United States Patent

Suchy

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[45] Sept. 26, 1972

[54] ELECTROMAGNETICALLY PROPELLED STIRRER AND SHAKER

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[21] Appl. No.: **173,925**

[52] **U.S. Cl.** **259/1**, 259/72

[51] **Int. Cl.** **B01f 9/00**

[58] **Field of Search** ..... 259/1, DIG. 46, 72; 310/8, 310/8.1, 8.7, 26

[56] **References Cited**

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Primary Examiner—Robert W. Jenkins

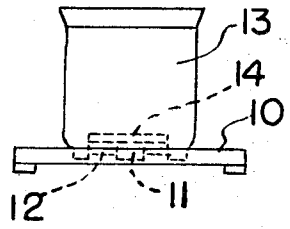
Attorney—Baldwin, Egan, Walling & Fetzer

[57] **ABSTRACT**

A motorless laboratory magnetic stirrer is composed from two fixed electromagnets whose magnetic poles lie in a common plane and are perpendicular to each other. Both electromagnets are supplied by alternating currents of adjustable, but equal, low frequency mutually phase-shifted by 90°, which are produced by a controlled switching of the network current. The angular velocity of the rotating magnetic field produced in this way equals the frequency of the supplying current and acts to rotate a magnetic rod in a liquid.

In a similar way a magnetically propelled shaker is constructed. Two permanent magnets perpendicular to each other are fixed to a tray and placed close to the electromagnets mentioned above. The tray is attached to a base in a manner which permits its free movement in the plane of the tray without rotation of the tray. The tray then exercises an orbital movement and acts to shake a liquid in a vessel placed on the tray. To obtain higher force for shaking, the principles of attracting two permanent magnets by stationary electromagnets is replaced by solenoids, attracting ferromagnetic cores.

