

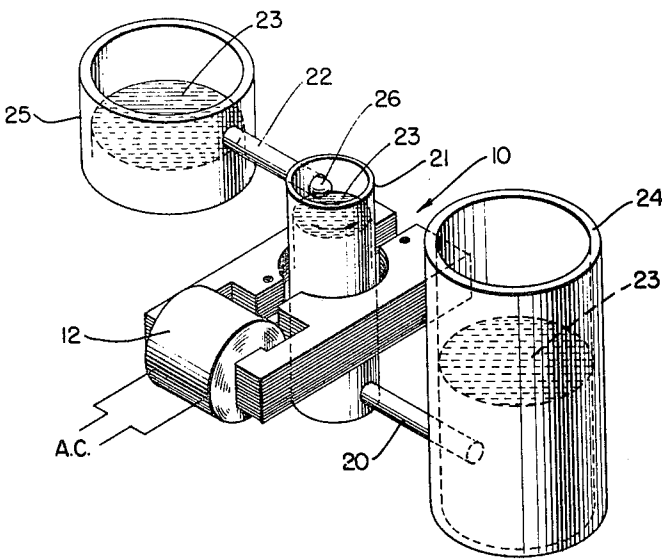
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[21] Appl. No. **710,108**
[22] Filed **Mar. 4, 1968**
Division of Ser. No. 776,884, Nov. 28, 1958,
Pat. No. 3,371,541.
[45] Patented **Apr. 13, 1971**
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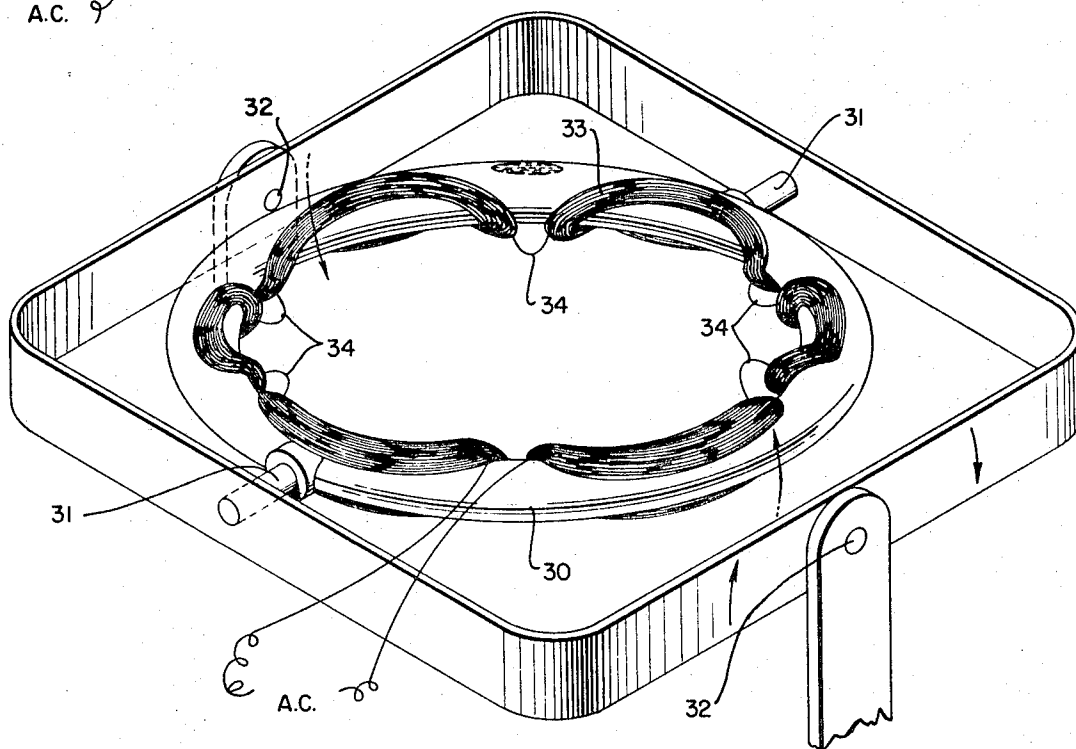
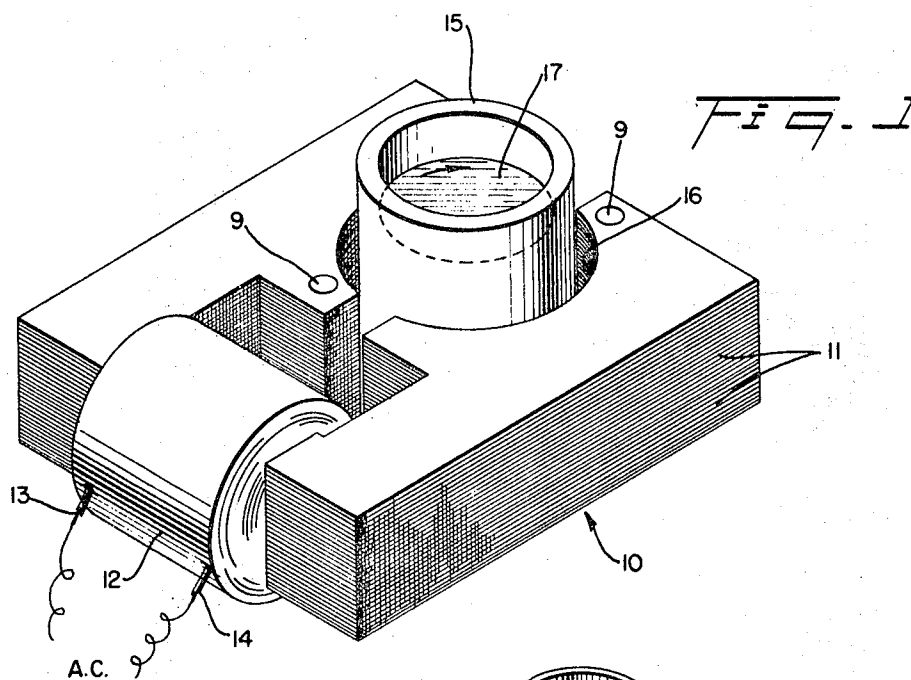
[54] **METHOD AND APPARATUS FOR MOVEMENT OF**
LIQUIDS BY ELECTROMAGNETIC MEANS
4 Claims, 10 Drawing Figs.
[52] U.S. Cl. **417/50**
[51] Int. Cl. **H02k 45/00**
[50] Field of Search. **310/172,**
11; 103/1; 230/1

