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(71) Applicants and
(72) Inventors: **HILTON, Derrick, Lionel** [ZA/ZA]; PO Box 18, 3740 Eston (ZA). **TYNE, Shelby, Kenneth, Campbell** [ZA/ZA]; PO Box 18, 3740 Eston (ZA).

(74) Agent: **HAHN & HAHN INC. C. BERNDT; JF LUTEREK; C MICHAEL; PCR VENTER; CJ WHEELER; VC WILLIAMS**; 222 Richard Street, Hatfield, 0083 Pretoria (ZA).

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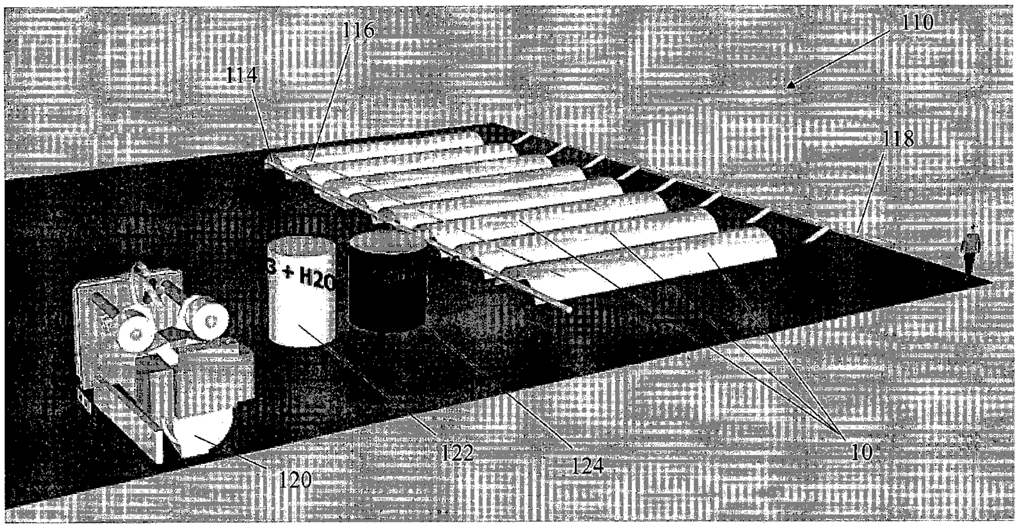

FIG. 2

(57) Abstract: A biomass digester system for generating biogas includes a battery of flexible, elongate digesters, at least one common biogas accumulator, connection means for connecting the digesters in gaseous communication with the accumulator and valve means fitted to the connection means, for adjusting flow of the biogas through the connection means thereby to permit a digester to be disconnected from the accumulator and taken offline. Each digester may include a flexible bag adapted to withstand pressure of the order of two bars, an inlet for biomass and an outlet for biogas. Also provided is a process for producing biogas from biomass.

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BIOMASS DIGESTER SYSTEM & PROCESS

THIS INVENTION relates to pollution control and utilization of renewable energy resources. Specifically it relates to a biomass digester of the type which can be charged with biomass for anaerobic digestion, from which biogas such as methane can be recovered. It relates also to a system including such a digester, and to a process for generating biogas from biomass.

TERMS AND ABBREVIATIONS

Biomass	For purposes of this specification, the term biomass includes waste material capable of fermenting to form biogas, for example animal excrement such as chicken litter or cattle manure, or vegetable matter such as hyacinth extracted from water bodies.
GSM	Grams per square metre (g/m^2)
PVC	Polyvinyl Chloride

BACKGROUND TO THE INVENTION

Systems for digesting biomass to form biogas have been taught but such systems are often complicated and involve numerous components.

For example, WO 2007/130513 teaches a continuous (or plug-) flow digestion system and method. The system includes a digester in the form of a flexible bladder. Biomass is intended to move along a constant flow path from an inlet to an effluent outlet. However, the inventors of the present invention believe that blockages in such a system are likely to occur and that it may be prone to failure. The inventors of the '513 patent application attempted to address this shortcoming by providing sludge access ports for manual or mechanical removal of accumulating solids. The necessity for such ports introduces additional cost and complexity.

Further complexities disclosed by the '513 patent include a displacement tank, a collection pit, a shallow lined separation basin/ step dam; a two-cell lined pond; and effluent disposal means.

A need exists for a relatively simple and inexpensive digester process and system for generating biogas.

SUMMARY OF THE INVENTION

According to a first aspect of the invention there is provided a process for generating biogas from biomass, which includes the steps of:

> providing a digester which includes a flexible bag;
> flushing the digester with a flushing gas selected to be non-toxic to methanogens, thereby to displace most of the air in the digester;
> mixing biomass with water to form a slurry;
> partially filling the digester with the slurry; and
> inhibiting aerobic ingress into the digester, thereby to allow anaerobic digestion of the slurry.

Preferably the process is a batch process, wherein the digester, once partially filled, is left to digest the slurry substantially completely, whereafter the majority of the slurry volume is removed and replaced.

The slurry may be mixed in a mixing tank, thereby to gravitate particulate matter out of the biomass. The mixing tank may be a trailer tank.

The flexible bag of the digester may include a membrane, for example a reinforced geo-membrane. It may include a PVC membrane.

The step of flushing the digester may include flushing with exhaust gas from a combustion engine.

The biomass may be manure, litter, vegetable matter e.g. hyacinth, or the like.

The process may include physically supporting a portion of the digester. The supporting step may include partially burying the digester. Instead or in addition, it may include securing the digester to the ground or in a trench using lines, nets or the like. The supporting step may include providing at least one retaining wall and supporting the digester with the retaining wall. The retaining wall may include

a plurality of elongate wall formations manufactured predominantly from a plastics material;

at least one buttress formation connected to each wall formation; and

connection means at either end of each wall formation, for connecting adjacent wall formations to each other. The connection means may include tongue and groove, pin-in-socket, or other appropriate interlocking arrangements.

The process for generating biogas may further include

providing a biogas-use device of a type which generates waste heat (e.g. a combustion engine);

operating the device fuelled with biogas;

providing a fluid reticulation system passing in contact with the digester; and

exchanging waste heat from the device into the reticulation system for heating biomass contained in the digester.

The process may further include a method of re-invigorating the biomass feedstock for increased biogas production which includes pumping out a portion of an elevated, more liquid fraction of the digester contents and pumping it back into a lower, solids-rich region of the digester contents.

The process may include manipulating the flexible bag, for example by walking on it, thereby to break up solids such as crusts which may form and inhibit gas production.

The process may include connecting a plurality of digesters to each other in a battery system via a common biogas accumulator defining a gas space.

The process may include a method of assessing when to refill a digester with slurry, which includes

isolating a first digester from the remaining digesters of the battery system so that only the first digester is connected to the accumulator;

allowing the first digester to generate gas thereby to fill the accumulator gas space; and

monitoring the time taken to fill said gas space.

Instead or in addition, the method of assessing when to refill the digester with slurry may include deflating the flexible bag such that it collapses onto the slurry it contains, then monitoring the time taken for the slurry in the bag to generate sufficient biogas to re-inflate the bag.

The process may include extracting digested slurry from the digester at the end of a batch run (for example when a digester has run down to the stage where it takes over a day to fill an accumulator with gas) and putting said digested slurry on agricultural lands to serve as organic fertiliser.

Instead the solids of the slurry may be separated from the liquids and re-utilised in a producer gas system (i.e. gasifier) to provide gas for a gas turbine or spark ignition motor; the spent solids from the gasifier may then also be utilised on agricultural lands.

A small quantity of said digested slurry may be left in the digester to seed the next batch of biomass and restart the anaerobic digestion.

According to a further aspect of the invention there is provided a digester for the conversion of biomass into biogas, which includes

a flexible bag adapted to withstand pressure of the order of two bars and to receive biomass in methane-producing conditions;

an inlet for the biomass and an outlet for biogas;

with the proviso that the digester has no sludge access ports.

The digester may further include an effluent outlet. The effluent outlet may be defined in an underside of the digester. The digester may be tapered in the region approaching the effluent outlet to inhibit build-up of solids around the outlet.

In a preferred form of the invention the bag is made from a woven or non-woven material that is substantially non-permeable to methane and is substantially waterproof. A particularly useful material is tarpaulin which is inexpensive and therefore preferred for the purpose of the invention. The tarpaulin may be of a type suitable for use elsewhere in covering loads on trucks or for manufacturing children's "jumping castles."

The tarpaulin material may have a thickness ranging from 700 to 1200 GSM.

The material may take the form of a reinforced PVC membrane.

The digester may include pressure relief means, for example valve means, for releasing biogas at predetermined levels of pressure in the digester thereby to reduce the possibility of bursting of the digester.

The biomass inlet, effluent outlet and biogas outlet may be made from suitable polymeric material.

The length to width ratio of the digester may lie in the range from 5:1 to 7:1, preferably greater than 5:1 but not greater than 6:1.

The digester may be shaped like an elongate sausage having a length ranging from 8 to 12 metres, preferably 10m long, and a diameter of the order of 1.9 metres. However, it will be appreciated that other sizes are equally useful and the shape may also vary considerably – for example the digester may take a Chinese shape or that of the Indian Gobar plants.

According to a further aspect of the invention there is provided a battery biomass digester system for generating biogas, which includes

a battery of digesters as described above;

at least one common biogas accumulator;

connection means for connecting the digesters in gaseous communication with the accumulator so that biogas from the digesters contributes to a common store of biogas in the accumulator; and

valve means fitted to the connection means, for adjusting flow of the biogas through the connection means, thereby to permit a digester to be disconnected from the accumulator and taken offline.

Thus, the digester system may be modular such that digesters may be added or subtracted from the system according to specific customer needs.

The battery system may include supplementary heating means for heating the digesters and their biomass contents. The system may include a biogas-use device (e.g. a biogas powered generator) capable of generating waste heat, and the heating means may then be a direct heating system comprising

a fluid reticulation system passing in contact with the digesters; and

heat exchange means for exchanging waste heat from the biogas-use device into the reticulation system thereby to heat biomass contained in the digesters.

The system may further include gas treatment means. The treatment means may include a gas scrubber comprising a tank containing a solution of water and slaked lime (or calcium carbonate), and means for delivering the generated biogas into the solution. The treatment means may further include a tank containing iron filings and/or shavings, and means for delivering the generated biogas through the filings and/or shavings.

In a further aspect of the invention there is provided a method of manufacturing a biomass digester which includes the steps of

providing elongate strips, at least 5 metres long, of a flexible polymeric material;

creating a tube by heat-sealing the long edges of the strips to one another;

cutting biomass inlet, biogas outlet and effluent outlet apertures into the tube; and

closing the tube to form a bag by heat-sealing transversely across the tube proximate opposite ends thereof.

According to a further aspect of the invention there is provided a retaining wall for supporting a flexible digester, which includes

a plurality of elongate wall formations manufactured predominantly from a plastics material;

at least one buttress formation connected to each wall formation; and

connection means at either end of each wall formation, for connecting adjacent wall formations to each other.

The connection means may include tongue and groove, pin-in-socket, or other appropriate interlocking arrangements.

The retaining wall may have dimensions selected in order to provide sufficient support to inhibit collapse of a digester as herein described, when set in contact with one elongate side of the digester and used in conjunction with a similar wall on the opposite elongate side of the digester, and when the digester contains an effective charge of biomass.

SPECIFIC DESCRIPTION

The invention will now be described by way of non-limiting example with reference to the accompanying drawings, in which:

Figure 1 shows, schematically, a perspective view of a digester according to the invention; and

Figures 2 shows, schematically, a perspective view of a battery biomass digester system according to the invention.

Referring to Figure 1, reference numeral **10** indicates generally a preferred embodiment of a digester in accordance with the invention. The digester **10** includes a flexible tubular bag **12** manufactured from a reinforced PVC tarpaulin material. The preferred embodiment has a length of approximately 10 metres and a diameter of approximately 1.9 metres.

The digester is fitted with a biomass inlet **14**, a biogas outlet **16** and an effluent outlet pipe **18**. Typically, all three of these fittings are manufactured from appropriate polymeric materials and are connected in substantially gastight manner to the bag.

The digester **10** further includes a fluid bladder **20** for pressurising biogas in the digester, thereby to provide a positive pressure for a gas appliance. The fluid bladder comprises an elongate bag **22** manufactured predominantly from a fluid-tight flexible sheet material, and valve means **24, 26** fitted to the bag and adapted for filling the bladder with variable volumes of a suitable fluid (typically water). Water hoses are typically connected to the valve means in use.

The bladder **20** interfaces with the bag **12** along an upper side of the latter.

By increasing or decreasing the quantity of water in the bladder **20** the weight of the bladder may be varied along with the pressure which it exerts on the biogas contained underneath it in the digester **10**. Using this system, the pressure of the biogas in the digester (and in an extended battery digester system) can be adjusted as desired through a wide range.

It will be understood by those skilled in the art that the fluid bladder in the abovementioned system may be replaced, in other embodiments, with weighted bags, stones, or the like. Such embodiments nevertheless fall within the scope of the present invention.

In preferred embodiments the flexible bag **12** of the digester is manufactured from a reinforced PVC tarpaulin material having a thickness of 700 or 800 GSM. The choice of material is made to ensure that if there is a leak the bag concerned will deflate without admitting substantial air quantities into the digester and thereby destroying the anaerobic bacteria.

The effluent outlet region (not shown) of each digester is tapered to inhibit buildup of solids around the outlet. This is done to overcome a deficiency of the prior art. In digesters taught by the prior art an accumulation of solids is likely to take place, especially in corners and crevices, and these solids need to be physically (e.g. manually) removed. By contrast, in the present invention there is no need for manual intervention i.e. for penetration into the digester. Corners and crevices are avoided as far as possible and the digester includes no baffles.

Referring to Figure 2, reference numeral **110** indicates generally a battery biomass digester system according to the present invention. The system **110** includes a battery of digesters **10** according to the invention. It further includes a common biogas accumulator (not shown).

The system **110** employs a battery batch approach. Components are modular and can be added or taken away according to need and without requiring downtime. For example, the plurality of digesters **10** ensures that a constant gas supply can be maintained even in the event of a problem arising with any particular digester (caused by dead bacteria, antibiotics or the like).

In the preferred embodiment shown the battery of digesters **10** are connected in parallel. Each biomass inlet **14** is connected to a single, collective biomass delivery pipe **114** which runs the length of the battery, through which biomass is delivered to the digesters. Valve means (not shown) are provided in connection with each biomass inlet **14** so that one or more of the digesters can be isolated from the others and be filled (or omitted from filling) selectively or in isolation from the others.

A collective biogas outlet pipe **116** and collective effluent outlet pipe **118** are also provided, running the length of the battery and connecting the various digesters via their respective gas and effluent outlets **16, 18**.

Valve means (not shown) are provided in association with the biogas and effluent outlets **16, 18** of each of the digesters to enable each digester to be isolated from the remainder of the system or from the other digesters.

Supplementary heating (not shown) can be supplied to the digesters. In preferred embodiments of the invention the generated biogas is used to fuel at least one biogas generator (i.e. an engine driving a generator for production of electricity). Reference numeral **120** in Figure 2 indicates such a generator. The supplementary heating system can then be an electrical system similar to that used for underfloor heating, taking energy from the biogas generator, or it can be a direct heat system using secondary or waste heat, such as that deriving from the exhaust of the biogas generator, which is exchanged into a circulating water reticulation system (not shown) passing under and in contact with one or more of the digester bags for heating the biomass contained therein.

The digesters **10** may be buried to three quarters of their capacity, the other quarter being used as a gas space, thus indicating a leak immediately by deflating and sitting on top of the slurry. In this way, the system herein described does away with expensive control devices; a cessation of biogas production is easily observed visually instead of requiring automatic monitoring devices.

There is also an important safety aspect associated with this design: the inventors believe that there is a restricted chance of asphyxiation or explosions or ignition of biogas in digesters due to the fact that head space in the digester bags is limited and the bags may be located in the open air. Thus any methane that would otherwise constitute a problem may immediately be diluted to a concentration in the air which is no longer inflammable or explosive.

For circumstances where there may be an over-production of gas or where supply exceeds demand a pressure relief valve (not shown) may be provided near the biogas outlet of each digester, to prevent bursting of the digester.

Should a hole or leak occur it can be easily patched *in situ* with basic tools and a repair kit. This reduces the need to get expensive technicians or equipment to fix such problems. The digester bag herein described may be repaired with low cost, skill and time demands and without serious compromise of biogas production.

Referring again to Figure 2, a scrubber **122** and a filter **124** are provided for cleaning the biogas from the digesters. These are housed in tanks of plastics material construction. Preferably the tanks are selected from commercially available tanks having the thickest plastics material walls available, to increase the likelihood of the tanks surviving heat generated by chemical reactions. An example of such a reaction is that which occurs when, for example, the hydrogen disulphide filter (see below) is regenerated by being opened to atmosphere, at which time an exothermic reaction occurs generating heat.

In a preferred embodiment, each tank is of 2500 litre capacity and has a half-moon cross-section. These are available locally in South Africa under the trade name "JO-JO" tanks.

In the first tank there is provided a scrubber solution comprising slaked lime (or calcium carbonate) and water in a ratio, typically, of 1:3. The method of drawing the biogas out of the digester determines the quantity of scrubber solution involved. If a compressor is used then more can be used. If there is no mechanical method of extraction and only gas displacement is used, then a lesser quantity is used.

The second tank is filled with iron filings and/or shavings from a machine shop and is intended to filter hydrogen disulphide from the biogas.

The scrubber **122** and filter **124** are situated between the digester **10** and the accumulator (not shown).

The digesters herein described are easily movable and may be transferred to a different location in the event of a disease outbreak.

The system herein described differs from systems taught by the prior art in various respects, as set out below:

Firstly, the existing WO/2007/130513 patent application describes a displacement flow or plug-flow system, whereas the system of the present invention is a batch system (that is to say the biomass is pumped into a digester and left to digest for a period before being pumped out; the digester is then refilled with fresh biomass).

Secondly, in the present invention the effluent outlet of each digester is on the underside of the digester, whereas the '513 document of the prior art specifically illustrates and describes the location of all orifices as being defined in the top surface of the digester (to make them accessible for maintenance).

Thirdly, the digesters of the present invention are modular and can be added or subtracted from the system according to specific customer needs. There is no mention in the '513 document of modularity or of the use of a plurality of digesters feeding into a common accumulator/storage container (a plurality of *storage containers* is illustrated, but not digesters).

Fourthly, the length to width ratio of digesters disclosed by the '513 document ranges from 3:1 to 5:1 whereas for the digesters of the present invention this ratio ranges from 5:1 to 7:1, typically 5:1 to 6:1.

Fifthly, the system of the present invention has an additional feature in the form of gas scrubbers which consist of water, slaked lime (or calcium carbonate) and iron shavings from a machine shop, contained in a tank or tanks of plastics material, to purify the gas. In addition to the purification function this inexpensive treatment may assist in safety.

Sixthly, the effluent outlet regions described in the present invention are tapered to inhibit build-up of solids around the outlet. In digesters taught by the prior art an accumulation of solids is likely to take place, especially in corners of the digester and around internal baffles. These solids need to be physically (e.g. manually) removed, hence the necessity for sludge access ports in the prior art digesters.