5 Claims, 6 Drawing Figures



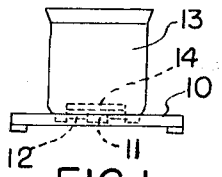


FIG. 1

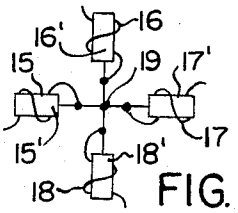


FIG. 2

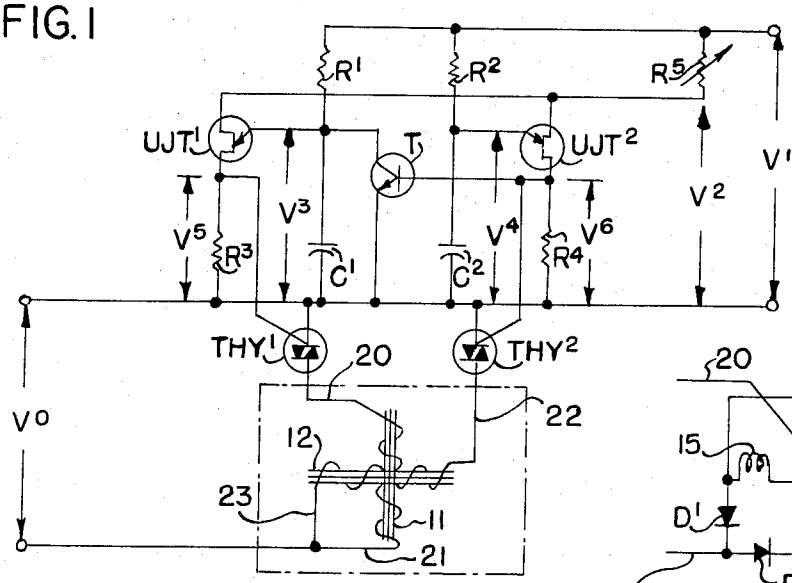


FIG. 3

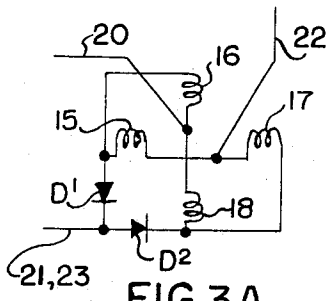


FIG. 3A

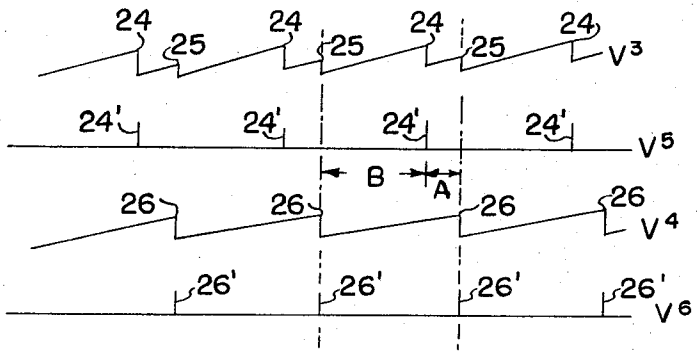


FIG. 4

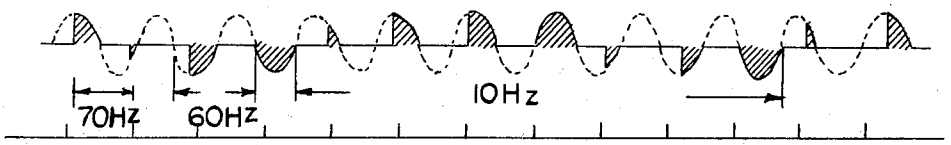


FIG. 5

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ELECTROMAGNETICALLY PROPELLED STIRRER AND SHAKER

BACKGROUND OF THE INVENTION

Most of the stirrers presently in use in chemical or similar laboratories consist of an electric motor with a vertically positioned drive shaft and a strong, permanent magnet connected to the upper end of the motor shaft. The motor with the attached magnet is enclosed in a housing, together with a potentiometer which permits some speed regulation.

When a solution in a beaker, or in another suitable vessel, is placed on the top of the housing and a stirring magnetic rod (usually glass or Teflon coated) is placed in the solution in the beaker, the stirring rod follows the rotation of the permanent magnet connected to the electric motor and stirs the solution.

This system has several disadvantages:

1. It tends to stall at low speed. The speed is given by the supplying energy (set by the potentiometer) and by the resistance in bearings and the rubbing of the stirring rod. Once stalled, the stirrer will not start moving by itself because the static friction is higher than the dynamic one.

2. It tends to stall in cold because of increased friction in the bearings, which causes problems in cold rooms.

3. The speed highly depends on the network voltage, which causes problems for unattended or overnight runs.

4. The vertical position of the stirring motor causes the housing to be rather high and, therefore, mechanically less stable than a lower construction would be.

Most of the shakers presently used consist of an electric motor, gears and an eccentric which moves a tray in a reciprocal or orbital way. Items to be shaken (for instance fermentation vessels) are placed on this tray.

The disadvantage of this system is fast wearing because of high stress on the gears and bearings.

An object of the present invention is to provide a motorless magnetic stirrer whose speed depends in general neither on the network voltage, nor on the load or temperature.

Another object of the invention is to provide a flat and stable construction of the stirrer mechanism which in the case of this invention is mainly controlled by the thickness of the electromagnets and may be less than one inch.

Another object of the present invention is to provide a stirring device having no moving parts and, therefore, wherein the wear is negligible. Also, the structure involved in this invention is very simple and, therefore, reliable and suitable for laboratory purposes.

Another object of the invention is to provide a shaking device having no bearings and gears and, therefore, wherein the wear is negligible.

Other objects and advantages of the invention will be apparent from the accompanying drawings and description and the essential features will be set forth in the appended claims.

In the drawings,

FIG. 1 is a side elevational view, of diminished size, showing a beaker resting upon the stirring device of the present invention;

FIG. 2 is a top view, of diminished size, showing the shaking mechanism of the shaking device of the present invention;

FIG. 3 is an electrical diagram suitable for carrying out the purpose of the present invention with respect to the stirring device;

FIG. 3A is a fragmental electrical diagram to be substituted for the portion of FIG. 3 enclosed in dot-dash lines, with respect to the shaking device;

FIG. 4 is a graph showing the voltage variations in the two triggering circuits used to cause a 90° phase-shift in the currents supplied respectively to two stationary electromagnets shown in FIG. 3; while

FIG. 5 illustrates the commutation of the alternating current to the two electromagnetic coils.

As to the stirrer, referring to FIGS. 1 and 3, a low flat support **10** adapted to rest upon a table or the like has fixed to its underside two stationary linear electromagnets **11** and **12**, together with the control devices shown in FIG. 3. The poles of magnets **11** and **12** lie in a common plane and are at right angles to each other. Each of the electromagnets **11** and **12** may be composed of two or more coils so that four or more coils appear in the electromagnet structure. However, the structure has altogether four magnetic poles only. These four poles may be extended to reach places with difficult access, for instance, a hot plate or heating mantle. A laboratory beaker is shown at **13** resting upon the support **10** and the stirrer **14**, positioned in the solution in beaker **13**, is a magnetic rod or bar magnet, usually coated with glass or Teflon.