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ABSTRACT: Apparatus for effecting selectively directed motion of contained conducting fluids by selective application of electromagnetic force fields thereto.





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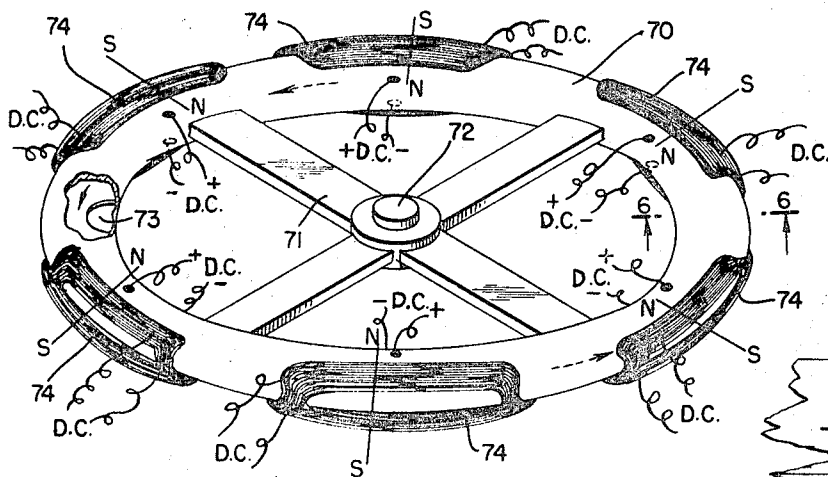


FIG. 6

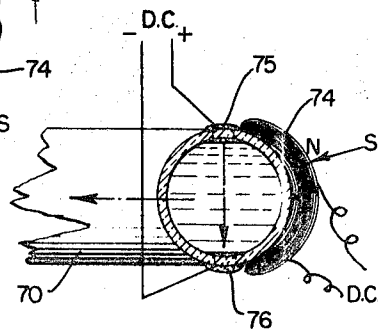


FIG. 6a

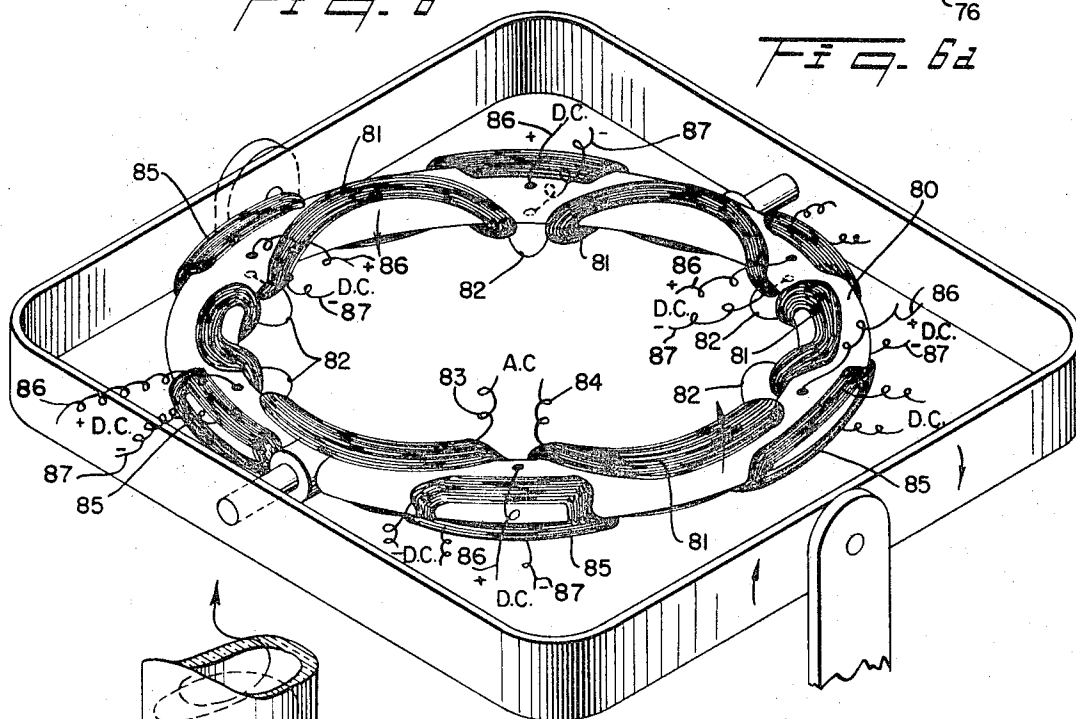


FIG. 7

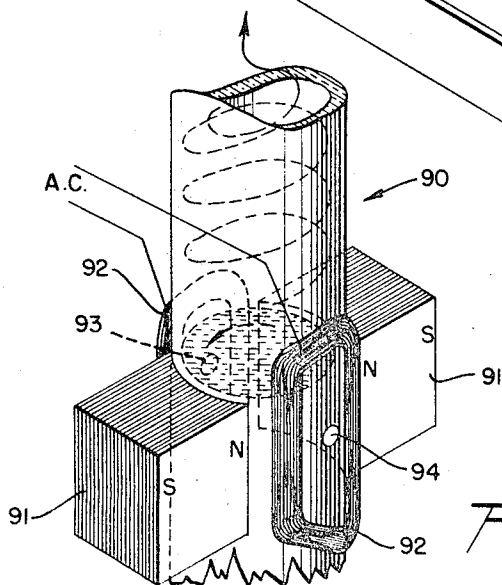


FIG. 8

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METHOD AND APPARATUS FOR MOVEMENT OF LIQUIDS BY ELECTROMAGNETIC MEANS

This application is a division of my copending application Ser. No. 776,884 filed Nov. 28, 1958, now U.S. Pat. No. 3,371,541.

