

May 25, 1971

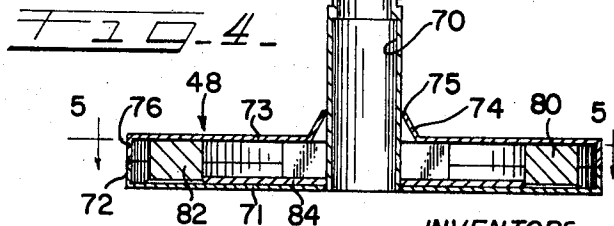
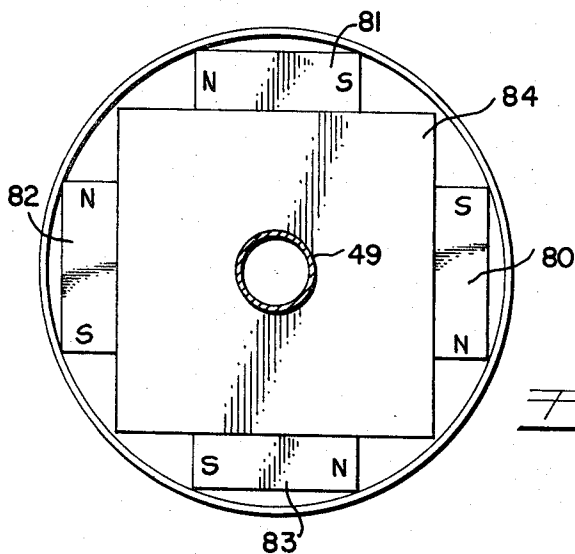
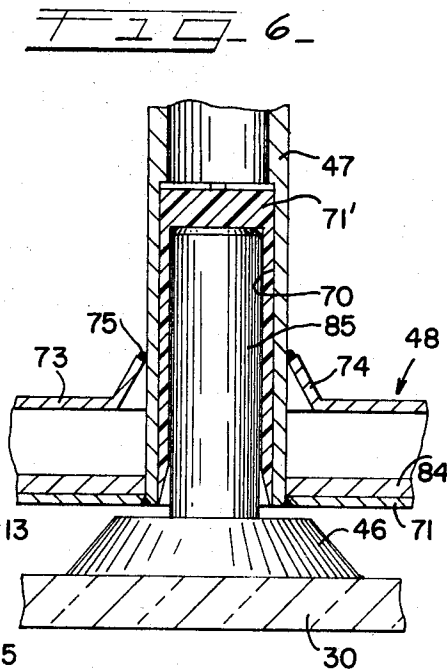
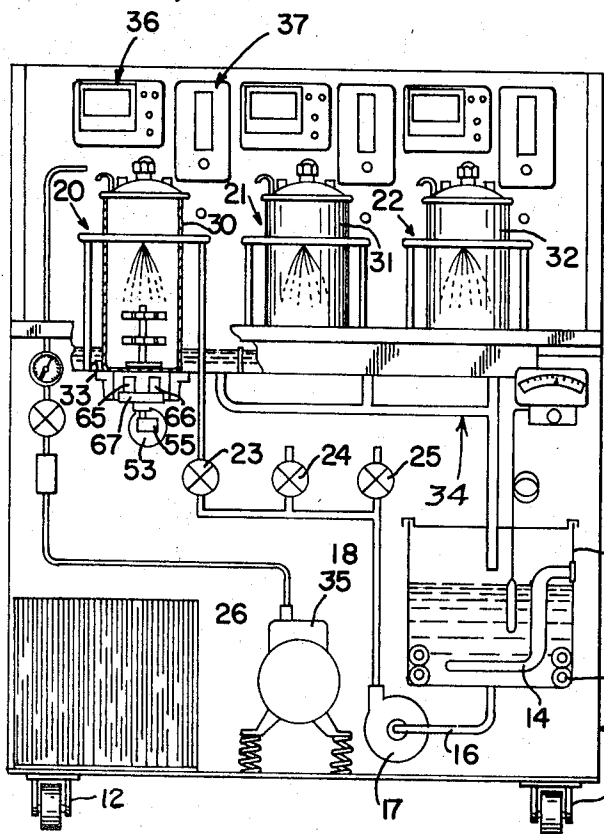
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3,580,812

FERMENTER HAVING A MAGNETICALLY DRIVEN AGITATOR

Filed Oct. 19, 1967

2 Sheets-Sheet 1



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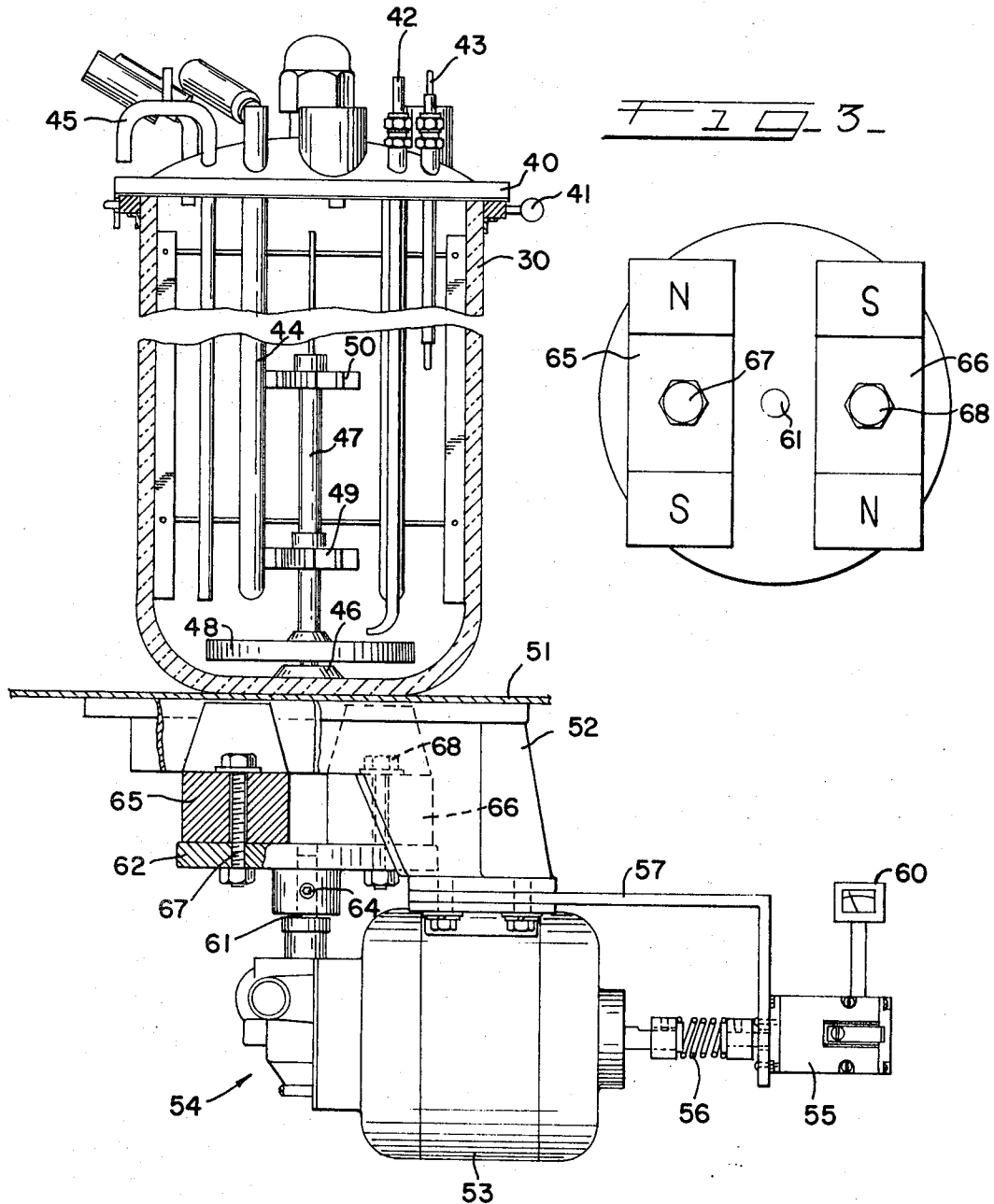
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FERMENTER HAVING A MAGNETICALLY DRIVEN AGITATOR

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Filed Oct. 19, 1967, Ser. No. 676,419

Int. Cl. C12b 1/00

U.S. Cl. 195—143

4 Claims

ABSTRACT OF THE DISCLOSURE

A magnetic drive arrangement for fermenters wherein the sample or culture agitated must be maintained free of contamination. The magnetic drive includes a driven plate and a driving plate. The magnets on the driven plate are polygonally arranged with like poles adjacent to maximize field strength, and are mounted in a cup-shaped receptacle, located and held by a simple spacer plate. A cover plate captivates the magnets and is joined to the cup-shaped receptacle to isolate them from the sample agitated. The rotational drive includes a double shaft motor which drives the driving plate at one end through a reduction gear drive, with the other end of the motor shaft directly coupled to a tachometer generator to provide accurate speed readings in the lower speed ranges.

