and peripheral upstanding wall 117 the latter of which carries at the upper interior portion thereof an inwardly extending stop ring or corbel 109 providing a stop for the gas holder or gas holder construction 113 and for supporting the latter in a lowermost position therefor at the upper interior portion of the tank. This stop ring or corbel 109 serves to prevent the loss of gas through the liquid seal around the holder by deflecting rising gas bubbles from the liquid sealing section. The tank 112 is also provided with a vertically extending centrally located guide post 118 which is fixedly secured at 119 relative to the floor of the tank structure.

The gas holder 113 is provided by a vertically yieldable and in fact a vertically movable structure which comprises a sheet metal top 120 and a depending peripheral wall 121, a vertically extending centrally located strut 122 and downwardly inclined connecting members 123 which extend from the peripheral wall 121 inwardly and downwardly to a place where they are connected to the vertically extending strut member 122. This vertically extending strut member 122 is preferably tubular in form and has a vertically sliding engagement with the guide post 118. See in this connection the arrangement in Fig. 11 wherein the post 118 is shown as carrying anti-friction rollers 108 that engage an interior section of the strut or guide tube 122. This strut member 122 has a dual function, it serves in conjunction with guide post 118 to guide the vertical movement of the gas holder 113 and to ensure that the top 120 thereof shall maintain a desired horizontal arrangement for all positions thereof. It also serves to reinforce and support the top 120 when the gas holder is resting in its lowermost position. This provides a construction for preventing the top 120 from buckling, bending or collapsing incident to external air pressure exerted on the gas holder.

The top member or portion 120 of the gas holder is in the form of an umbrella cover or inverted saucer. More specifically and more accurately it may be described as preferably in the form of a top section of a hollow sphere, the periphery of which section is in plan a true circle.

The gas holder however need not be circular in horizontal cross section as any other geometrical form which in horizontal cross section presents a symmetrical arrangement could be employed as for example one showing a hexagonal, octagonal or other symmetrical form. Moreover the top member or top construction of the gas holder need not be in the form of a sphere top, of an inverted saucer, or resembling that of an umbrella top since any suitable geometrical form could be employed, be it that of a cone, of a pyramid, a frustrum of a cone or a frustrum of a pyramid. An essential factor is that the top member or top construction of the gas holder shall be hollow so as to have a concave portion at the under side and which is well constructed to withstand either internal or external pressures as and when applied thereto.

The peripheral wall 121 of the top holder de-

pends downwardly from said concave top section or inverted saucer shaped top member. This peripheral wall may be defined as a peripheral ring or member which has a gas-tight connection or union with the top member whereby a gas-tight top construction for the holder is provided. This peripheral ring or wall 121 is of metal and is loaded with concrete ballast 107. This concrete ballast is relatively heavy and the function thereof is to place a relatively progressive and increasing load on the gas holder particularly as the gas holder rises sufficiently to lift the concrete ballast so that it projects above the sealing liquid whereby a progressively and substantially increasing load is imposed upon the movable holder according to the amount of ballast projected above the liquid level. In the lowermost position of the gas holder the lower edge portion of the peripheral wall or ring 121 rests upon the stop ring or corbel 109. An inspection of the drawings will make it clear that this stop ring is positioned so that the gas holder even in its lowermost position is located adjacent to the upper portion of the primary digester and also that the vertical movement of the gas holder during any normal operation thereof is small or relatively limited particularly as compared with the vertical movement of the gas holder for the secondary digester, as will presently appear. As previously indicated, according to and within the broader aspects of the invention, it is feasible to construct the primary digester so that the gas holder thereof can have a long range of movement and so that the gas holding capacity thereof can be relatively large.

The strut member 122 heretofore described as a tubular member is provided with openings 106 at the top end thereof whereby any pocketing of gas that might otherwise affect the movement of the gas holder is avoided.

Mixing devices or sludge impelling mechanisms 124, frequently referred to as turbo-mixers, are carried by the gas holder so as to be vertically movable therewith. The arrangement of these mixing devices is clearly shown in Figs. 3 and 4 and the general construction thereof and mode of mounting the same is clearly shown in Figs. 10 to 16 inclusive. The mixing device (or devices) 124 is similar in essential operative characteristics to the mixing device or sludge impelling mechanism previously referred to in connection with the early system of Figs. 2 to 5 inclusive of said Patent 1,989,589. Each of these mixing devices 124 comprises a base 125 which is detachably secured to the top 120 as through the medium of bolts 126 and in a manner whereby a gas-tight joint is provided as between the top 120 and the base 125. Upon this base 125 there is carried the housing 127 of an electric motor 128 the rotor of which is connected so to drive through the medium of suitable gearing and coupling 129, a vertically extending shaft 130 of the mixing device so as to effect the normal rotary movement of the latter. Suitable gas-tight packing 131 is provided below said coupling 129. In the immediate region of each mixing device a depending ring 132, which is circumferentially arranged with respect to the shaft 130, depends from the cover a sufficient distance to extend into the liquid or digesting sludge maintained up to a minimum level within the primary digester when the latter is functioning. The purpose of this depending ring 132 and liquid seal resulting from the use thereof is to provide an arrangement whereby, at will, the mixing device as a whole can be removed from place without allowing the escape of gas from the holder by merely removing nuts from the bolts 126.

Each mixing device is provided with non-clogging impellers as 133 in vertically spaced arrangement. Each of these impellers comprises a hub section 134, a body section 135 arranged in an inclined position in respect to the hub axis whereby when the impellers are in place the bodies are tilted at a slight angle from the horizontal and each impeller also includes vanes or blades 136 for producing impeller effects in directions away from the axis. The inclination of the body as it rotates produces vertical components of flow movements while the vanes or blades produce horizontal components of flow movements and the functioning of these impellers produces what may be referred to as the razzle-dazzle or circumnutatory motion or mixing action within the liquid body affected thereby. The functioning of these impellers, which are also offset or eccentrically located in respect to the general axis of the tank as is manifest from Figs. 3 and 4, produces what may be generally termed epicyclic type of currents or movements throughout the various sections of the liquid body.

Some or all of these impellers are frequently made and employed so that the body section thereof need not be inclined to the hub axis with the result that the body section and the impellers move in true horizontal paths thus avoiding most or much of the vertical components which are experienced where the body is inclined to its axis. Impellers with bodies at right angles to their axes are useful in the lowermost layers of the sewage sludge but it will be pointed out that the impellers with the bodies inclined to their axes of rotation are particularly useful in the upper layers of the sludge since the operation thereof assists in breaking down scum and in the thorough mixing of the tank contents in such a manner that the accumulation of scum at the upper interior portion of the primary digester is avoided due to scum particles being swept by the razzle-dazzle currents back to submergence within the body of digesting sludge.

The mixing devices as illustrated herein have been described in considerable detail and as previously indicated function as non-clogging impellers or in other words are of the non-clogging type. It is feasible to construct each impeller so that it primarily comprises or consists of a body or hub portion and blade members, which body or hub portion is secured to the vertical extending propelling shaft to which the impeller corresponds and which blade members extend outwardly from said body or hub portion. Such blade members may be considered as compositely defined by the upper and lower blade elements heretofore described. The blade elements function to effect a forced or circulatory movement of liquid away from the shaft particularly since there is no peripheral restraint against outward flow because there is not any ring or other restraining member located at or in the immediate vicinity of the periphery of the impeller.

As to the impellers herein shown some have body members in effect provided by plates that extend at right angles to the axis while some have body members in effect provided by plates that are inclined to the axis about which they are rotated. It is feasible, however, to construct impellers that will function along the same lines as the impellers herein illustrated and this even though the plate portions just referred to are not

necessarily employed. By bearing in mind the particular work to be done by a particular impeller it is merely a matter of design to construct the impeller to do the work desired therefor.

The lower ends of the mixer shafts 130 are provided with removable steady bearings each of which includes a bearing member 137 that is retained upon the shaft 130 and which is removable therewith because of spaced collars 138—138 which are secured to the shaft. In this connection see Figs. 10, 11, and 12. Each bearing member 137 has an outer section 105 in the shape of a frustrum of a cone whereby it readily sets or positions itself in place on the conical seat section 139 which is carried at the outer end of the corresponding extension arm construction 140 that includes parallel channels 141 and 142. The intermediate sections of these channels are secured in any suitable manner as by welding at 143 to the vertically extending strut member 122. Braces 144 are relied upon for firmly supporting the outer ends of the arm construction 140 against downward deflection. It will be noted that the outside diameter of each impeller 133 and of the removable steady bearing member 137 is less than the inner diameter of the depending ring 132 with the result that the mixing device 124 as a whole can be readily removed and replaced at will solely by the operator removing nuts from the bolts 12 and vertically moving the mixing devices from or towards its normal position in respect to the gas holder top.

The primary digester receives the sewage sludge to be digested in any suitable manner as through the feed pipe 145 which it will be noted according to the arrangement shown delivers the incoming or influent sewage sludge into the upper interior portion of the primary digester tank, preferably through a section of the feed pipe 145 which is located somewhat below and which extends past the supporting surface at the top of the stop ring or corbel 109.

Sewage sludge, which has been treated, passes from the primary digester through a discharge section 146 into a discharge pipe or conduit 147 having a valved branch 148 and an upwardly extending branch 149 the latter of which terminates in an adjustable overflow or weir construction 150 that is relied upon for ensuring that the minimum level of the body of sewage sludge retained in the primary digester shall always be at least up to the height determined by the overflow. For the details of the overflow arrangement of both the primary and secondary digesters see particularly Figs. 5 to 8 inclusive.

In the normal functioning of the primary digester the valved branch 148 is closed whereby all of the sludge passing from the primary digester must pass through the overflow branch 149. It will also be here noted that as sludge is supplied to the primary digester for treatment therein a corresponding amount of sludge which has undergone digestive treatment in the primary digester passes therefrom through the overflow branch 149 on its way to a secondary digester as will hereinafter more clearly appear.

The primary digester also has a gas offtake piping or conduit 151 the upper intake end 152 of which extends into the gas receiving space which is always maintained within the upper interior portion of the primary digester, to wit, into the gas receiving space at the under side of the gas top 120 on the one hand and the top of the body of sewage sludge maintained within the primary digester on the other hand. This gas piping 151 extends into the secondary digester and terminates in a pipe section 153 the upper end of which extends into a gas space provided in the upper portions of the secondary digester with the result that during the normal functioning of the digesters the gas spaces of both digesters are in constant communication. The upwardly extending delivery end portion or pipe section 153 derives support from the floor of the tank of the secondary digester through the medium of supporting rod 153'.

The primary digester is also preferably provided with a normally closed depending pipe 154 (see Fig. 3) that always dips into the sludge within the primary digester but which is arranged to provide a sampling opening by which ready access for sampling purposes is realized.

The primary digester is provided with heating coils 155 which are useful in ensuring sufficient heat to the sewage sludge to facilitate the digestion that is carried out therein. The gas holder is secured against horizontal rotation relative to the tank through the medium of chains 156 and 157 which are referred to as tangential guides.

The secondary digester 111 is shown larger than the primary digester and comprises a secondary digester or sedimentation tank 114 provided with a downwardly and inwardly inclined bottom 116 and upstanding peripheral wall 117 carrying spaced stops 161. The secondary digester has a vertically yieldable or vertically movable gas holder 115 that comprises the umbrella shaped top sections 163 from which there depends the peripheral wall 164 preferably carrying at the lowermost edge thereof a ring of concrete ballasting material 165. The peripheral wall 164 of the gas holder when the latter is in lowermost position rests upon the stops 161. The general construction of the gas holder of both digesters is substantially the same in that each comprises a centrally located vertically extending strut as 122 for the primary digester or 166 for the secondary digester and inwardly and downwardly extending tie rods or connecting members as 123 for the primary digester or 167 for the secondary digester, which rods or members serve to support the lower end of the centrally located strut corresponding thereto. The lower edge portions of the peripheral ring 164 are supported against inward collapse by radial strut members 162 the inner ends of which rest upon and are secured to the strut 166. The strut 166 in the secondary digester is also a tubular member having vent holes 158. The guide member or tube 169 slides along a fixed vertically extending guide post 168 which is positionably secured in place in respect to the masonry providing the floor of the secondary digester tank. By this construction the secondary gas holder is guided throughout the entire range of its normal vertical movement and the strut construction also serves to interiorly support the plate top section of the digester against internal buckling or collapsing should there be realized a decrease in pressure within the tank and an excessive unbalanced pressure on the outside of the tank.

Reference has heretofore been made to the valved branch 148 of the primary digester. This branch is connected to a T or cross pipe fitting 169 leading for example to a sludge pump as along path 100 or to a place for other mode of sewage solids disposal as along the path SB to a sludge bed.

The tank of the secondary digester has a solids

discharge section 170 leading to a valved sludge pipe or conduit 171 which terminates in a T pipe fitting 169. It will therefore be apparent that the piping which includes the pipe 147, cross fitting 169 and pipe 171 when the valves are open can be employed for the direct passage of sewage sludge from the primary digester to the secondary digester. Normally the valves are closed so this direct transfer cannot take place. Upon the opening of either the valved pipe 147 or the valved pipe 171 it will be manifest that sludge can be pumped at will from the primary digester or secondary digester to and through the cross fitting 169, thence along the path 100 by a pump as 7 or 8. See Figs. 6, 4, 3, and 1. It would also be possible to effect a reverse pumping action to unplug the valved pipes 147 or 171 should occasion require. The secondary digester normally functions over an extended period without the withdrawing of sludge and then at the proper time the deposited solids remaining after the digestion and sedimentation carried out therein are removed through the pipe 171. This removal of sludge solids of course effects a lowering of the normal water level within the secondary digester and this is accompanied by a lowering of the gas holder. In order to avoid lowering of the liquid within the secondary digester in such a manner as to unduly reduce the gas pressure therein whereby too great a differential as between the exterior air pressure and the internal pressure will take place—so great a differential as will tend to cause the gas holder to collapse or fail—there are provided certain ordinary check arrangements as follows: a sludge check or ball valve 172 that is carried by chains 173 is provided and which sets itself in the solids discharge section 170 slightly before or at least by the time that the secondary gas holder reaches its lowermost position; also a gas check comprising a valve or pipe closing member 174 supported at the upper end of rod 175 arranged to effect a closing of the upper end of the gas pipe or conduit 153 at or by the time the secondary gas holder reaches its lowermost position with the result that communication between the digesters is shut off and also with the result that further withdrawal of gas from the secondary digester cannot take place. A sealing ring 160 depends from the top member 163 of the gas holder for the secondary digester (see Fig. 5). This sealing ring dips into the sludge liquid within the secondary digester when the gas holder is in its lowermost position and provided the liquid is up to the minimum height as determined by the overflow weir construction for the secondary digester. Under such conditions access to the valve 174 is afforded without allowing the escape of gas from within the secondary gas holder. Likewise a similar sealing ring 159 is provided at the under side of the top portion of the gas holder for the primary digester. The sealing ring 159 dips into the sewage sludge when the gas holder is in its lowermost position. Under the conditions specified—with the gas holders in their lowest position—the flow of gas therefrom into the gas pipe 151 is prevented.

It has heretofore been pointed out how the sewage which has undergone treatment in the primary digester passes therefrom by the overflow 150 as sewage sludge to be treated is supplied to the primary digester through the feed pipe 145.

An inspection of Figs. 6 to 8 inclusive will make it clear that the digesting sewage sludge which passes the overflow 150 enters the receptacle or trough 176 and flows therefrom through a pipe 177 that delivers the sewage to the secondary digester and more particularly into the lower section of the liquid body maintained within the secondary digester.

These figures also show a second overflow pipe or conduit 178 leading from the primary digester and terminating in the adjustable overflow section 179 that is somewhat higher than the overflow 150. This second overflow, 178 and 179, is provided in case the overflow branch 149 which terminates in overflow 150 becomes plugged or unduly loaded, thereby avoiding any undue excess of liquid level within the primary digester during the normal operation thereof.

The secondary digester has an overflow construction relatively remote from the place where sewage sludge is introduced into this secondary digester as will be seen from an inspection of Figs. 3 to 10 inclusive. The overflow arrangement for the secondary digester comprises an offtake or outflow pipe or conduit 180 leading from below but near the upper normal water level for the body of liquid within the secondary digester as is determined by the overflow arrangement for this digester. This pipe or conduit 180 leads through the wall of the digester and terminates in an adjustable overflow or weir section 181 for determining the maximum normal water level within the digester. The upwardly extending intake end section of the pipe or conduit 180 derives support from the floor of the tank of the secondary digester through the medium of supporting rod 180'. In case this pipe construction 180 or 181 should become plugged or ineffective there is provided an auxiliary overflow or outflow pipe 182 that terminates in an adjustable overflow or weir 183 the latter of which is somewhat higher than the overflow 181. For convenience and comparison the overflow arrangements of the primary and secondary digesters have been brought into close relationship in Figs. 5 and 6. Overflows 181 and 183 of the secondary digester deliver into a tank or receptacle 184 from the bottom of which there extends a pipe or conduit 185 for conducting the relatively clear delivered effluent to such place of use or disposal as is deemed desirable. The normally functioning overflow 150 for the primary digester occupies a higher elevation than the normal overflow 181 or even the overflow 183 for the secondary digester and it will be apparent that when the liquid level within the secondary digester is up to the normal maximum level as determined by overflow 181 that a feed of sewage into the primary digester simultaneously effects a flow of a corresponding amount of treated sewage from the primary digester into the secondary digester and a corresponding flow of relatively clear effluent from the secondary digester past the overflow 181 thereof. The secondary digester is preferably provided with sampling pipes 186, 187, etc., where samples from the various levels within the secondary digester can be readily obtained. The secondary digester has any suitable sway bracing and guides such as are provided for example by sway chains 188 and 189 and by the vertical guideways indicated at 190.

In certain localities where freezing may take place arrangement is made for employing a removable seal heating coil pipe as at 191 for the primary digester and as at 192 for the secondary digester whereby the sealing liquid or sludge around the gas holders will not become frozen

and thus prevent a moving or yielding of the holders. Each gas holder is also preferably provided with a normally closed manhole such as indicated at 193 for the primary digester or at 194 for the secondary digester.

The combination of primary and secondary digesters as just described in detail particularly as shown in section in Fig. 3 typifies the construction of the primary and secondary digesters employed in the system of Fig. 1. A somewhat better or more comprehensive understanding, however, is obtainble upon a further consideration of the arrangement and operation of the parts as outlined in Fig. 1 and therefore a more detailed statement in respect to said figure is now set forth.

The reference character "V" which appears in several places on the drawings indicates a valve which can be opened or closed to permit a flow therethrough or to shut off a flow past the same according to the desires of the operator.

Water supply pipes are indicated on the system by W and are provided whereby water is available if desired for any particular purpose.

WL indicates the normal minimum liquid level within a particular digester as determined by the overflow or weir construction associated therewith.

As previously stated the sewage supply to be treated passes from SS along a path 1 or 3 as the case may be, to a clarifier or thickener 2 or 4 wherein the sewage sludge is settled out and from which the sewage sludge thus settled out is withdrawn for passage to the primary digester 110. It is well within the contemplation of the present scheme that chemical treatment or even aeration of either the raw sewage prior to sedimentation in the clarifier 2 or 4 or of the sewage sludge therefrom can be carried out.

The effluent from the clarifier is passed therefrom as along the path 2A or 4A for such disposition as may be desired for a particular plant. Any scum collecting at the top of the clarifier may be passed therefrom as along the path 2B or 4B to a point where it will join the sludge from the clarifier.

Sludge pumps 7 and 8 are connected in the piping system that includes the pipe lines 5 and 6 whereby at will either one of the pumps can be operated to function in the pumping of sludge from either of the clarifiers or whereby if desired one pump can be pumping from one clarifier while the other is pumping from the other clarifier or whereby one of the pumps may be pumping from one clarifier while the other of the pumps may be pumping sludge solids from the secondary digester as will hereinafter more fully appear.

Either or both of the pumps 7 and 8 can be relied upon as desired to pass sewage sludge into the primary digester through the feed pipe section 145 thereof or at will either or both of the pumps can deliver liquid pumped thereby along the path 9B for such use or disposition as desired or as along the path 9A as for example to a sludge receiving bed along the path marked SB.

From Fig. 1 it will be seen that the suction side of either or both of the pumps 7 and 8 can at will be connected through the medium of pipe line 100 in a manner to draw or pump sludge solids from the secondary digester 111 or even to pump sludge from the primary digester 110.

In the normal functioning of the system this line 100 is closed and the normal functioning of the pump or pumps then is to deliver raw sewage sludge into the primary digester thereby forcing or else causing a feeding of sludge which has undergone digestion from the primary digester into the secondary digester and, providing the liquid level in the secondary digester is up to the minimum level to be maintained therein, there follows a flow from the secondary digester of relatively clear effluent which can be passed along the path 185 and branch 102 to one place for disposition or as along the branch 103 back into the raw sewage supply. If, however, it is desired to withdraw sludge from the bottom of the secondary digester either of the pumps can be employed for this purpose by opening the proper valve and the withdrawn sludge can be passed from the system as along the path 9B or 9A as desired and this can take place even though the other pump is functioning to supply raw sewage to the primary digester tank.

The arrangement whereby sewage sludge can be pumped from either of the digesters 110 or 111 through the pipe line 100 is clearly shown in Figs. 3, 4, and 6 and comprises the pipe 147 and valved control pipe 148 leading to the cross member 169 and the valved control pipe 171 also leading to the cross member 169. The gas piping or conduit which includes the parts 152, 151 and 153 previously referred to (and in this connection see Figs. 1, 3, 4, and 6) places the gas receiving portions of the primary and secondary digesters in communication and it includes a condensate trap CT whereby accumulating water may be eliminated from the gas line. The gas will be employed for heating by passing the same along the path 104 through condensate trap CT past meter M to the furnace of a hot water boiler 205 or directly to burners for lighting or other use as along the path 206. A pressure relief trap may be provided at 207. The hot water boiler includes a heating coil HC which is in a circulatory system that includes the heating coils 155 of the primary digester and which may also include the removable heating coils 191 and 192 provided for preventing any freezing of the seals in the primary and secondary digesters. The circulation may be maintained as by means of the circulating pump 208. In Fig. 14 there is shown an arrangement of primary digester and secondary digester each having a tank and associated vertically movable gas holder or top constructed so that the top for the primary digester has a relatively limited movement while the top for the secondary digester has a relatively long vertical movement whereby the latter can function as a gas storer as well as a gas collector. The functioning of the arrangement of this Fig. 14 follows very closely the functioning of the arrangement shown in Figs. 3 and 4 and therefore any extended description in reference to Fig. 14 is not necessary. The gas holder, however, of Fig. 14 is designated as 210 and it will be seen that there is associated with the sheet metal top or roof portion 213 thereof a buoyant peripheral ring provided by the hollow gas-tight annular section or pontoon 214 which is defined by the outer portion 215 of the top 213, the lowermost annular portion 216, an upright outer ring 217 and an inner ring 218. In Fig. 14 the gas holder 210 is shown resting on the stop ring or corbel 109 but in the normal functioning of the digester this cover occupies a slightly elevated position approximately that indicated by the dotted lines. It will be readily appreciated that this cover can have a slight vertical movement incident to any fluctuations of liquid level within the tank, also in response to variations in gas pressure conditions, but that the pontoon con-

struction provided by the hollow annular section **214** described is sufficiently heavy to effect a material loading of the top whereby any extended lifting movement of the top relative to the liquid and incident to fluctuation in gas pressures during normal operation is avoided.