This invention is concerned with the movement of liquids by electromagnetic means and more specifically relates to the application of the movement of liquids by electromagnetic means. Reference herein to liquids should be understood to include fluids, generally such as gases and vapors. By the proper adjustments of temperature and pressure, materials may be handled as liquids or vapors or gases. Fluidized solids are also contemplated within the scope of the term liquid.

In the handling of liquids which are extremely corrosive or are at greatly elevated temperatures or liquids which are radioactive in nature, the problem of transferring the liquids from one container to another and of agitating liquids has been a difficult problem. In order to move such liquids from one container to another, pumping means and valve means have been necessary. Each of such means have required moving parts in contact with the corrosive, extremely hot or otherwise destructive liquids, and great difficulties have been experienced. Also where it has been necessary to agitate or stir the liquids, difficulty has been encountered in effecting such agitation and stirring because of the corrosive and other destructive effects of such liquids on any agitators fixed in the vessels containing the liquid or introduced into the liquid for the purpose of such agitation.

Furthermore, in the treatment of other liquids which must be treated under pressure or for other reasons must be sealed from the atmosphere because of the nature of the treatment or of the liquid to prevent contamination of the liquid or contamination of the atmosphere, the handling of such liquids in sealed containers and the treatment thereof has been greatly complicated by the necessity of actuating the liquid in the sealed containers.

Frequently where liquids of a dangerous or corrosive nature require treatment by agitation, it has not been possible or practical to permit movement of the container thereby effecting a degree of agitation of the contained liquid.

It is an object of this invention to provide a means of moving or otherwise agitating liquids in containers without movement of the containers or without contact with the liquids whereby liquids of destructive and corrosive qualities may be safely handled.

In addition, in the field of gyroscopes and devices which make use of the gyroscopic principle, difficulty has been encountered in freeing the gyrorotor from the mechanical limitations attendant upon rotating a member by mechanical means and allowing it to continue its rotation in the same horizon.

It is an object of this invention to provide a means of effectively rotating a body of liquid for gyro applications wherein the liquid freely rotates unfettered by mechanical rotational limitations. A still further object of the invention is to provide means whereby liquids may be handled by controlling their movement from outside of the container and directing their movement by the shape of the container.

Other objects and advantages of the invention will be understood from the following description thereof.

The invention broadly comprises imparting movement to liquid by electromagnetic force and more specifically comprises imparting movement to an electrically conductive fluid or fluid containing electrically conductive material in an electromagnetic field, the electromagnetic force being used as a motive force to move the liquid confined in a container in a field of the electromagnetic force. In one of its simplest forms the invention can be said to comprise supporting a body of liquid in a container which is in an electromagnetic field and causing the movement of the liquid by applying an electromagnetic force to the body of the liquid. By varying the shape of the container and by controlling the electromagnetic force, the various objects and advantages of this invention can be achieved.

For a more complete description of the invention reference is made to the drawings, wherein:

FIG. 1 is a schematic perspective view illustrating a simple form of apparatus embodying the invention wherein the liquid is contained in a cylindrical container and the electromagnetic force is applied by an electromagnetic induction stator adapted to induce a rotating magnetic field;

FIG. 2 is a schematic perspective view of another form of apparatus embodying the invention in which a toroid containing liquid is mounted in gimbals, so that the liquid contained in the toroid may be used as a rotor, the rotational motion being imparted to the liquid by induction coils creating a rotating magnetic field;

FIG. 3 is a schematic perspective view of another form of apparatus embodying the invention wherein the container for the liquid is a sphere which may also be adapted for use as a gyroscope, rotational motion being induced in the liquid contained in the sphere by induction coils on the outer surface;