This invention relates to improvements in fermenters and, more specifically, is directed to a new and improved magnetic drive which permits agitation of a sample or culture while it is completely isolated from contamination.

In the production of vitamins, polysaccharides, antibiotics, viruses, enzymes, cell proteins, bacteria, molds, organic acids and solvents, it is almost a requirement that the metabolic processes be studied under submerged conditions with the conditions of temperature, agitation and aeration very carefully controlled. In the past, one problem which was encountered was maintaining agitation at a controlled and uniform rate while maintaining the culture sample isolated from contact with any foreign materials. Magnetic drives were developed in an effort to overcome this problem and were somewhat successful, however, were not completely satisfactory because of the lack of torsional strength and the tendency to weaken with the passage of time. Coupled with this, the exact speed of rotation was difficult to determine with known speed control arrangements, particularly in the lower speed ranges. This problem was further complicated because it was desired that the culture be fully visible throughout the fermentation and agitation processes. Other important requirements such as temperature control, removability, and ease of cleaning of the fermenter receptacle added to these complications.

The present invention relates to a new and improved magnetic drive particularly adapted for use in fermenters of the type briefly described above and provides a satisfactory solution to the above-enumerated problems. The present magnetic driving arrangement includes axially spaced driving and driven plates, each having magnetic means mounted thereon. The driving plate includes a pair of horseshoe magnets arranged in parallel relation, symmetric with respect to the rotational axis of the plate. The poles or tips of the horseshoe magnets project axially of the plate and are located in closely spaced relation to the bottom wall of the fermenter flask or receptacle. On the driven plate, which is wholly contained within the fermenter flask, is provided a plurality of bar magnets arranged in polygonal fashion with the like poles of each positioned in close proximity. In this manner, a magnetic field is established in axial alignment with the poles of

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the horseshoe magnets to form a coupling which is relatively powerful when considering the size of the magnets used. The bar magnets maintain their strength over extended periods because of their arrangement.

In the preferred form of the invention, the driven plate consists of a cup-shaped receptacle which receives four bar magnets arranged at right angles to each other with the poles positioned as set forth above. The receptacle is of non-magnetizable material such as stainless steel. An aluminum spacer maintains the magnets held against an upstanding flange on the cup-shaped receptacle and a cover formed of similar material is joined to the receptacle to effectively locate and captivate the magnets in the desired relation while effectively isolating them from the sample to be agitated. The driven plate drives an impeller mounted on the same shaft, which serves to agitate the sample.

Advantages other than those specifically noted above will become apparent upon consideration of the objects achieved and consideration of a description of a preferred form of the invention.

It is an object of this invention to provide a new and improved fermenter having an improved magnetic drive arrangement.

It is a further object of this invention to provide a new and improved magnetic drive arrangement for use in agitating a sample or culture which must be maintained completely isolated from foreign material.

It is a further object of this invention to provide a new and improved magnetic drive having a speed indicating means thereon which provides accurate indication of speed, particularly in the lower ranges.

It is a further object of this invention to provide an improved magnetic coupling for use in driving coaxially arranged shafts.

It is a still further object of this invention to provide a new and improved magnetic coupling which will provide increased torque transmittal between driving plates due to the novel arrangement of the magnets thereon.

Objects other than those specifically set forth will become apparent upon consideration of a detailed description made in conjunction with the accompanying drawings.

In the drawings:

FIG. 1 is a schematic view of a three-station fermenter;

FIG. 2 is an enlarged cross-sectional view of the fermenter receptacle or flask illustrating the impeller and driven plate in full elevation and with portions of the driving plate in cross section;

FIG. 3 is an enlarged top plan schematic view of the driving plate shown in FIG. 2;

FIG. 4 is a side elevational view of the impeller shown in full elevation in FIG. 2;

FIG. 5 is an enlarged cross-sectional view taken generally along the line 5—5 of FIG. 4; and

FIG. 6 is an enlarged cross-sectional view of the impeller spindle and mounting.

In FIG. 1 is schematically illustrated a three-station fermenter which includes a cabinet 10 mounted on rollers 11 and 12 for portable movement about the laboratory. The cabinet 10 houses a reservoir 13 having a centrally positioned heating coil 14 while around the circumferential portion of the reservoir, adjacent the bottom, is provided cooling coils 15 which are adapted to cool the liquid within the reservoir to any selected temperature. A conduit 16 is joined to the intake of a centrifugal pump 17 which supplies liquid through conduit 18 to each of the fermenter stations indicated generally at 20, 21 and 22. Control valves 23, 24 and 25 control the flow of liquid to each of the stations, permitting flow adjustment of the liquid which is sprayed circumferentially about the surface of the fermenter receptacles 30, 31 and

32. Inasmuch as the fermenting stations are substantially identical, further description will be limited to the station shown in partial, broken-away cross section in the left-hand portion of FIG. 1. The receptacle 30 rests with its bottom positioned on the bottom of a drain pan 33 which is adapted to receive the liquid sprayed on the receptacle and recirculate the same through a drain line 34 back to the reservoir 13. A cooling unit 26 supplies the cooled refrigerant to the cooling coils 15. The heater 14 and cooler 26 are provided with suitable controls (not shown) to permit selection of the desired temperature for the fluid bath on the exterior of the flask 30. An air compressor 35 provides a source of compressed air to service each of the fermenter stations 20, 21 and 22. The temperature of the cooling fluid may be indicated and controlled through a control panel and indicator arrangement, shown at 36, with the flow rate indicated by a flow meter 37.

As seen in FIG. 2, the flask 30 is formed of clear glass, permitting observation of the sample during the fermentation process. A cover 40, having a cam operated locking means 41 of known type locks the cover to the flask 30. Service outlets which permit controlled access to the interior of the fermenter flask 30 are also provided in the form of a sparger 42, foam probe port 43, thermometer probe well 44 and sample port 45. At the base of the fermenter flask and mounted on the inner side of the bottom wall is a bearing support assembly 46 which mounts an impeller shaft 47 having a driven plate 48 at the lower end. Impeller blades 49 and 50 provide uniform agitation of the sample with rotational motion imparted to the impellers through the driven plate 48 of the novel magnetic coupling. In the preferred form, the impeller shaft 47 and driven plate 48 are formed of stainless steel, as is the bearing mount 46. Obviously, any material which has similar properties and meets the requirements specifically set forth below may be used as an alternate.

The bottom wall of the drain pan 33 is shown in cross section at 51 in the cross-sectional view of FIG. 2. On the underside of the bottom wall 51 is mounted a bracket assembly 52 which supports a variable speed drive motor of the double-shaft type. The output shaft at the left-hand end of the motor is connected to the driving plate 62 via shaft 61 through a reduction gear drive indicated generally at 54 of conventional design. The opposite end of the motor drive shaft drives a DC generator 55 through a spring coupling 56. The DC generator 55 is supported by a generator bracket 57 which is attached to the motor mounting bracket 55 with the fasteners mounting the motor 53. The DC generator output is connected by conventional means to a tachometer of known type with the tachometer indicator shown schematically at 60.

The output shaft 61 of the reduction gear drive 54 mounts the driving plate 62 through a hub portion 63 which is fastened to the shaft 61 by means of a set screw 64 or the equivalent. A pair of horseshoe magnets 65 and 66 are mounted on the driving plate 62 and, as seen in FIG. 3, are arranged in parallel relation and symmetric relative to the rotational axis of the shaft 61. The magnets 65 and 66 are joined to the driving plate 62 by suitable fasteners such as bolts 67 and 68, and are positioned with the tips of the poles disposed closely adjacent the underside of the bottom wall 51 of the fluid drain pan 33. The poles are arranged in the fashion indicated by the letters N and S, with the north poles positioned on opposite diameters and the south poles positioned on opposite ends of a diametric line passing through the axis of rotation of the shaft 61. The spacing of the poles is selected to correspond with the location of the flux areas at the ends of the bar magnets, as will be described below.

As is apparent, rotation of the motor shaft causes rotation of the driving plate 62 and magnets 65 and 66. Simultaneously, the DC generator is driven at the actual motor speed, which may be approximately twice that of the speed of the output shaft 61. In this manner, when the fermentation process calls for low agitation speeds, 75

they will be accurately indicated because the DC generator is operating at a shaft speed approximately twice that of the impeller speed. Tachometer bounce and error are thus minimized and the experiment may be performed with a greater degree of accuracy than previously known. Uniform rotation of the impellers 49 and 50 is assured even in more viscous liquids by virtue of the strong magnetic coupling between the driving plate 62 and driven plate 48.

As seen in FIGS. 4 and 6, the shaft 47 which supports the impeller blades 49 and 50 is formed with a counter-bored lower end 70 which receives a bearing 71' formed of low friction material such as Teflon or the like. The lower end of the shaft 47 is joined to an annular plate 71 which is of cup-shaped design having a continuous annular flange 72 at the periphery. The cup-shaped plate 71 is closed off by a cover 73 which is joined to the shaft at the inner margin of an integral frusto-conical wall portion 74 through welding, as at 75. The cover 73 is provided with a flange 76 at its outer periphery which co-operates with the flange 72 at the periphery of the plate 71 with the two plates being welded to each other to form a sealed unit after installation of the magnets to be described.