Seventhly, the digesters of the present invention do not have sludge access ports since these are not required because of design improvements (as described immediately above and elsewhere herein) over the '513 digester. The inventors believe that this difference leads to a cost and complexity advantage over the '513 digester.

Turning to the process of the invention, manure is loaded into a trailer or other container that is relatively watertight and transported to the site where the digesters are situated.

Manure is mixed in the trailer or container with extra water or liquid carrier that can be digested (distillery slops, molasses, blood, etc.). The mixing is done by means of a slurry pump which recirculates the manure until the mixture is the consistency of very runny porridge. This is then pumped in or gravity fed into the digester. Each digester is preferably filled with slurry to a level ranging from 75% to 80% by volume.

Digesters are filled at specific times having regard to the batch nature of the system. Thus, manure that is fed into a digester on day one will be left to digest for a period of 30-60 days depending on the heating system used: a shorter time where supplementary heating is used and a longer period for straight solar radiation.

One of the common problems with anaerobic digestion of animal manures is the buildup of a scum layer on top of the slurry surface, inhibiting gas production. This problem is addressed in other digester systems by using access ports or expensive mixing devices situated inside the digester. In the present invention this problem is addressed by simply walking on top of the digester to physically break up the scum layer.

Another common problem in the prior art is the settling out of solids and the cleaning of digesters.

In the present invention, once biogas production from the biomass has run down to low levels and before extraction of the spent effluent, the gas in the digester is removed. Cleaning of the digester is then carried out in a way which does not involve physical or manual penetration into the digester. To understand the process, the physical configuration of the digester and its fittings must be explained. The inlet to the digester is, in normal use, situated at a higher level than the outlet and on the other end of the digester from it. When cleaning is required the flexible digester is pressed down in the immediate area of the inlet until the inlet pipe lies approximately at the same level as the outlet. This placement makes it likely that the inlet will now be immersed in the denser part of any settled solids and sludge. The step of pressing down the inlet pipe is typically carried out manually in view of the simplicity of that approach, but it will be understood by those skilled in the art that various other methods or apparatuses may be used to perform this function.

The biomass inlet and effluent outlet pipes are then connected to one another externally of the digester and the contents of the pipe and digester are circulated, using a slurry pump, to create a mixture.

Instead or in addition, liquid in the *top layer* can be sucked out with the slurry pump and discharged back into the digester via the effluent outlet, thus putting the solids back into suspension.

These processes ensure that most solids can be extracted when emptying of the digester is carried out by pumping out after the solids have been placed in suspension.

The above methods (excluding pumping out) can also be used for re-invigorating the biomass feedstock when biomass digestion runs low, thereby to obtain a further limited period of biogas generation.

Not all of the effluent is removed during pumping out as some is left for inoculating or seeding of the next batch of manure. This leads to an advantage of the invention, namely that the digester bags do not require continual complete cleaning because the residue of the biomass after gas production is actually required to provide the inoculant or seed material for each fresh charge of biomass feedstock.

The digested biomass slurry can be spread over lands as fertilizer or used in other ways, such as burning in a furnace or as a fuel. An initial step of separating the solids of the slurry from the liquids may be carried out, and the solids may then be used as fuel for a producer gas system (i.e. gasifier) to provide gas for a gas turbine or spark ignition motor; the spent solids from the gasifier may then also be utilised on agricultural lands.

Turning to the method of manufacture of the digesters, one preferred method involves manufacturing a tube by heat-sealing along the edges of a number of elongate strips, each at least 5 metres long and 1.4 metres in width. The strips are typically of a flexible, reinforced PVC tarpaulin material as herein described. Good seams are made if heat-sealing is performed along straight edges (i.e. if curves are avoided). The tube is then closed to form a bag by heat-sealing transversely across the tube proximate opposite ends thereof.

CLAIMS

1. According to a first aspect of the invention there is provided a process for generating biogas from biomass, which includes the steps of:

   providing a digester which includes a flexible bag;

   flushing the digester with a flushing gas selected to be non-toxic to methanogens, thereby to displace most of the air in the digester;

   mixing biomass with water to form a slurry;

   partially filling the digester with the slurry; and

   inhibiting aerobic ingress into the digester, thereby to allow anaerobic digestion of the slurry.

2. A process as claimed in Claim 1, which is a batch process wherein the digester, once partially filled, is left to digest the slurry substantially completely in a batch run, whereafter the majority of the slurry volume is removed and replaced.

3. A process as claimed in Claim 1 or Claim 2, in which the slurry is mixed in a mixing tank, thereby to gravitate particulate matter out of the biomass.

4. A process as claimed in any one of Claims 1 to 3 inclusive, in which the flexible bag of the digester includes a reinforced PVC membrane.

5. A process as claimed in any one of Claims 1 to 4 inclusive, in which the step of flushing the digester includes flushing with exhaust gas from a combustion engine.

6. A process as claimed in any one of Claims 1 to 5 inclusive, which includes physically supporting a portion of the digester by partially burying it.

7. A process as claimed in any one of Claims 1 to 5 inclusive, which includes physically supporting a portion of the digester by providing

at least one retaining wall for supporting the digester, said wall including a plurality of elongate wall formations manufactured predominantly from a plastics material;

at least one buttress formation connected to each wall formation; and

connection means at either end of each wall formation, for connecting adjacent wall formations to each other.

8. A process as claimed in any one of Claims 1 to 7 inclusive, which includes

providing a biogas-use device of a type which generates waste heat

operating the device fuelled with biogas;

providing a fluid reticulation system passing in contact with the digester; and

exchanging waste heat from the device into the reticulation system for heating biomass contained in the digester.

9. A process as claimed in any one of Claims 1 to 8 inclusive, which includes a method of re-invigorating the slurry for increased biogas production by pumping out a portion of an elevated, more liquid fraction of the digester contents and pumping it back into a lower, solids-rich region of the digester contents.

10. A process as claimed in any one of Claims 1 to 9 inclusive, which includes manipulating the flexible bag by walking on it, thereby to break up solids such as crusts which may form and inhibit biogas production.

11. A process as claimed in any one of Claims 1 to 10 inclusive, which includes connecting a plurality of digesters to each other in a battery system via a common biogas accumulator defining a gas space.

12. A process as claimed in Claim 11 which includes a method of assessing when to refill a digester with slurry, the method comprising

isolating a first digester from the remaining digesters of the battery system so that only the first digester is connected to the accumulator;

allowing the first digester to generate gas thereby to fill the accumulator gas space; and

monitoring the time taken to fill said gas space.

13. A process as claimed in any one of Claims 1 to 11 inclusive which includes a method of assessing when to refill a digester with slurry, the method comprising deflating the flexible bag such that it collapses onto the slurry it contains, then monitoring the time taken for the slurry in the bag to generate sufficient biogas to re-inflate the bag.

14. A process as claimed in any one of Claims 2 to 13 inclusive, which includes extracting digested slurry from the digester at the end of a batch run and putting said digested slurry on agricultural lands to serve as organic fertiliser.

15. A process as claimed in any one of Claims 2 to 13 inclusive, which includes extracting digested slurry from the digester at the end of a batch run, separating the majority of the solids of the slurry from the liquids thereof, re-utilising them in a producer gas system to provide gas, and thereafter putting the spent solids from the producer gas system onto agricultural lands.

16. A process as claimed in any one of Claims 2 to 13 inclusive, which includes extracting digested slurry from the digester at the end of the batch run and leaving a seed quantity thereof in the digester to seed the next batch of biomass and restart the anaerobic digestion.

17. A digester for conversion of biomass into biogas, which includes

a flexible bag adapted to withstand pressure of the order of two bars and to receive biomass in methane-producing conditions;

an inlet for the biomass; and

an outlet for biogas;

with the proviso that the digester has no sludge access ports.

18. A digester as claimed in Claim 17, which further includes an effluent outlet defined in an underside of the digester.

19. A digester as claimed in Claim 18, which is tapered in a region approaching the effluent outlet to inhibit build-up of solids around the outlet.

20. A digester as claimed in any one of Claims 17 to 19 inclusive, in which the flexible bag is made from a woven or non-woven material that is substantially non-permeable to methane and is substantially waterproof.

21. A digester as claimed in Claim 20, in which the woven or non-woven material includes a reinforced PVC tarpaulin having a thickness ranging from 700 to 1200 GSM.

22. A digester as claimed in any one of Claims 17 to 21 inclusive, which includes pressure relief means for releasing biogas at predetermined levels of pressure in the digester thereby to reduce the possibility of bursting of the digester.

23. A digester as claimed in any one of Claims 17 to 22 inclusive, in which the biomass inlet, biogas outlet and effluent outlet are made from suitable polymeric material.

24. A digester as claimed in any one of Claims 17 to 23 inclusive, having a length to width ratio ranging from 5:1 to 7:1.

25. A digester as claimed in any one of Claims 17 to 24 inclusive, which is shaped like an elongate sausage having a length ranging from 8 to 12 metres.

26. A digester as claimed in Claim 25, having a length of the order of 10 metres and a diameter of the order of 1.9 metres.

27. A battery biomass digester system for generating biogas, which includes

a battery comprising a plurality of digesters as claimed in any one of Claims 17 to 26 inclusive;

at least one common biogas accumulator;

connection means for connecting the digesters in gaseous communication with the accumulator so that biogas from the digesters contributes to a common store of biogas in the accumulator; and

valve means fitted to the connection means, for adjusting flow of the biogas through the connection means, thereby to permit a digester to be disconnected from the accumulator and taken offline.