As to the shaker, referring to FIGS. 2 and 3A, two pair of opposing solenoids **15** and **16**, and **17** and **18** lying in common planes and fixed to a base attract, respectively, when energized, four cores **15'**, **16'**, **17'** and **18'** connected flexibly at **19** to the bottom of a tray (not shown) which is supported by springs (or by other flexible connections) fixed to a base similar to **10**.

As previously mentioned, means is provided for causing a phase-shift of **90°** between the currents magnetizing the electromagnets **11** and **12** in the case of the stirrer and solenoids **15, 16, 17** and **18** in the case of the shaker. The current to the electromagnets is provided by an alternating current source V_o which in one embodiment is 120 volts A.C. at 60 Hertz. The current to magnet **11** in the case of the stirrer, and to solenoids **16** and **18** in the case of the shaker passes through a current switching device of a type adapted to be triggered by an impulse. One satisfactory type of device for this purpose is a bi-directional triode thyristor, one satisfactory type of which is manufactured by General Electric Company under the trademark Triac. Such a device indicated as THY_1 occurs in the line **20, 21** which energizes magnet **11** in the case of the stirrer. In the case of the shaker either solenoid **16** or **18** is energized; depending on the direction of the current controlled by diodes D_1 and D_2. A similar device THY_2 is shown in lines **20, 21** which energizes stirrer magnet **12** or shaker solenoids **15** and **17**. It should be understood that these thyristors stay in a non-conductive state at gate currents below a critical value. At this critical value of gate current, the thyristor switches to a high-conductive stable state. It then remains on even though the triggering voltage to the gate is removed.

Two triggering circuits are provided, one for THY_1 and the other for THY_2. In the triggering circuit for THY_1, the capacitor C_1 is charged through the resistor R_1 from the current source V_1 until the emitter voltage V_3 of the unijunction transistor UJT_1 reaches the peak

point, at which time the unijunction transistor turns on and discharges the capacitor C_1 through the resistor R_3.

It should be understood that the unijunction transistor acts as a time delay, since the impulse will not appear at the base until the capacitor is sufficiently charged. Thus, the time constant necessary to charge C_1 through R_1 will determine the delay between the application of power to the circuit and the time when the transistor UJT_1 fires. After a fast discharge, the UJT_1 turns off and the cycle is repeated. This repetitive action is unaffected by the transistor T until the latter is placed in a non-conductive state.

A second triggering circuit is provided for THY_2. In this circuit, the capacitor C_2 is charged through the resistor R_2 and in this case, by adjusting the value of R_2 the time period necessary for reaching the peak discharge point at UJT_2 is by one-third longer than that necessary for UJT_1. Whe UJT_2 turns on, the voltage V_6 appearing across the resistor R_4 opens the transistor T and discharges capacitor C_1 which in the meantime has become partly charged. From this point on, a new cycle starts for both UJT_1 and UJT_2 simultaneously.

Referring to FIG. 4, the voltage V_3 reaches a peak **24** when capacitor C_1 is fully charged through the resistor R_1. At the time UJT_2 fires, the capacitor C_1 has been partially charged as indicated at **25** but is then discharged through transistor T as previously described to start another cycle. These points **24** and **25** are repeated cyclically as shown. The time elapsed at A, between **24** and **25**, is one-quarter of the triggering cycle for THY_1 and the time at B equals three-quarters of that cycle. In other words, the time period from **24** to **25** is one-third longer than the time cycle from **25** to **24**.

The cycle of the triggering circuit for THY_2 is shown in the lower portion of FIG. 4 indicating the voltage graph for the voltage V_4 when C_2 is charged through R_2. The voltage builds up to peaks indicated at **26**, at which time UJT_2 fires, at which time the voltage V_6 appearing across the resistor R_4 opens the transistor T which discharges C_1 as previously described.

As indicated in FIG. 4, the peak voltage occurring at points **24**, as V_3 causes a triggering pulse **24'** which triggers on THY_1. In like manner, the voltage peaks **26** at UJT_2, shown on the graph for voltage V_4 causes a triggering pulse **26'** and triggers on THY_2.