As seen in FIG. 5, four bar magnets 80, 81, 82 and 83 are arranged in polygonal fashion about the axis of the shaft 49. Each of the magnets is disposed in outward abutting relation with the upstanding flange 72 and depending flange 76 on the upper and lower plates 71 and 73 which co-operate to form the driven plate 48. A spacer plate 84 is fitted around the lower end of the shaft 47 and has its outer margins in engagement with the inner side of each of the magnets to prevent inward movement.

As is apparent in FIG. 5, the magnets are arranged at right angles to each other with the similar pole ends adjacent so that the field strength is greatest at each of the corners of the spacer plate. In this manner, a relatively strong field is provided when considering the size and number of the magnets. Because the like poles repel, the magnets retain their magnetic strength over a long period of time. The corners of the spacer plate between the magnet poles are of a dimension so as to be in axial alignment with the opposite pole on the horseshoe magnets 65 and 66.

The spacer plate 74 and the driven plate 48, as well as the shaft 47, are formed of non-magnetic material. In one embodiment, the shaft and driven plate were formed of stainless steel with the spacer plate 84 being formed of aluminum.

When the impeller shaft is installed over the bearing support 46, the low friction bearing 71' has the end walls engaged on the end of a cylindrical bearing post 85 to limit the downward movement and to locate the driven plate in closely spaced relation to the bottom wall. It is to be appreciated that the field strength of the magnets is normally limited by the physical limitations on their size. The problem of torque transmission in the environment described is complicated by the fact that the spindle must be supported for rotation internally of the fermentation flask 30 to prevent possible contamination. In addition, a water bath is sprayed on the flask which requires a drain pan. Thus, an additional thickness of material is interposed between the driving and driven plates in the form of the bottom wall of the drain pan. As is well known, the magnetic strength is a function of the square of the distance and, therefore, to solve the problems, the magnets were arranged in the fashion shown in FIGS. 3 and 5. Good torque transmission is assured to provide the proper rotational speeds and coupling strength for agitation during the fermentation process.

Because of its uncomplicated design, the magnetic coupling of the present invention may be easily manufactured and is virtually maintenance-free in use. The possibility of contamination of the fermentation sample is completely avoided by the present construction. The impeller shaft assembly is easily removed to permit cleaning of the flask after an experiment is completed. Replacement

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of the impeller shaft assembly is easily accomplished without requiring any special mechanical skill.

Upon a consideration of the foregoing, it will become obvious to those skilled in the art that various modifications may be made without departing from the invention embodied herein. Therefore, only such limitations should be imposed as are indicated by the spirit and scope of the appended claims.

We claim:

1. In a fermenter wherein a sample is to be agitated in a flask under controlled conditions while isolated from contact with any foreign substance, the improvement comprising means to agitate said sample in said flask, said means including an impeller mounted on a shaft means wholly contained within said flask for rotation about the axis of said shaft means, a driven plate disposed at a lower end of said shaft in closely spaced relation to a bottom wall portion of said flask, said driven plate being rotatable with said shaft about its axis to drive said impeller, said driven plate having a plurality of magnets arranged in polygonal fashion about a shaft axis with like poles adjacent each other to provide areas of increased magnetic flux density, a driving plate located externally of said flask in closely spaced relation to said driven plate, magnetic means mounted on said driving plate and having unlike pole portions thereof adjacent like poles of said magnets on said driven plate whereby rotation of said driving plate will rotate said driven plate, and means to rotate said driving plate at selected speeds.

2. The improvement in fermenters as defined in claim 1 wherein the magnetic means on said driving plate com-

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prises a pair of horseshoe magnets disposed in parallel relation on opposite sides of said shaft axis, each of said magnets having a pole portion in axial spaced relation to said flux areas for improved coupling.

3. The improvement in fermenters as defined in claim 1 wherein said means to drive said driven plate includes a reduction gear drive driven by an electric motor, said electric motor having a shaft means thereon which is directly connected to speed indicating means driven at the motor speed, whereby accurate readings of rotational speeds are obtainable in lower speed ranges.

4. The improvement in fermenters as defined in claim 1 wherein said plurality of magnets on said driven plate are held in radially spaced relation to said shaft axis through the provision of non-magnetic spacer means co-operating with the inner margins thereof and axially projecting flange means co-operating with at least a part of the outer margin to confine each of said magnets.

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U.S. Cl. X.R.

310—103