28. A battery system as claimed in Claim 27, which includes supplementary heating means for heating the digesters and their biomass contents.

29. A battery system as claimed in Claim 28, which includes a biogas-use device capable of generating waste heat, and in which the heating means is a direct heating system comprising

a fluid reticulation system passing in contact with the digesters; and

heat exchange means for exchanging waste heat from the biogas-use device into the reticulation system thereby to heat biomass contained in the digesters.

30. A battery system as claimed in any one of Claims 27 to 29 inclusive, which further includes gas treatment means selected from the group consisting of

a gas scrubber comprising a tank containing a solution of water and slaked lime and/or calcium carbonate, and means for delivering the generated biogas into the solution; and a tank containing iron filing and/or shavings, and means for delivering the generated biogas through the filings and/or shavings.

31. A method of manufacturing a biomass digester which includes the steps of

providing elongate strips, at least 5 metres long, of a flexible polymeric material;

creating a tube by heat-sealing the long edges of the strips to one another;

cutting biomass inlet, biogas outlet and effluent outlet apertures into the tube; and

closing the tube to form a bag by sealing transversely across the tube proximate opposite ends thereof.

32. A method as claimed in Claim 31, in which the method of sealing is heat-sealing.

33. A retaining wall for supporting a flexible digester, which includes

a plurality of elongate wall formations manufactured predominantly from a plastics material;

at least one buttress formation connected to each wall formation; and

connection means at either end of each wall formation, for connecting adjacent wall formations to each other.

34. A retaining wall as claimed in Claim 33, in which the connection means includes interlocking arrangements selected from tongue and groove, and pin-in-socket arrangements.

35. A retaining wall as claimed in Claim 33 or Claim 34, which has dimensions selected in order to provide sufficient support to inhibit collapse of a digester as claimed in any one of Claims 17 to 26, when set in contact with one elongate side of the digester and used in conjunction with a similar wall on the opposite elongate side of the

digester, and when the digester contains an effective charge of biomass.