Once triggered, the thyristor stays in a conductive state to the end of the half period, or half cycle, of the supplying alternating current as illustrated in FIG. 5. When the triggering action occurs with a frequency different from the network frequency, for instance as indicated at 70 Hz in FIG. 5, a new frequency will occur as a result of commutating the alternating current line. Because the triggering pulses from both pulse generators have a mutual phase-shift, the two currents supplying the electromagnets will be equally phase-shifted.

In FIG. 5, the upper line illustrates the sine curve of the 60 Hz. current while the impulses of the 70 Hz. triggering current are shown on the lower line. The commutation of the 60 Hz. current will cause a full cycle to occur every six cycles, showing how the thyristor, once triggered, stays in a conductive state to the end of the half period of the supplying alternating current as indicated by the shaded portions along the upper line of FIG. 5.

The above described electrical circuits provide that the frequency of pulses produced by both generators is equal, but the pulses are mutually phase-shifted by 90°. The frequency of both generators may be adjusted by varying the resistor R_5 (FIG. 3). The change of voltage V_2 shifts the peak points of UJT_1 and UJT_2 and causes a change in frequency without affecting the mutual phase-shift. The angular velocity of the magnetic field is controlled by the frequency of the supplying current as commutated by the illustration shown in FIG. 5. By this means, the speed of rotation of the magnetic field can be efficiently regulated between 0 to 1,200 r.p.m. This range is fully satisfactory for a laboratory stirrer or shaker.

What is claimed is: vessel,

1. Electromagnetic means for causing a movement in a laboratory reaction the such as a beaker, comprising two stationary linear electromagnetic devices arranged with pairs of coils lying in a common plane at right angles to each other, means for supplying alternating currents to said magnetic devices at adjustable but equal low frequencies, means for causing phase-shifting of said currents between said two magnetic devices by 90°, and a support above said electromagnetic devices, whereby a beaker or other liquid filled container may rest upon said support and movement in the liquid will be caused responsive to the rotating magnetic field of said magnetic devices at an angular velocity determined by the adjustment of said frequencies.

2. Electromagnetic means as defined in claim 1, wherein said movement is orbital motion of a tray carrying a beaker and resting upon said support, and wherein said stationary magnetic devices comprise two pairs of opposing solenoids, and four cores one for each of said solenoids, said cores connected to said tray and consecutively attracted by said four solenoids in a cycle, whereby a fermentation flask or other liquid filled container may rest upon said tray and will be caused to exercise an orbital motion responsive to the energizing of said four solenoids sequentially at said angular velocity determined by the adjustment of said frequencies.

3. Electromagnetic means as defined in claim 1, wherein said movement is the rotation of a magnetic rod as a stirrer in a liquid filled beaker resting upon said support, and wherein said stationary magnetic devices are tow electromagnets, whereby a magnetic rod in the liquid two be caused to rotate responsive to the rotating magnetic field of said magnets at said angular velocity determined by the adjustment of said frequencies.

4. Electromagnetic means as defined in claim 3, wherein each of said current switching devices is a bidirectional thyristor, each of said triggering circuits includes a unijunction transistor having an charging circuit including a resistance and a capacitance in series arranged to provide a long charging period in the triggering circuit than in the other, and a connection between said triggering circuits causing discharge of the capacitance in said other triggering circuit simultaneously with the firing of said unijunction transistor in said one triggering circuit.

5. Electromagnetic means as defined in claim 1 for rotating a magnetic field, wherein said means for causing phase shifting of said currents to the coils of said two electromagnetic devices comprises an alternating

current source in two circuits one respectively with each pair of said coils, a current switching device in each of said circuits of a type adapted to be triggered by an impulse, a triggering circuit in circuit with each of said current switching devices including a power source adapted to provide said impulse, and including a time-delay device in one of said triggering circuits causing the same to reach critical voltage in a time period one-third longer than the time period required in the other of said triggering circuits to reach said critical voltage.

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PO-1050
(5/69)

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,693,941 Dated September 26, 1972

Inventor(s) Jan B. Suchy

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

The inventor's middle initial should be corrected to "B" on the first page of the patents.

In the claims:

Column 4, line 15, cancel "vessel,"; line 17, cancel "the" and substitute therefor -- vessel,--; line 49, correct the spelling of "two"; line 50, cancel "two" and substitute therefor -- will --; line 58, cancel "the" and substitute therefor -- one --.

Signed and sealed this 3rd day of April 1973.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents