THE GASLIFTER

A TIME-HONORED, PROVEN ANAEROBIC DIGESTER MIXING SYSTEM

by

Arthur C. Schlicht

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Walker Process Equipment
Division of McNish Corporation
840 North Russell Avenue
Aurora, IL 60506

PHONE: (630) 892-7921
FAX: (630) 892-7951

HISTORICAL

Walker Process Equipment developed the GasLifter in the mid-1950's, and since that time, there have been hundreds of installations.

The GasLifter is a confined gas injection system, using recirculated, compressed digester gas injected into an eductor tube to create an airlift effect, hence its name, "GasLifter."

Early on, it was deemed important to know exactly what the pumping capacities of the various sizes of eductor tubes at various gas rates actually exhibited, since classical airlift curves could not be used because these devices pump against virtually no head, contrary to the case with airlift pumps. These tests were conducted in full-scale digesters with clean water, using divers to monitor the flow through the eductor tubes, measuring velocities vs. gas flow applied. This ultimately led to the pumping capacity used from then on, 75 GPM/CFM gas applied, at 12' submergence.

SYSTEM DESCRIPTION

The basic GasLifter installation as recommended typically consists of a single, centrally located, floor-mounted eductor tube with individual gas lances, and is shown in Figure 1. The gas release point, regardless of the depth of the digester, is 12', permitting the use of a 7 psi gas compressor. In spite of the relatively shallow submergence, mixing is effected to the bottom of the digester because the recommended bottom-supported eductor tube extends to within 2’ to 4' of the bottom center of the digester, from which point the sludge is pumped.

The GasLifter has the following advantages over other gas-recirculation digester mixing devices:

1) The ability to use a maximum 7 psi gas compressor establishes the choice of a rotary positive gas compressor, negating the need for the more expensive and less efficient liquid ring seal compressors required by those who release gas at a much deeper submergence. Additionally, liquid ring seal compressors require water lines, which require maintenance of the control valves, and if exposed to freezing climates, require heat tracing to prevent freezing.

2) Each gas lance (Figure 2) is surrounded by a seal pipe, which permits any individual gas lance to be removed for inspection or infrequently needed cleaning of debris, without the need to dewater the digester or lose collected gas. Such is not the case with bottom-fed eductor tubes. Notice also that the diffuser has the “bottomless” feature, the tail pipe, which permits continuing operation in the unlikely event of orifice plugging.

3) The eductor tube enables the GasLifter to operate as a true pumping apparatus, which imparts a “rolling” action to the entire digester contents which mixes the contents while also suppressing scum, contrary to unconfined gas injection devices, which tend to simply bubble gas vertically rather than provide a strong pumping current.

Additionally, swirl vanes are located in the top of the GasLifter eductor tube, providing a rotational force to the digester contents, a feature that the unconfined gas injection devices cannot provide.

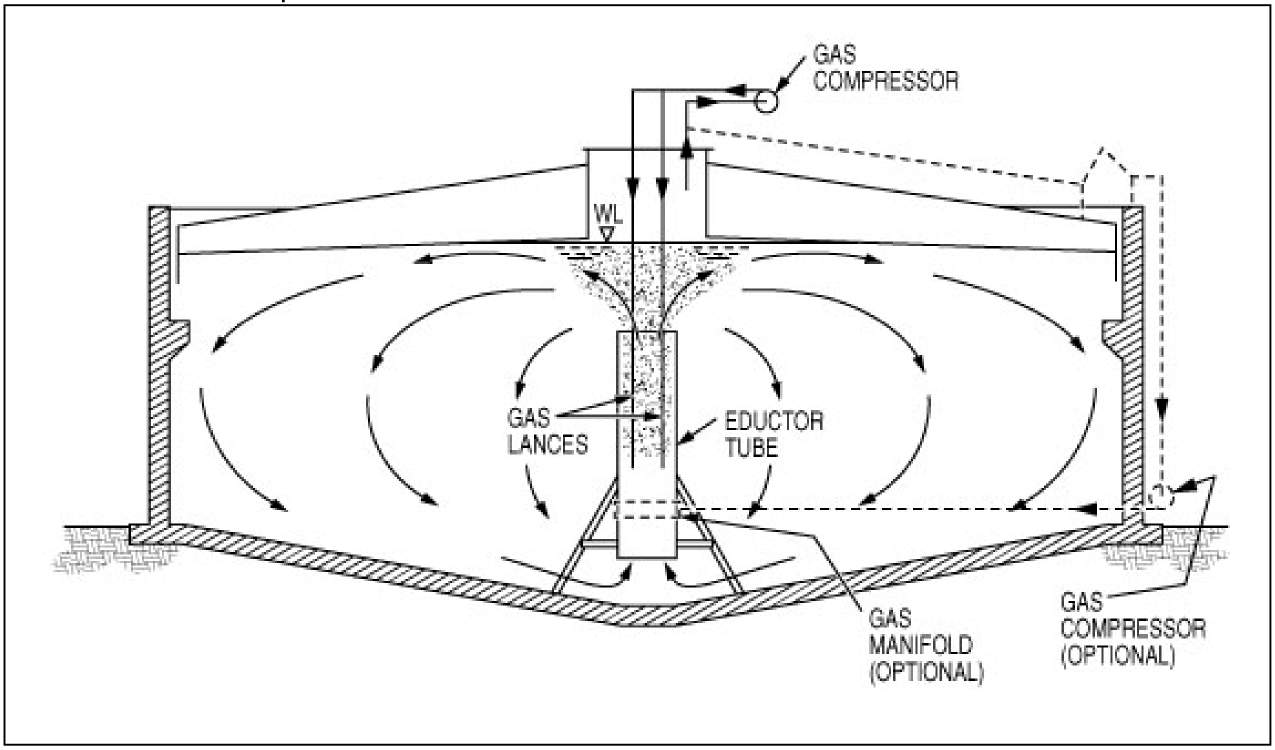

Figure 1

4) The eductor tube also permits a heating jacket to surround the tube when "in-basin" heating is preferred, rather than external heat exchangers. In this arrangement, a boiler is provided, and hot water is circulated through the heating jacket, providing heat exchange through the eductor tube wall while pumping occurs within the eductor tube. This arrangement is what we call the "DirecTube" GasLifter.

5) Competitive cover-supported unconfined gas injection devices, which rise above the digester bottom by the magnitude of the cover vertical travel (i.e.: the Pearth system, see Figure 4), fail to have any real effect on the tank bottom and even less so in their raised position. Contrarily, the bottom-supported eductor tube of the GasLifter always remains in the same position relative to the tank floor, thereby maintaining its most efficient effect on the floor of the basin.

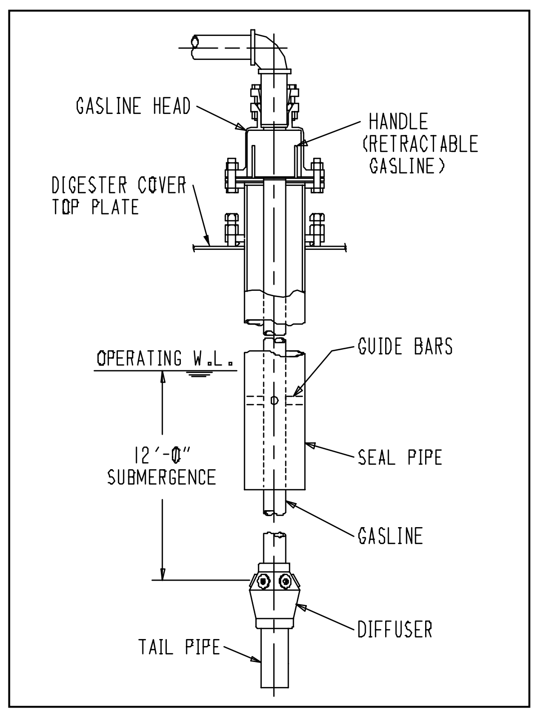

Figure 2

6) The gas compressor, housed with all its safety devices, electrical controls and moisture separators in an FRP housing, may be mounted on the digester cover, thereby eliminating the need for gas line penetration through the sidewalls of the digester, or the cumbersome flexible gas lines or pivot joint gas lines to allow for the range of cover travel. Only the electrical feed needs to be brought to the compressor housing with allowance for the cover travel.

7) Flexibility permits supply of the compressor housing to be located off the cover when desired, either on an adjacent building rooftop, or on a ground-level pad, but the cumbersome appurtenances mentioned above become a reality must necessarily now be used.

RECOMMENDED APPLIED POWER

Traditionally, Walker Process Equipment has recommended applied power based on the ability of the GasLifter to pump, through the eductor tube, satisfactory flow such that a turnover can be calculated. That is, the volume of the digester, expressed in gallons, divided by the pumping capacity, in GPM, equates to a turnover rate, in minutes. We recommend 20-minute turnover for thickened sludges, ranging to 30 minutes for unthickened sludges.

Other researchers have made recommendations based on HP/1000 cu ft, and on velocity gradient ("G" value), which align well with our recommendations. In a separate paper, we discuss these other recommendations, and compare these with our turnover rates; should you be interested in this discussion, a separate paper entitled "Digester Mixing Systems - Can You Properly Mix With Too Little Power?" is available for a more in-depth discussion.

From competitive experience, we know that others offer various types of digester mixing systems, which claim "greater efficiency" and promote devices consuming less horsepower, but the question exists as to whether buying into these claims will result in a well-mixed digester, or rather as good as it can be, short of entering the arena of diminishing returns.

It is also important to note, when comparing power input of competing mixing regimes, that intermittent operation can be realized with higher power input, such as 6 hours on, 6 hours off, or even 8 hours on (during complete staffing during the day), 16 hours off, whereas the power-starved devices must operate continuously. The advantage of the higher power input is that when mixing, especially when adding raw sludge, it is important to apply adequate power to thoroughly mix the digester, and at the same time have the ability to save power during the off cycle. This can be easily accomplished by the use of a programmable timer, and/or interlocking the GasLifter with the raw sludge pump starter.

Also, when comparing power applied, it is mandatory that useful power be considered, not motor HP. In the case of gas injection systems, the adiabatic HP must be considered, whereas mechanical devices, such as rotating impellers or recirculating pumps, must subtract the inefficiency of the drive train, piping losses, etc. to arrive at the useful power input.

DIGESTER GEOMETRY

The geometry of the digester is important when considering the overall effect of the mixing regime. That is, a "pancake" shape, say 80' Dia. X 14' SWD with 1":12" floor slope is not an ideal shape with a single centrally-located eductor tube, but an 80' Dia. X 25' SWD with a 3":12" floor slope would be ideal.

Given a reasonable side liquid depth and adequate floor slope, our experience is that a single eductor tube in the center of the digester will properly mix a digester, in sizes through 100' Dia.

Data is available on solids and temperature dispersion from an 80' Dia. X 18.5' SWD digester with a 1.2":12" floor slope, with 23.4 minutes turnover from a single centrally-located eductor tube, and the sampling done at 2' vertical intervals through a single sampling hatch. Solids concentrations were within 8% of mean, temperatures within 0.5 deg C, both of which are exemplary of a well-mixed digester.

Regardless of our own opinions, we are aware that opinions of others might vary in this regard. We can, and have, provided multiple eductor tubes spread around the digester floor to better suit the comfort of the client. We are flexible, and open to these varying opinions.

COMPETITIVE EQUIPMENT

Competitive digester mixing equipment falls into four (4) distinct categories:

1) Confined Gas Injection (as is the GasLifter);
2) Unconfined Gas Injection;
3) Mechanical Impellers;
4) Mechanical Pumps.

Following is a discussion of the competitive offerings within these categories:

1) CONFINED GAS INJECTION

There are few, if any, instances of actual "copies" of the GasLifter. Only one competitor (IDI) offers their version of a confined gas injection system. This is the same system that had been offered until the early 1990's by Atara. See Figure 3.

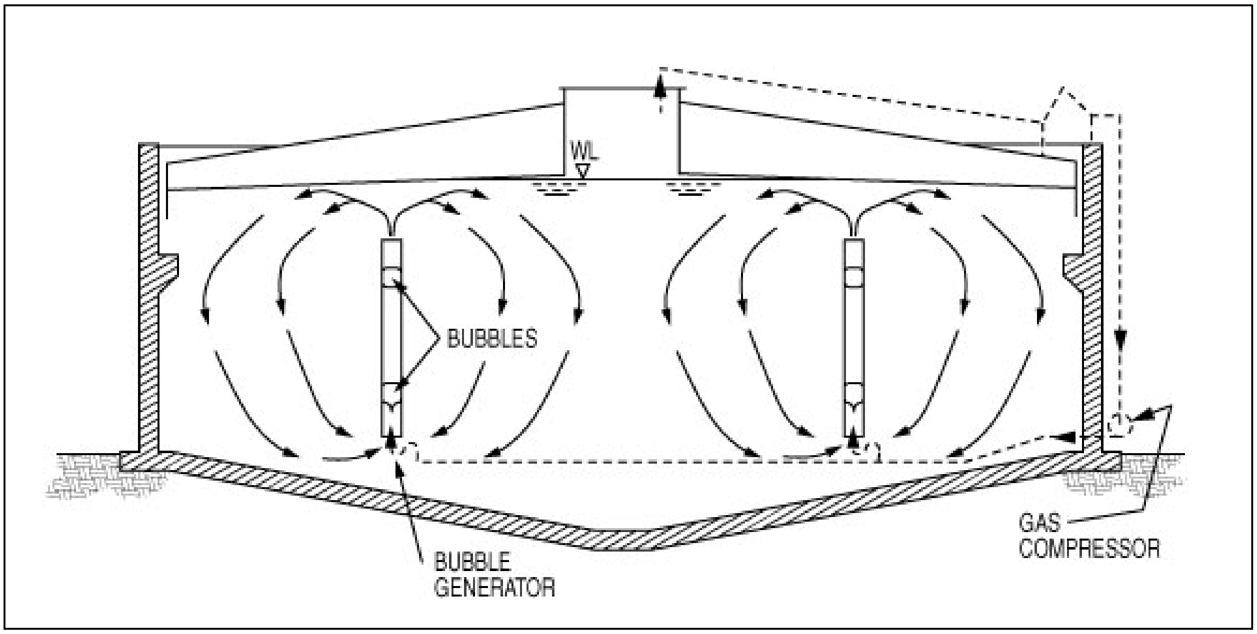

Figure 3

This system has been promoted as the "Bubble Gun" or the "Cannon" mixer. The eductor tubes are relatively small as compared with the GasLifter using up to a 72" diameter eductor tube. The eductor tubes are fed from the bottom, through the sidewalls of the digester, into a "bubble chamber" which, it is claimed, injects a whole bubble into the eductor tube, completely filling the cross section of the tube. The promotion goes on to state that the bubble remains in this total form, without breaking apart, and when emitting from the top, "bursts with fury," breaking surface scum.

It is claimed that because the bubble does not break apart, that this is a more efficient type of device than the airlift, or GasLifter principle, which intentionally strives for as fine a diffusion of gas bubbles as can be made. It is this latter principle that is classic airlift design. Nonetheless, the bubble, even if whole, still acts in the airlift principle, and nothing can be said for increased efficiency as opposed to complete diffusion of the gas.

We have all seen the exhibit demonstration of the whole bubble in a 3" tube, remaining whole to the top; but do you really believe that the bubble remains whole in a 30" tube? (Or even if emitted into the tube initially as a whole bubble?) The 30" tube seems to be the largest tube IDI will offer, and hence the need to promote multiple eductor tubes; they will promote as many as a dozen tubes spaced around the digester floor.

In as many as 5 bids, in which equipment pricing was evaluated based on guaranteed power consumption, WPE beat Atara/IDI, disproving the notion that the Bubble Cannon is a more efficient device.

The downside of the IDI promotion is threefold: first, the gas distribution system outside the digester wall is complex, to assure equal gas distribution to the multiple eductor tubes; secondly, the gas compressor must be higher pressure due to the bottom feed, normally requiring less-efficient and more costly liquid ring seal compressors; thirdly, the eductor tube and its bubble generator are inaccessible, and if plugged, the digester must be dewatered to gain access.

2) UNCONFINED GAS INJECTION

There are two competitive offerings in this category: the US Filter/Envirex Pearth system (Figure 4), and the US Filter/FMC shearbox diffusers (Figure 5), sometimes referred to as "strawberry boxes".

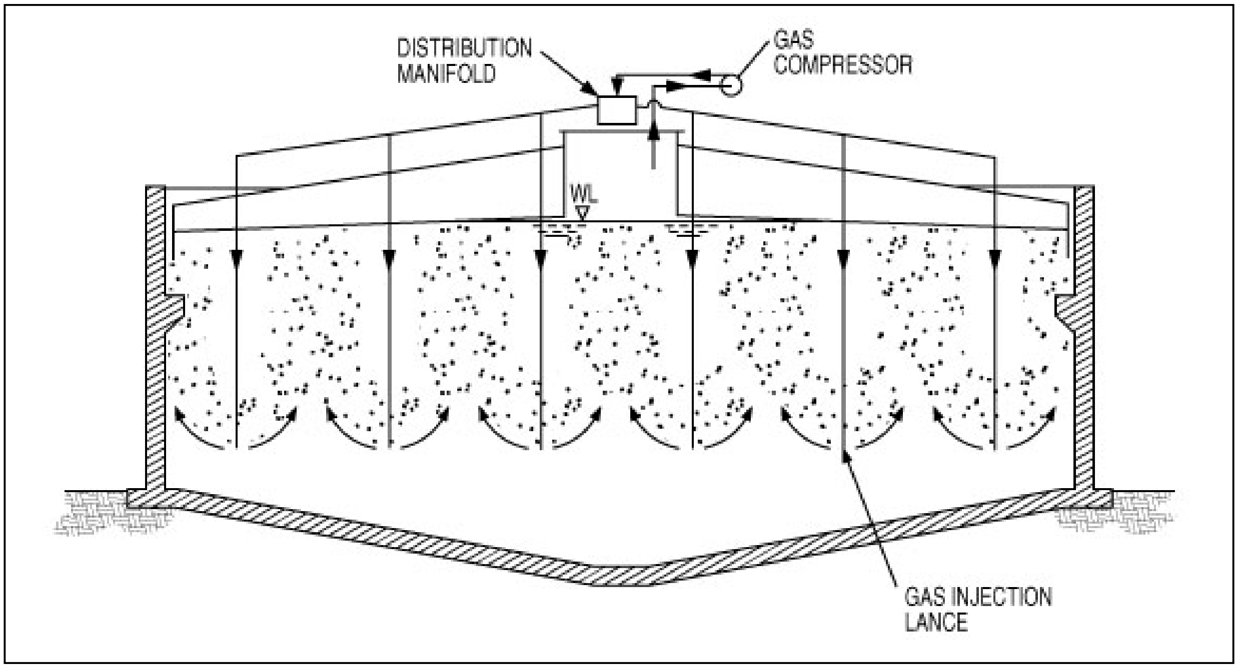

Figure 4

The Envirex Pearth has been offered for many years, originally being a low-submergence, multiple-point lance arrangement used exclusively for scum breakup. This system features a rotary valve, which causes alternating lance emission, only one lance at a time being in operation.

Some years back, Envirex decided to extend the lances to a deeper submergence, and use this device as a digester mixer. Their promotion is that a power saving can be garnered through the use of alternating gas injection, basically indicating that a partial gas injection to a partial volume for a partial time period will give full mixing effectiveness to the entire digester, with less power input. Again refer to the discussion of recommended applied power, page 4; will this lower power really mix a digester adequately? Experience would infer not.

An additional consideration of the ineffectiveness of such an unconfined gas injection system is that the lances, when mounted on covers which rise and lower due to liquid level variations and/or gas storage volume, actually rise to such an elevation at the highest level that the floor of the digester is virtually unaffected by the gas emission; it is doubtful that there is much effect even at the lowest level. Compare this with the floorsupported eductor tube, as with the GasLifter, which continues to scour the digester floor even when the cover is in the raised position.

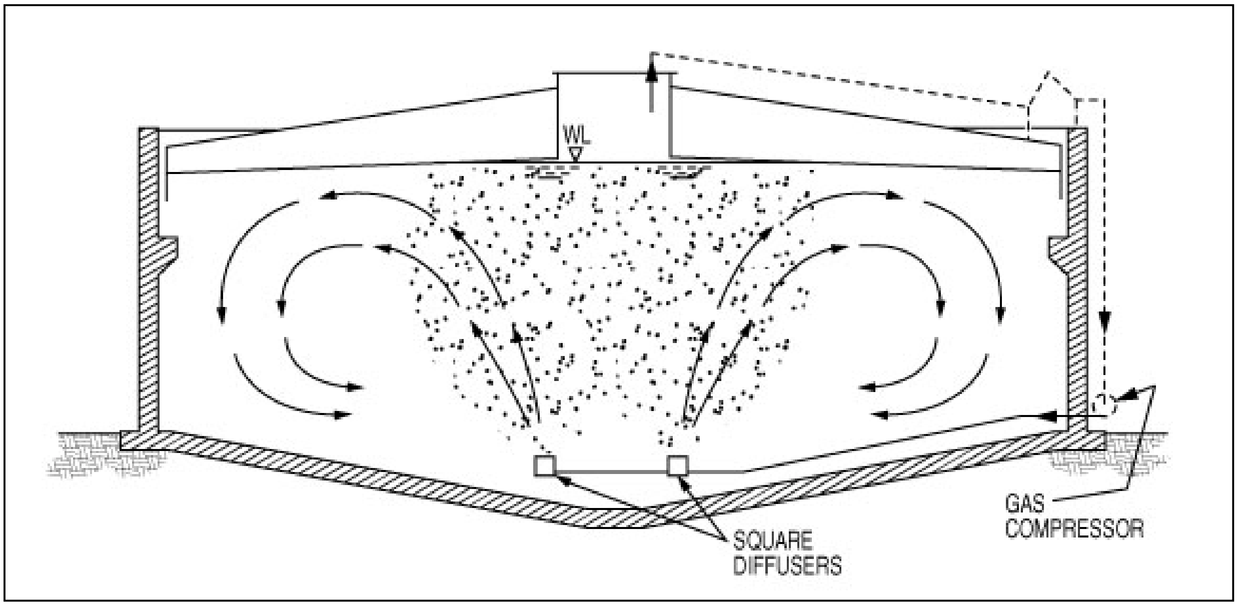

Figure 5

The shearbox diffusers are normally multiple depressions in the digester floor, fed through the side of the digester, exhibiting the disadvantages of the IDI system, as mentioned above. Additionally, the ineffectiveness of the shearbox diffusers are legion, and since FMC is now also a US Filter company, as is Envirex, it is doubtful we will see this promotion in the future.

3) MECHANICAL IMPELLERS

At least two (2) types of mechanical impeller systems exist, both of which are enclosed by draft tubes. One of these types (Figure 6) is mounted inside the digester, typical of those offered by Westech, usually in multiple eductor tubes; the other is mounted outside the digester (Figure 7), also multiple, and collects suction and discharges output in a radial fashion, typical of those offered by Eimco.

Traditionally, impellers in digesters have been fraught with problems of "ragging". The more modern approach is to use so-called "ragless" impellers, and also feature reverse-rotation motors to theoretically discharge the rags free of the impeller blades. It would be a good guess as to the success of these ragless impellers.

As is true of all digester mixers, as mentioned above, with devices such as these, the power input must be considered at the impeller blade, i.e. the actual water HP exhibited by the impeller blade, specifically <u>not</u> the motor HP.

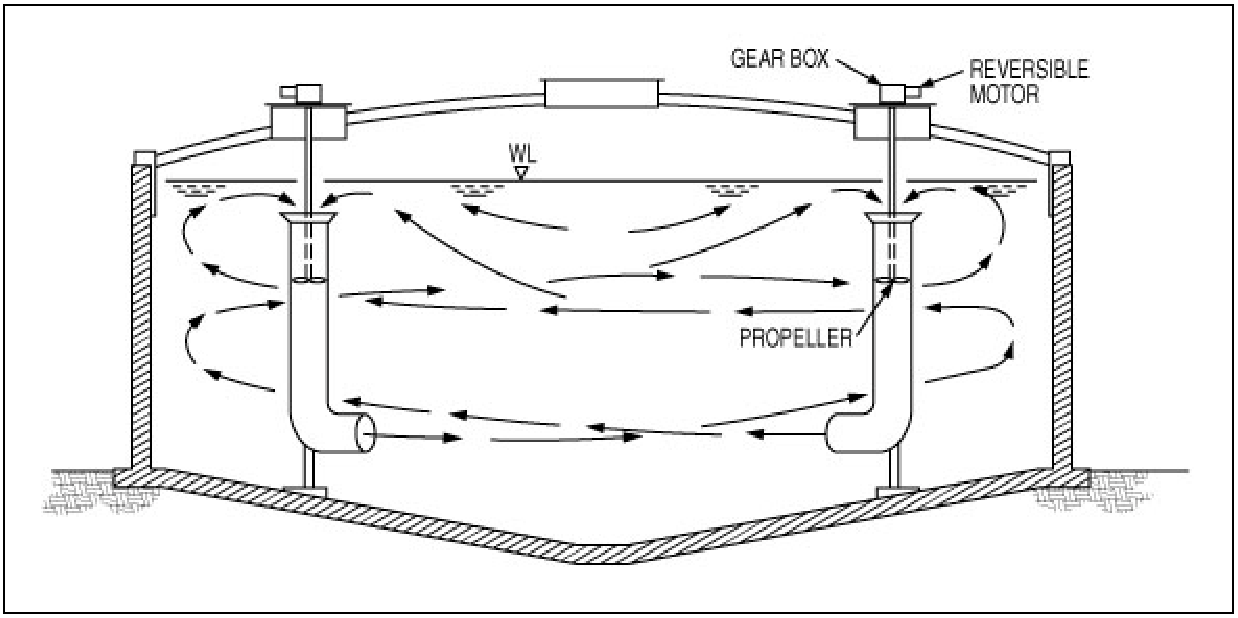

Figure 6

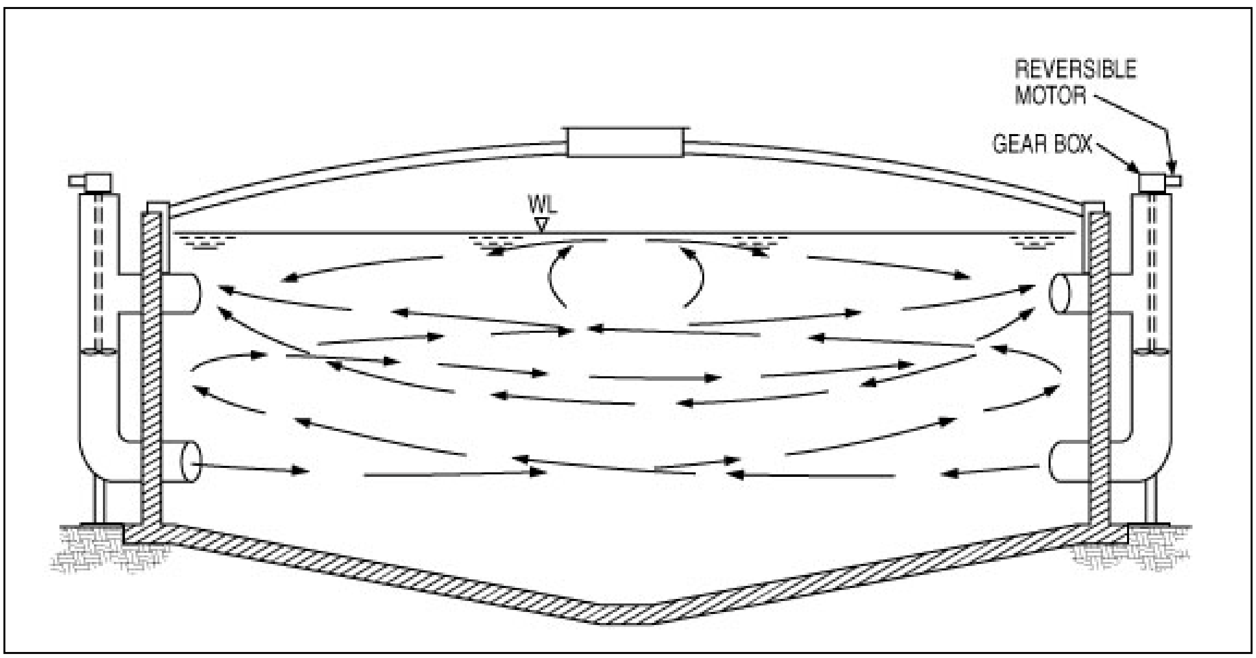

Figure 7

4) MECHANICAL PUMPS

Two known devices that fit this description exist, one of which is shown in Figure 8, typical of that previously offered by Dorr. This device consists of an external recirculation pump, taking suction from the center surface of the digester, primarily to remove scum from the surface, and hopefully to blend it into the sludge and ultimately cause it to digest. The discharge back into the digester is through radially discharging nozzles, intending to impart a circulatory vector from the periphery. To even begin to mix the digester as intended, multiple nozzles must be considered.

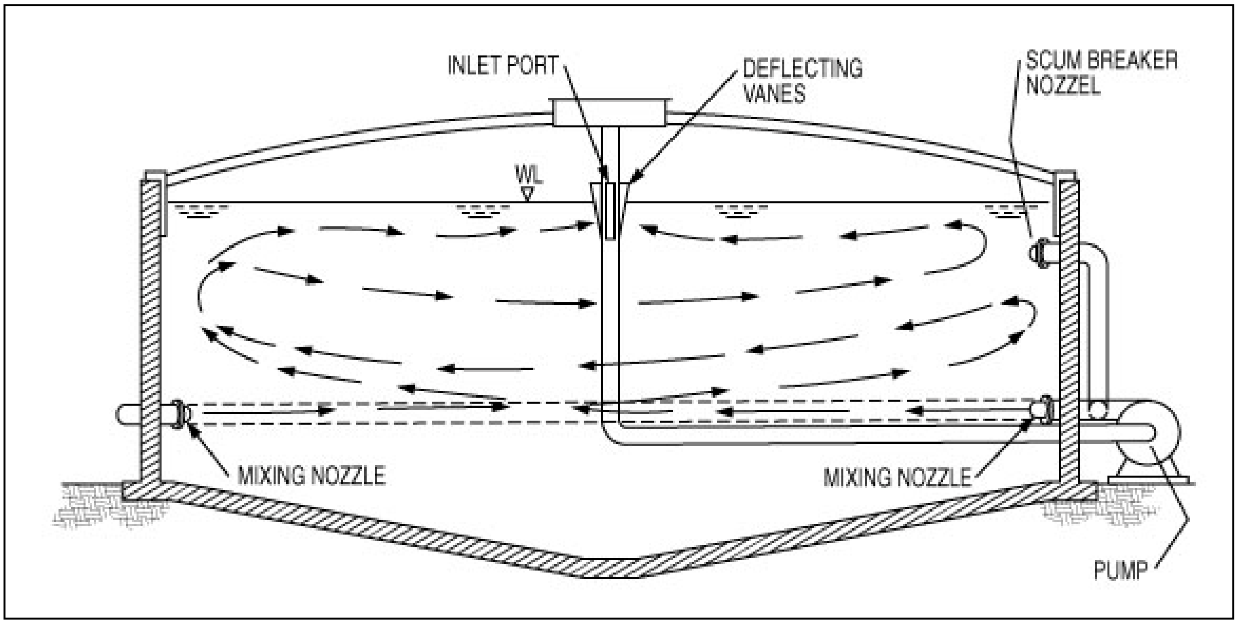

Figure 8

The latest entry into this arena is the JetMix (Figure 9) offered by Liquid Dynamics, and was offered originally for mixing sludge holding tanks. Only recently have they promoted the product for use in anaerobic digesters, and consequently they have no known track record at this time. (Their latest advertisements still lead with the idea of mixing <u>storage</u> tanks.) The external pump is a chopper pump, the internal nozzles being floor-mounted, multiple, and rotatable to achieve differing angles of attack. As expected, they also promote power inputs less than that recommended for adequate mixing. Additionally, the adjustment linkage to operate the nozzle angle is typically imbedded in the basin floor, and would appear to be inaccessible should it fail mechanically.

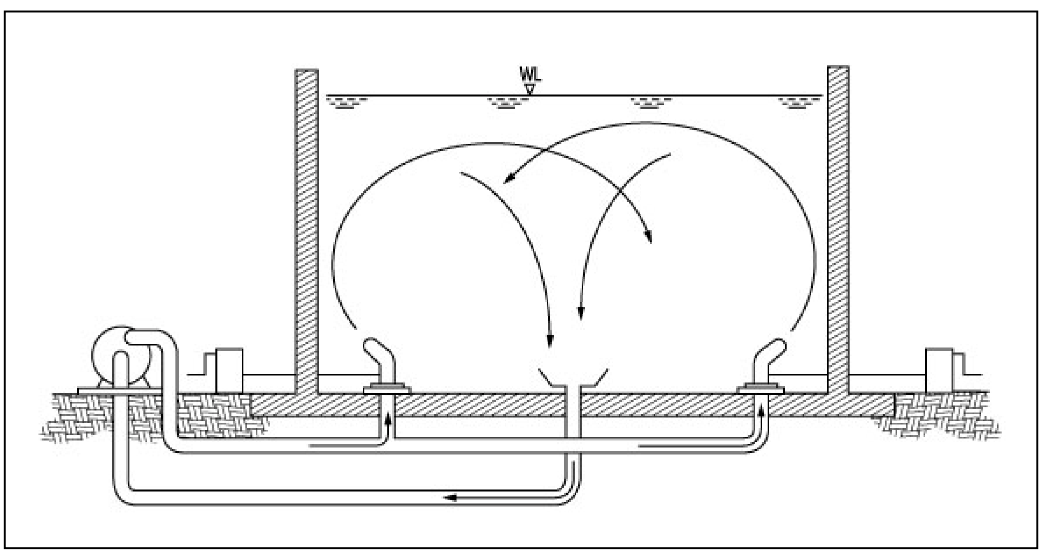

Figure 9

A newer entity, offering basically the same type of system, is the Vaughan Rotamix, essentially the same as the JetMix, but with fixed, bi-level, floor-mounted cast iron nozzle assemblies.

As is the case with the mechanical impellers in the previous section, the power must be considered as the dynamics of the nozzle discharges, specifically not the motor HP.

INDEPENDENT REPORTING OF VARIOUS DIGESTER MIXERS

Probably the most extensive examination of various types of digester mixing devices is a report by Alan B. Cooper and Rudy J. Tekippe, Ph.D., entitled "Current Anaerobic Digester Mixing Practices", presented at the 55th WPCF conference, St. Louis, 1982.

> This paper compared various types of digester mixing devices, selected to mix a theoretical 65' Dia. x 30' SWD, at "G" values of 50 and 85, a range preferred by the authors.
>
> The GasLifter stacked up as superior to "Unconfined Gas Injection" devices, which were given no claim of turnover rate, and therefore turnover time.
>
> Against "Mechanical Pumping" devices, turnover times were markedly different, with the GasLifter being given credit for 28.7 minutes, and the best mechanical impeller device, in conjunction with a draft tube, could claim only 67.1 minutes turnover. Bare mechanical pumped circulation could only claim a 322-minute turnover (!)
>
> Only the "Gas Piston" stacked up well with the GasLifter, but with the requirement of a discharge pressure of 12.12 psig compared to 6.06 psig for the GasLifter; as stated earlier, this demands a more expensive, less efficient liquid ring seal gas compressor for the gas piston device.

A second paper, "A Survey of Anaerobic Digester Operations", by John W. Filbert, Vice President, CH2M Hill, was presented at the 1985 Specialty Conference sponsored by the Environmental Engineering Division, ASCE, at Northeastern University, Boston, MA, July 1-5, 1985. This paper investigated several parameters of anaerobic digester operations, one of which was problems associated with various types of mixing. This report offers the following:

> "The types of problems most often associated with each method are listed below:

1. -External pumped circulation--equipment and line plugging, housekeeping, inadequate mixing, mechanical problems, and others
2. -Pump by propeller in internal draft tube--mechanical problems
3. -Gas from floor diffusers--inadequate mixing, mechanical problems, and others
4. -Gas ceiling lances--line plugging, mechanical problems
5. -Gas in draft tubes—“none in particular"

CONCLUSION

The GasLifter is undoubtedly the most efficient, reliable and maintainable digester mixing device on the market today. Because of the widely varying products offered in the marketplace for this purpose, each vendor obviously has a "story" to tell about why theirs is best. In most cases, this message has a basic theme that says theirs is "more efficient," and consequently will do the job with less power input. This claim is both easy and hard to counter; easy because there are enough references to disprove adequate digester mixing with power input below a given level, as explained earlier; hard because a digester will "work" with inadequate mixing, but how much better it would perform if properly mixed is an unknown to the owner of the lesser product.

COMPANION EQUIPMENT

In addition to the GasLifter described within this paper, Walker Process Equipment offers to the marketplace a broad range of equipment for anaerobic digesters: the HeatX external tube-in-tube heat exchanger, both with and without a self-contained boiler; digester covers of four varieties (floating covers, gasholders, fixed covers and combination covers); and other smaller appurtenant items.

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