Feb. 20, 1951 H. HUMFELD ET AL 2,542,031

FERMENTOR FOR SUBMERGED CULTURES

Filed Sept. 12, 1947 2 Sheets-Sheet 1

Fig. 1.

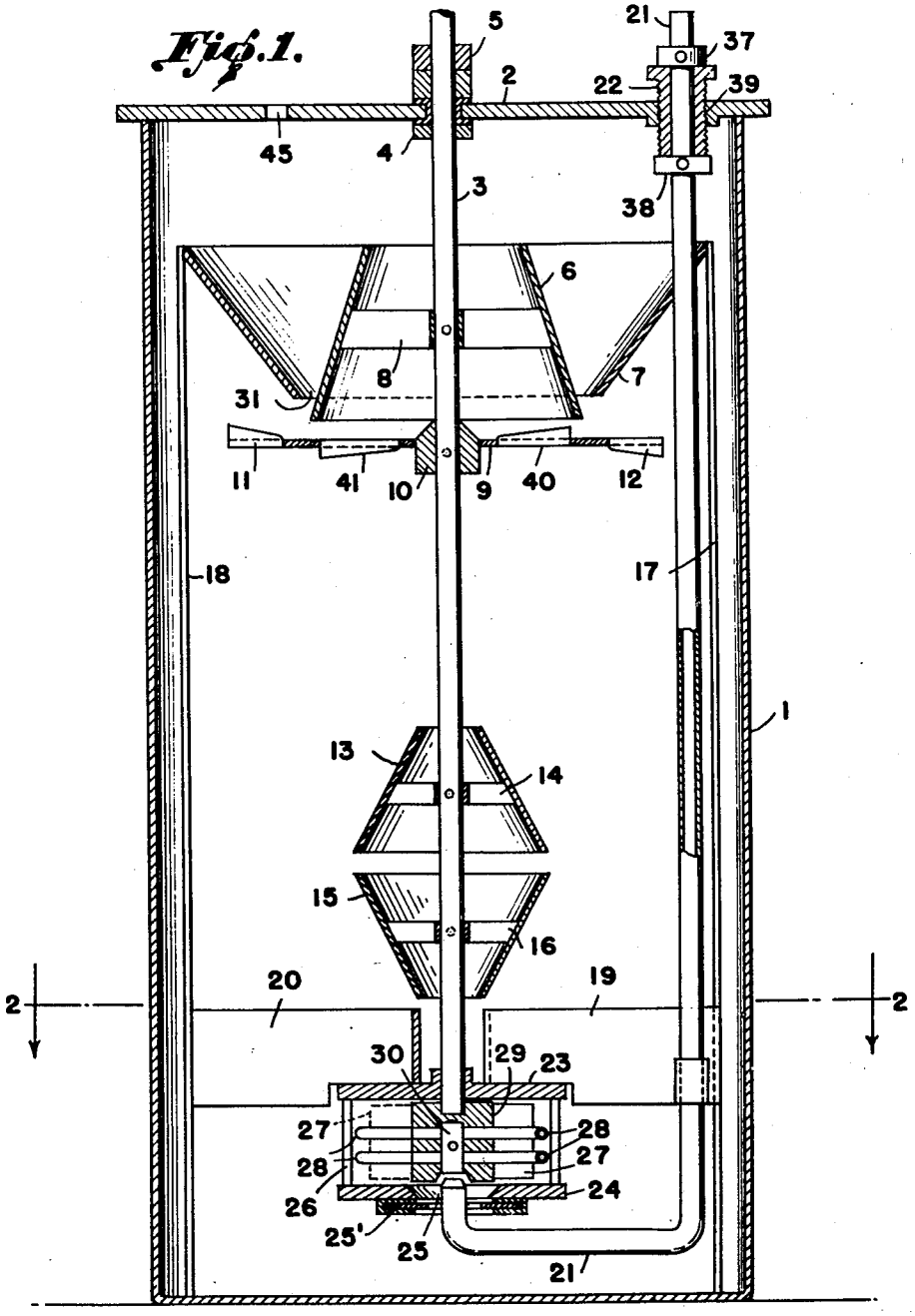

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Fig. 2.

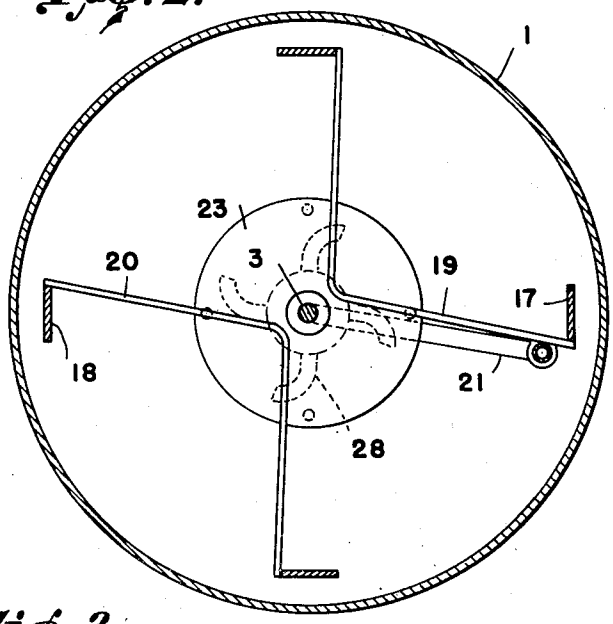


Fig. 3.

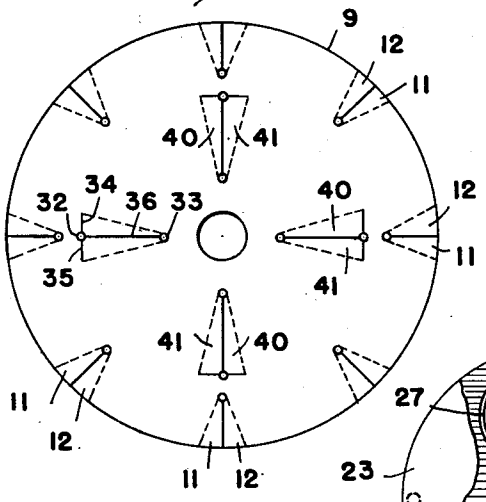
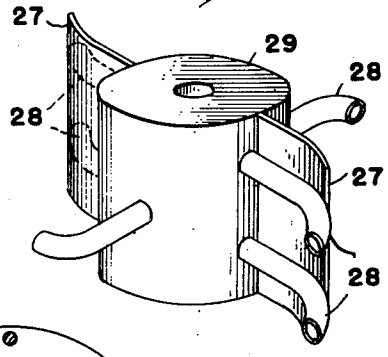


Fig. 5.



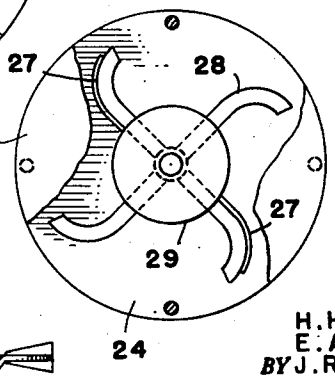
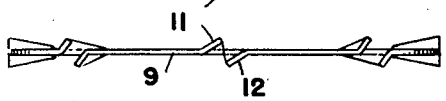


Fig. 6.

Fig. 4.



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UNITED STATES PATENT OFFICE

2,542,031

FERMENTOR FOR SUBMERGED CULTURES

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3 Claims. (Cl. 195—137)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

1

This application is made under the act of March 3, 1883, as amended by the act of April 30, 1928, and the invention herein described, if patented, may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment to us of any royalty thereon.

This invention relates to a novel fermentor for submerged cultures.

The use of large vats without agitation devices has been known for generations but has the disadvantage that fermentations carried out under such conditions are comparatively slow and tie up vast quantities of materials as well as requiring large-sized, and consequently expensive, equipment. The trend, therefore, in recent years has been to attempt to use agitation and also to introduce air directly into the reaction mixture. These developments brought with them serious problems, and foremost among them being foam-formation. Both the agitation and the introduction of air caused such large volumes of foam as to render the method impracticable without modification. One remedy involved the addition to the reaction mixture of chemicals having foam-breaking characteristics. This method has the disadvantage of introducing undesired materials into the system and introduces an unknown factor into an already complicated problem.

We have invented a fermentor by the use of which fermentations can be carried out at extremely rapid rates. Air is added to satisfy the oxygen requirements of the organisms and agitation is employed to bring about intimate contact between the reactants. At the same time the foam formed is broken down, the gas released to the atmosphere, and the liquid returned to the vessel. No foam-breaking chemicals are required.

An object of this invention is to provide a fermentor having both novel aeration and foam-breaking devices.

Another object of this invention is to provide a fermentor having a novel aeration device.

Another object of this invention is to provide a fermentor having a novel foam-breaking device.

Other objects and advantages will be apparent to those skilled in the art from the description herein.

The accompanying drawing illustrates the device of this invention, in which:

Figure 1 is a vertical longitudinal section of the fermentor;

Figure 2 is a horizontal section on line 2–2 of Figure 1;

2

Figure 3 is a plan view of the foam-breaking disc, illustrating a method of making it;

Figure 4 is an edge view of the disc;

Figure 5 is a pictorial view of the aeration device;

Figure 6 is a top view of the aeration device, the top plate being broken away.

In Figure 1 is shown the assembled device. Vessel 1 is provided with a lid 2, which serves to cover the contents and to support shaft 3. Shaft 3 extends through lid 2 into the vessel 1. At its lower end, shaft 3 is provided with an enlarged boss 29, having a longitudinal bore 30. Shaft 3 is held in place by collars 4 and 5. At its upper end, shaft 3 is provided with suitable means for rotation, such as an electric motor (not illustrated).

The aeration device is situated at the lower end of shaft 3. This device includes a casing comprising upper and lower stationary circular plates 23 and 24 fixed in place by pins 26. Upper plate 23 is attached to bars 19 and 20, which in turn are attached to struts 17 and 18. Thus the casing is held stationary. Shaft 3 extends through top plate 23 and is attached at its lower end to 29. To the boss 29, and therefore indirectly to the shaft are attached tubes 28 which extend at right angles to the shaft. The outer ends of the tubes curve rearwardly, opposite to the direction of rotation of the tubes. These tubes communicate with bore 30. Attached to 29 and positioned adjacent of two of the tubes are vanes 27. Bottom plate 24 is provided with a port 25 through which extends pipe 21. The position of this pipe is adjustable to vary the proximity of its tip to the inlet of bore 30. The adjustment device consists of collars 37, 38, hollow screw 22, and threaded hole 39. Collar 37 is positioned above screw 22 and collar 38 below screw 22. Both of these collars are fastened on pipe 21 by the use of set screws or other suitable means. Hollow screw 22 is freely rotatable about pipe 21 and the thread on screw 22 engages in threads in the hole 39 in the lid through which the screw and pipe protrude. Upon rotation of screw 22 the entire pipe will be raised or lowered. Thus the proximity of the pipe tip and the bore 30 can be adjusted for the desired amount of air. There is one position of the pipe tip that will give maximum flow of air which can easily be determined with a flow meter. Raising or lowering the tip from this maximum position gives decreasing amount of air flow. Pipe 21 extends from the vicinity of the end of shaft 3 through the vessel 1, lid 2, and is open to the atmosphere.

Shaft 3 is caused to rotate counterclockwise at high speed. Rotation of vanes 27 attached to the shaft causes flow of liquid up through port 25, bore 30, tubes 28 and radially out of the casing past pins 26. Liquid also flows through port 25 directly into the interior of the casing and out past pins 26. The passage of the liquid past the tip of pipe 21 causes air to be sucked through pipe 21 into the liquid stream where it passes through bore 30, tubes 28 and out of the casing. The amount of air entering the system can be regulated by raising or lowering the tip of pipe 21 as previously described.

Port 25 may be made adjustable in diameter. This can be accomplished by use of rotatable laminae 25', such as is employed in making iris diaphragms in photographic cameras. This adjustable feature is advantageous as when the liquid in the fermentor is thoroughly aerated, its apparent specific gravity drops. To maintain the proper flow of air through pipe 21 under such conditions, the volume of material passing through port 25 must be increased and this can easily be accomplished by enlargement of the diameter of the port as described above.

Mixing and agitating cones 13 and 15 are secured to the shaft 3 by webs 14 and 16, respectively. Rotation of these cones in the liquid causes violent agitation by reason of the flow of liquid past the cones due to centrifugal action.

The foam breaker comprises cones 6 and 7 and disc 9, located above the normal liquid level in vessel 1. Cone 7 is stationary and is supported by struts 17, 18. Cone 6 is secured to shaft 3 via web 8. A passage 31 is provided for flow of fluids between the cones. Beneath the cones a disc 9 is attached to shaft 3 through collar 10. This disc is provided with an inner set of vanes 40, 41. In this inner set, vanes 40 are turned up, while vanes 41 are turned down. The disc 9 is also provided with an outer set of vanes 11, 12. In this set, vanes 11 are turned up and vanes 12 are turned down. Thus it is evident that the inner set of vanes is positioned in opposite relation to the outer set of vanes. The result of this is that when the disc 9 is rotated counter clockwise, vanes 40 and 41 tend to force material up toward cone 6 while vanes 11 and 12 tend to force material down toward the body of liquid in the vessel.

A convenient method of forming the vanes is by drilling holes 32, 33 in disc 9 then making saw cuts along lines 34, 35, and 36. Flap 40 is then bent upwardly about 30° and flap 41 is bent downwardly about 30°. The other vanes are made in similar fashion.

In operation, shaft 3 is rotated counterclockwise whereby the interior set of vanes 40, 41 tend to force material upwardly while exterior vanes 11, 12 tend to force material downwardly. Foam rising from the reaction mixture contacts the inner series of vanes 40, 41 whereby the foam is thrown upwardly through the passage between adjacent vanes onto the inner surface of cone 6. The rotation of cone 6 forces material down again onto disc 9 beyond the inner series of vanes. Contact with the rapidly spinning disc forces material toward the walls of the vessel. Some of the material is thrown downward by the outer series of vanes 11, 12. The flow of liquid and gases produced by rotation of disc 9 causes a downdraft about the inner circumference of the vessel whereby foam is pushed down at this point. Thus the rising body of foam has a dome-like structure and it appears that the foam actually contacts the disc 9 only toward the center and in the vicinity of the interior set of vanes. Regardless of the paths of flow of the materials, it has been observed that in the device as illustrated, the foam is broken. In operation the body of foam rises until it just touches the bottom of disc 9. It goes no further as a body, although the production of foam progresses continuously. The device effectively separates the foam into its components, gas and liquid, and thus it has been established as an operative device, regardless of the theory of operation. It has been observed that cone 7 is not essential, although it may be necessary if the volume of foam suddenly increases and rises through cone 6. In such case, the foam will be directed back to the outer surface of cone 6 by disc 7.

The fermentor of this invention may be provided with conveniences to aid in control of the reaction. For instance, it is usually advisable to add a well for a thermometer, a well for an electrode to measure the pH of the reaction mixture and provide one or more sampling tubes. Such devices are easily mounted on lid 2 and pass through holes in cone 7 beyond the periphery of disc 9. A gas outlet is provided at 45.

The apparatus of this invention can be used for growing all types of cultures under submerged conditions. For instance, it may be used for the production of yeasts such as baker's yeast, torula yeast, etc. It may be used for the production of antibiotics such as subtilin, penicillin, streptomycin, and other antibiotics produced by micro-organisms. Further, the device may be used for the preparation of various chemical compounds such as citric acid, gluconic acid, acetic acid, and other compounds produced by micro-biosis. In all such cases the particular micro-organism is grown on the usual media and the use of the device of this invention gives more rapid and economical production.

Having described our invention, we claim:

1. A fermentor comprising a vessel, means for introducing a gas into the body of liquid therein, comprising means in said vessel mounted for rotation about a vertical axis, said means providing an axial chamber, and providing lateral passageways communicating with said chamber, upwardly and outwardly extending vanes mounted for rotation with said passageways and mounted adjacent said passageways, said axial chamber having a lower inlet communicating through a passageway with the body of liquid, a conduit communicating at one end with a source of the gas and at the other end with said lower inlet.

2. The apparatus described in claim 1 in which the lower inlet is provided with valve means operable to narrow or enlarge the passageway communicating with the body of liquid, whereby the volume of liquid recirculated through the axial chamber and lateral passageways may be controlled.

3. The apparatus described in claim 1, the means mounted for rotation comprising a vertical shaft provided with a longitudinal bore at its lower end, the bore being the axial chamber, the lateral passageways being tubes attached to, rotating with, and communicating with the bored end, the outer ends of the tubes curving rearwardly, that is, opposite the direction of rotation, the outer portions of the vanes also curving rearwardly, whereby gas is drawn into the fermentor through the gas conduit, and means to adjust the distance between the said other

end of the gas conduit and the lower inlet of the axial chamber.

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