Title: METHOD AND APPARATUS FOR PRODUCING METHANE GAS

Abstract: A system and method of generating methane gas from organic material, e.g., animal waste. A mixture known to produce methane gas which may include animal waste and vegetation as desired, is treated, also as desired, with an inoculant and inserted into a plastic bag. The plastic bag is extended at one end beyond the portion filled with organic material to produce a collection space for collecting the gas. As the gas is generated, the gas migrates to the provided space and is released for collection and use as an energy source. An upper passage provided in the material enhances migration of the gas to the provided space. As desired, aeration conduits are provided in the material and upon depletion of the methane gas, the mixture may be treated for composting and used as fertilizer.
METHOD AND APPARATUS FOR PRODUCING METHANE GAS

Applicant claims priority rights in European Patent Application 01102374.4 filed 02/02/01.

FIELD OF THE INVENTION

This invention relates to an apparatus for producing methane gas particularly on cattle ranches and dairy farms wherein the apparatus is portable and can be expanded and contracted or totally collapsed to accommodate the need of the user.

BACKGROUND OF THE INVENTION

It has been known for years that manure generated by cattle emits methane gas and can be enclosed so that the gas can be captured. In a preferred process, the manure is mixed with certain vegetation, e.g., straw, and then treated with inoculants to generate a reaction that accelerates the production of methane gas. The material to be treated is
referred to as biomass material. The methane gas can be drawn off and used as a source of power, e.g., by burning. In spite of this knowledge, it has not been considered feasible to set up a methane production plant on a farm site nor has it been considered feasible to haul the manure to an off site methane producing plant.

BRIEF DESCRIPTION OF THE INVENTION

The present invention enables low cost production of methane gas by replacing heretofore fixed structures with a large plastic bag, an example of which is used in composting. See U.S. Patent No. 5,461,843.

The flexible bag brings a number of advantages to the methane producing process. The bags are available in sizes, e.g., 5 and 10 feet in diameter and 100 or more feet in length. The bag can be deployed from a bag filling machine as desired to accommodate the amount of biomass material to be processed. Multiple bags can be connected to accommodate any volume of the material. The bags can be used to compost the material upon depletion of methane production. Following the composting stage, the material can be used as fertilizer and the bags can be readily collapsed to a small fraction of its filled capacity for disposal or recycling.
These and other advantages will become more apparent upon reference to the following detailed description and accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a perspective illustration of a machine such as used for filling a bag with compost including tubing for aeration purposes, the machine being here used for filling the bag with biomass material for methane production in accordance with the present invention;

Fig. 1A is a top plan view of the machine of Fig. 1;

Fig. 2 illustrates a bag that has been filled with the biomass material for methane production, the bag end being extended and tied off for receiving the methane gas;

Fig. 3 illustrates the bag of Fig. 2 but following expansion of the bag end resulting from methane gas production;

Fig. 4 is a cross sectional view as taken on lines 4-4 of Fig. 3;
Figs. 5 and 5A illustrate a modification of the filled bag of Fig. 3 provided with components for heating the material in the bag; and

Fig. 6 is a schematic overview of the system for producing and utilizing methane gas produced from multiple bags.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Reference is first made to Fig. 1 which illustrates a bag filling machine 10 used for filling a bag 12 with material to be processed for producing methane gas in accordance with the present invention. The bag 12 having a diameter, e.g., of 5 feet, is placed over the collapsed tunnel 14 and the tunnel is expanded to the size of the bag diameter (dash line 14), e.g., 5 feet in diameter. However such machines are also designed to accommodate bags that are various sizes up to 10 feet in diameter. The machine illustrated is similar in most respects to a bagging machine used for bagging and processing compost disclosed in U.S. Patent No. 5,724,793 which patent and the present invention are commonly owned.

As will be noted, preceding the tunnel 14 is a hopper 16 into which a biomass material (arrow 17) is deposited. A piston 18 sized to fit the opening in the tunnel indicated at dash line
14 is reciprocated through the hopper to shove the material 17 from the hopper into and through the tunnel 14 and thus into the bag 12.

The biomass material is preferably a material that does not readily flow and can be somewhat compacted into the bag as will be discussed. A mixture having a solids content of about 30% is desired but can be varied (generally upward) to accommodate a user's need.

The machine also includes one or more fixed guide tubes 20, e.g., a machine adapted to fill a five foot diameter bag may have one guide tube and for filling a ten foot diameter bag have two guide tubes. The guide tubes 20 extend through sized openings in the piston 18 and through the hopper 16 and into the tunnel 14 as seen in Fig. 1A. Lengths of perforated conduit are fed through the guide tubes 20 and are deposited into the bag as the bag is filled. As the bag 12 is filled, the machine moves away from the filled portion of the bag and the conduit 22 is held in place by the material to continuously draw the conduit off the stored coil 24 of conduit housed in bins 26 carried by the machine.

When the bag 12 is filled to the desired capacity, a length
of bag 28 is removed from the tunnel, e.g., about 10 feet of bag, the end is then tied shut as indicated in Fig. 2. The end 28 of the bag as shown remains collapsed only until the reaction of the inoculant with the biomass begins producing the methane gas whereupon the methane gas indicated by arrows 32 expands the bag to fill end 28 as shown in Fig. 3.

A tube or pipe 30 is inserted into the bag end 28 and the methane gas is released from the bag end 28 through the tube 30 as illustrated in Fig. 3. As will be understood, the gas will rise to the top and then seek the open cavity of the bag. This can be enhanced by the placement of a perforated conduit 34 along the top of the bag as seen in Figs. 3 and 4. This conduit is inserted in the same manner as conduit 22. However, conduit 34 is not exposed to the atmosphere as oxygen is detrimental to the methane producing process. Conversely, conduit 22 is exposed to the atmosphere as infusion of oxygen is desirable for the composting step of the disclosed process.

The process as described continues until the biomass material is depleted of its ability to produce methane gas. The depleted biomass material in the bag can be discarded or preferably the material is composted in the manner described for the '793 patent. The conduit for providing such treatment is
indicated in Fig. 4 as perforated conduit 22. Thus, the biomass material is reduced to compost and used as fertilizer and the bag can then be collapsed to a small fraction of its filled state and recycled.

Figs. 5 and 5A illustrate a variation from the above-described apparatus and process only in that in Figs. 5 and 5A it is assumed that the climate is cold and that it may be desired to provide additional heat to insure the desired reaction rate of the biomass material. Such additional heat is provided in a couple of ways. The bag 12' is laid down on pad 36 which is provided with water passages 38 which passages are connected to in and out water lines 40. Hot water can thus be circulated through the pad to warm the biomass material from the bottom up. Further, a plastic sheet or robe 42 can be placed over bag 12' and water lines 44 can be placed between the robe 42 and bag 12' with hot water again circulated through the lines 44 to maintain a desired temperature of the biomass and material in the bag. The engine of the bagging machine may be used to heat the water circulated through the pipes 44.

Reference is now made to Fig. 6 which schematically illustrates a system using the above-described bag filling process. It will be appreciated that the system can include a
single bag or a plurality of bags 12. In Fig. 6, a plurality of bags 12 containing the methane gas producing biomass material 17 are linked together via a methane gas line 46. Thus, the tubes 30 are each connected to line 46 which conveys the methane gas to a collection site 48. Equipment for using the methane gas, e.g., at the site 48, may include a furnace, an engine, a chiller, fuel cells or other equipment that can beneficially burn methane gas. Alternatively, the gas can be selectively conveyed to a multiple of other sites as indicated by arrows. If heat is produced at site 48, hot water circulating lines 40 can be connected between the site 48 and the hot water lines 44 and pad passages 38.