In Fig. 15 there are shown a primary digester and secondary digester similar in many respects to the arrangements shown and described in conjunction with Figs. 3 and 4. According to the construction of Fig. 15, however, the gas holder of the primary digester is vertically yieldable but it is loaded so as to remain during the normal operation of the digester in the lowermost position therefor, to wit, at rest upon the stop ring or corbel **109**. In this figure the gas holder as a whole is designated as **310**. It comprises the umbrella shaped sheet metal top member or roof portion **313** and has a peripheral ring **317**, part of which ring depends from and part of which ring extends above the peripheral edge of the umbrella shaped portion **313**. At the exterior top peripheral portion of this gas holder or top member **310**, as at **318**, there is placed suitable weighting material as concrete which ensures weight somewhat in excess of that required for normally holding the cover in lowermost position on the stops and which functions in opposition to any buoyant effect of the sludge liquid within the tank **117** and against the normal gas pressures experienced within the digester. Otherwise than as indicated the arrangement of this Fig. 15 operates substantially along the lines described in connection with the arrangement of Figs. 3 and 4.

We claim:

1. A gas holder construction for use in conjunction with a sewage sludge digesting tank comprising in combination a top member having intermediate the central section and the periphery thereof apertured sections for receiving agitating means, a depending portion providing a peripheral flange having a gas-tight connection with the top member, intermediate flange portions depending from the intermediate apertured sections and having gas-tight connection with said sections, a vertical strut member extending downwardly from the central section of the top member, connecting members extending downwardly from the region of said peripheral flange to the lower end of said strut member, for each of said apertured sections an agitating means comprising a vertically extending shaft, impellers thereon and a seating member at the lower end thereof, arms outwardly extending from and carried by said strut, and seating members carried by said arms in the regions directly below the apertures of said apertured sections, which last mentioned seating members are provided for receiving and holding the corresponding seating members of the agitating means.

2. A gas holder construction as defined in and by claim 1 according to which the intermediate flange portions extend downwardly to an elevation which is lower than that of the lowermost edge portions of the peripheral flange.

3. A gas holder construction as defined in and by claim 1 according to which a hollow gas-tight annular pontoon is provided which includes the depending peripheral flange as a portion thereof.

4. A gas holder construction as defined in and by claim 1 according to which an annular concrete ballast is carried at the lower portion of the peripheral flange.

5. A gas holder construction as defined in and by claim 1 according to which the strut is a centrally disposed tubular guide post.

6. A gas holder construction as defined in and by claim 1 according to which the strut provides a centrally disposed guide post and according to which the outer ends of the supporting arms have inclined supporting connections extending therefrom upwardly and inwardly to an upper section of the post.

7. A gas holder construction as defined in and by claim 1 according to which the agitating means are removable and replaceable by vertical movement, according to which the seating member on each arm and the seating member carried by the shaft of the corresponding agitating means are constructed so as to provide conical seating surfaces for self-adjustment and automatic alignment of the associated shaft as introduced in place by vertical movement, and also according to which the seating member carried by its shaft is mounted so that vertical relative movement between it and its shaft can take place as the shaft is moved downwardly and incident to the last mentioned seating member coming into operative seating engagement with the corresponding seating member carried by the arms.

8. A construction as defined in and by claim 1 according to which the agitating means comprises a motor, according to which the vertically extending shaft is actuated through the medium of speed reducing gearing operatively located between the rotor of the motor on the one hand and the shaft on the other hand, according to which the shaft has thereupon at different elevations along the same impelling devices of the centrifugal type, and according to which the seating member on the shaft is mounted so as to permit not only rotary movement but also vertical movement as between the shaft and the seating member.

9. A gas holder construction for use in conjunction with a sewage sludge digesting tank comprising in combination a sludge stirring device; a sheet metal top member having intermediate the central section and the periphery thereof an intermediate aperture for receiving the sludge stirring device, a depending portion providing a peripheral flange having a gas-tight connection with the top member and an intermediate flange portion depending from the section defining the intermediate aperture and having gas-tight connection with said section; a vertical strut member extending downwardly from the central section of the top member; connecting members extending downwardly and inwardly from the region of said peripheral flange to the lower end portion of said strut member; said sludge stirring device comprising a vertically extending shaft driven from above the top member depending downwardly through the intermediate aperture and carrying sludge impellers located at the underside of the sheet metal top member; an arm construction providing an arm extending from said strut; and a steady bearing for and associated with the lower end portion of the shaft and carried by said arm in the region directly below the intermediate aperture.

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