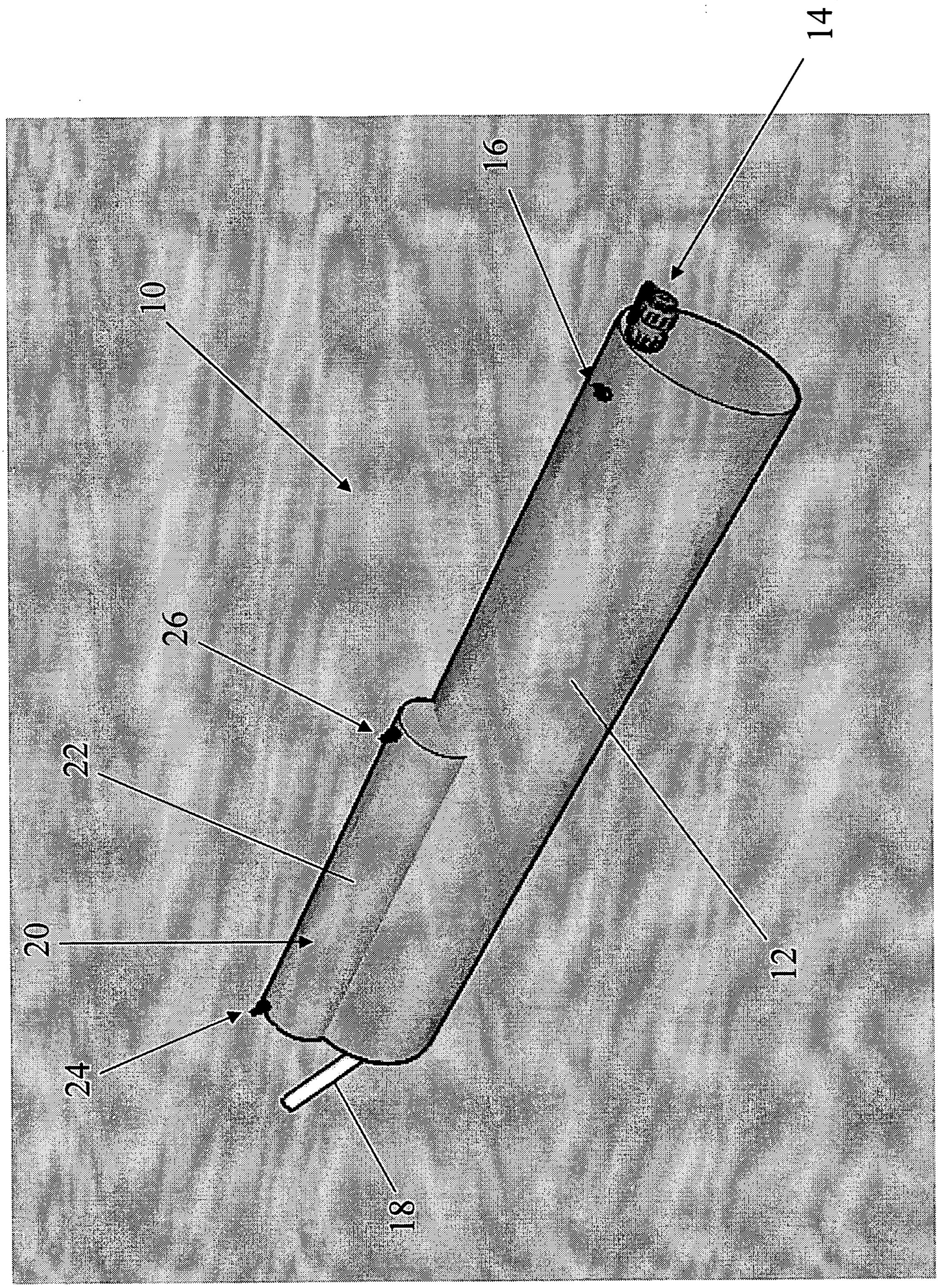

FIG. 1

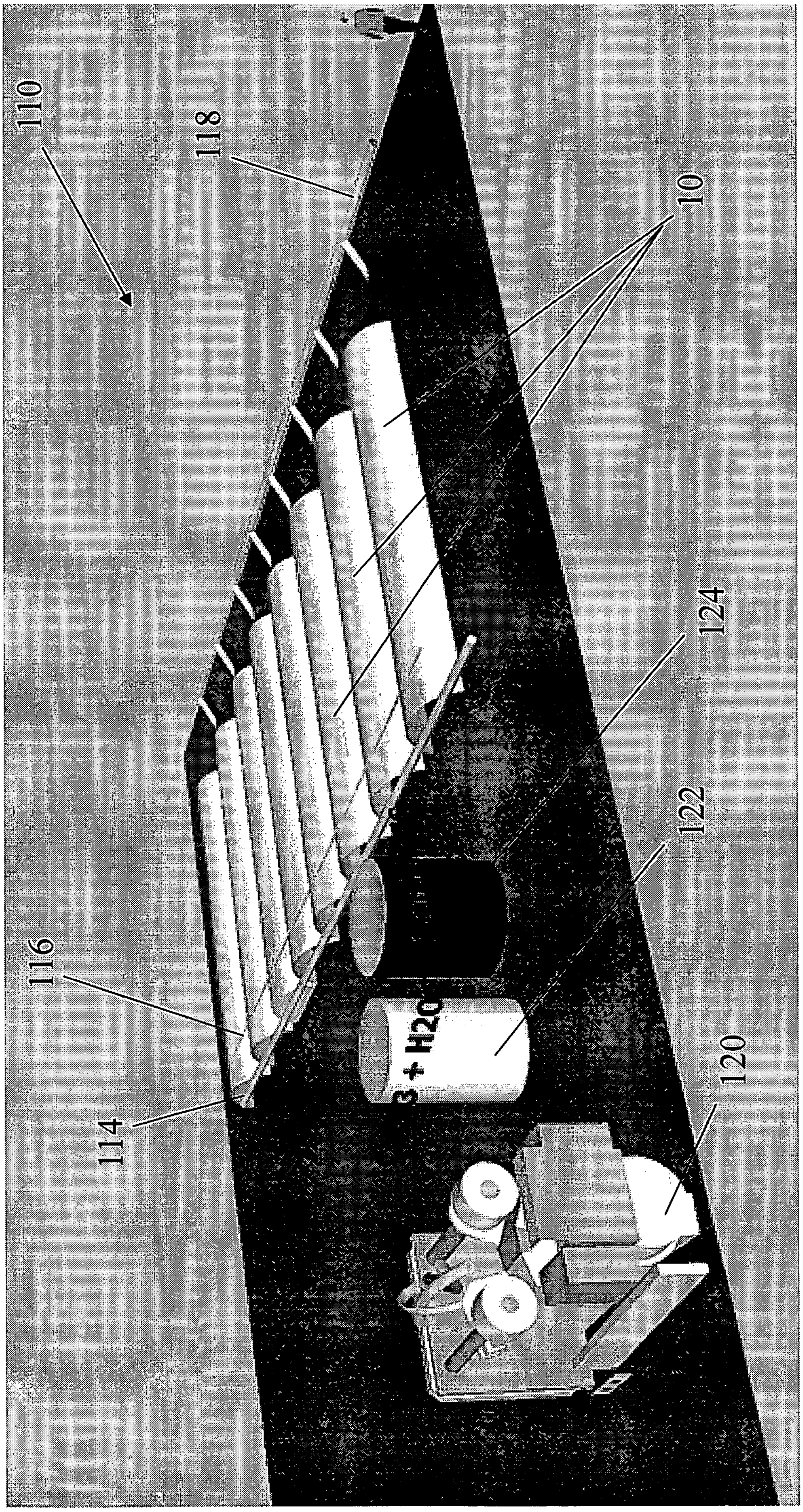

FIG. 2