The process and apparatus as described above is greatly simplified over prior methane producing plants. The structure is readily made portable prior to and after completion of the gas production and the system can be expanded or reduced as desired to meet the need of the user. Whereas a preferred embodiment is described, numerous modifications will become apparent to those skilled in the art. The invention as defined in the accompanying claims is intended to encompass such modifications. Accordingly, the claim terms are to be interpreted in accordance with their normal and usual meaning.
CLAIMS

The invention claimed is:

1. A method for producing methane gas which comprises:
   providing a biomass material that will yield methane gas;
   adding or not adding inoculants as desired and inserting
   the biomass material into a large flexible plastic bag to
   provide a first portion of the bag filled with the biomass
   material and sealing off both ends of the bag to provide a
   second bag portion at one end that is unfilled with the
   material;
   said material emitting methane gas that is directed to the
   second bag portion;
   connecting a tube into the bag at the unfilled bag portion
   with an end of the tube protruded from the bag; and
   directing methane gas from the bag and through the tube to
   a point of collection or use.

2. A method as defined in Claim 1 including placing a
   perforated conduit inside the bag along the top of the filled
   portion of the bag and extended to the unfilled portion of the
   bag and thereby facilitating flow of the gas to the unfilled
   portion.
3. A method as defined in Claim 1 including placing aeration tubes in the biomass material in the filled portion of the bag and extending an end thereof to the bag exterior and compost treating the material following substantial extraction of the methane gas from the material.

4. A method as defined in Claim 1 including filling multiple bags with the biomass material in accordance with Claim 1 and further including a gas line interconnected with the multiple tubes of said multiple bags and conveying methane gas through the gas line to a collection site.

5. A method as defined in Claim 1 including placing the bag on a heating pad while being filled and upon being filled, directing hot water to the heating pad to heat the filled bag as desired and to enhance the reaction of the methane gas production.

6. A method as defined in Claim 1 which includes placing an insulating robe over the bag, inserting water lines between the robe and bag and flowing hot water through the lines to achieve a desired temperature of the material in the bag.

7. A system for generating methane gas which comprises:
a flexible bag having a horizontally extended tubular length, a majority of said length filled with biomass material in a composition known to produce methane gas and as desired adding an inoculant to the material that induces a reaction with the biomass material to induce methane gas emission from the biomass material;

a remaining tubular length of the bag unfilled with the material and to be filled with said gas emitted by the biomass material, a pipe inserted through the bag wall for releasing methane gas from the remaining tubular length and a continuation of said pipe directing said gas to a gas collection site.

8. A system as defined in Claim 7 wherein a conduit is positioned inside the bag at the top of the material in the filled tubular length and extended to the unfilled tubular length for transmitting gas to the unfilled tubular length.

9. A system as defined in Claim 8 wherein a heating pad underlies the bag, water passages are provided in the pad and connected to a hot water source for flowing hot water through the pad and heating thereby the material in the bag.

10. A system as defined in Claim 9 wherein a robe is placed over the bag, water lines are positioned between the bag
and robe and hot water is circulated through the lines for heating the material in the bag.

11. A system as defined in Claim 7 wherein multiple of the defined bags are placed in adjacent relationship and a gas line is connected to the pipes and extended to a collection site for transmitting gas from the bag to the collection site.

12. A system as defined in Claim 7 wherein the dominant portion of the biomass material is animal waste.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
   IPC(7) : B09B 3/00
   US CL : 48/127.3; 422/184.1
   According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
   U.S. : 48/127.3; 422/184.1, 164; 53/428, 434, 469, 483; 34/218, 225, 233; 71/9

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<tbody>
<tr>
<td>A</td>
<td>US 1,990,523 A (BUSWELL et al.) 12 February 1935 (12.02.1935)</td>
<td>1-12</td>
</tr>
<tr>
<td>A</td>
<td>US 4,046,551 A (ANDERSON) 6 September 1977 (06.09.1977)</td>
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<td>A</td>
<td>US 4,208,279 A (VARANI) 17 June 1980 (17.06.1980)</td>
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<tr>
<td>A</td>
<td>US 5,724,793 A (INMAN et al.) 10 March 1998 (10.03.1998)</td>
<td>1-12</td>
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☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

Date of the actual completion of the international search

20 April 2002 (20.04.2002)

Name and mailing address of the ISA/US
   Commissioner of Patents and Trademarks
   Box PCT
   Washington, D.C. 20231
   Facsimile No. (703) 305-3230

Date of mailing of the international search report

10 MAY 2002

Authorized Officer

Briana Ridley

Telephone No. (703) 305-0661

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