FIG. 3a is a schematic perspective view of apparatus similar to FIG. 3 but showing the provision of a plurality of sets of coils on the periphery of the sphere and relay sensing means to selectively energize the respective sets of coils responsive to tilt of the sphere;

FIG. 4 is a schematic perspective view of a still further form of apparatus embodying the invention wherein the liquid is contained in a cylindrical pipe which is provided with an internal helix and movement is induced in the liquid by induction coils, on the outer surface of the pipe, to induce a rotating magnetic field;

FIG. 5 shows a device similar to the form of invention shown in FIG. 1 with a cylindrical container having inlet and outlet pipes as indicated.

FIG. 6 is a schematic perspective view of another form of apparatus embodying the invention in which liquid is confined in a toroid and a rotational motion is imparted to the liquid by imposing upon the liquid a unidirectional electromagnetic force;

FIG. 6d is a cross-sectional view of the apparatus of FIG. 6 taken along the lines 6-6 to show interior detail;

FIG. 7 is a still further form of apparatus embodying the invention wherein the liquid is contained in a toroid and is subjected to two types of magnetic forces, one of the unidirectional type illustrated in FIGS. 6 and 6a and the other the rotating induced magnetic force illustrated in FIG. 2, the two types of forces being combined to rotate the liquid;

FIG. 8 is a further embodiment of the invention wherein is combined both the unidirectional and the rotating induced magnetic forces to raise liquid in a container. As illustrated, the container is provided with internal means to mechanically assist in the raising of the liquid.

The invention, as embodied in the form shown in FIG. 1, comprises a means for inducing a rotating electromagnetic field which means is designated 10. This may be in the form of a stator similar to that used for an induction motor and may be made up of laminated metal plates 11 and have a suitable coil or winding 12 having lines 13 and 14 for connection to suitable AC voltage source. Shaded poles, such as brass bars 9 positioned in drill holes in the laminated plates 11, are provided to create unbalance to produce a rotating magnetic force field. A container 15 may be disposed in the opening 16, defined by the stator 10, so that it is in the field of rotating magnetic force.

A liquid 17 to be rotated may be confined in the container or poured therein after the container has been positioned in the opening 16.

It has been found that the liquid should be electrically conductive in order to be satisfactorily rotated in the container, however, in the case of liquids which are not electrically conductive, a readily separable electrically conductive liquid can be combined with the liquid to be rotated so that rotation may be achieved of the nonconductive liquid. Certain alkali metals have been found favorable for this purpose. Another means of rotating a nonconductive liquid is to disperse electrically conductive solid particles through the nonconductive liquid. Such particles will be caused to rotate and cause the nonconductive liquid to rotate with them.

Upon application of alternating current to the coil 12, the conductive liquid or the nonconductive liquid which has been combined with conductive liquid or conductive solids at first develops small eddies at various parts of its body and slowly the entire body of the liquid starts rotating about the axis of the container. If a physical axis is placed in the container or if the container has a physical axis located therein, it has been found that the liquid will begin to rotate more rapidly. However, a central axis is not necessary for achieving rotation. The speed of rotation appears to be a function of the frequency and the induced voltage.

A specific application of the apparatus of FIG. 1 can be for stirring or the agitation of liquids in sealed containers, such as various fluid mixtures must be agitated or mixed prior to sale or use. The extend of the stirring or agitation which can be induced in a liquid will be appreciated from the fact that a body of mercury liquid weighting 15 pounds was placed in a container within a rotating magnetic field using 2,000 watts of electricity. The mercury was thereby rotated at a sufficient speed to cause a large vortex in the center of the container and the mercury rose up the sides of the container. The frequency of the apparatus was 60 cycles per second. It has been determined that if the frequency or voltage is increased, the speed of rotation will be increased.

It will be understood that the invention is not limited to the rotation of a metal such as mercury, which is liquid at normal temperatures and pressures, but may also be used with other metals in a molten vapor or gaseous state. The invention may also be used with nonmetallic liquids which are electrically conductive. The container should usually be of suitable nonconductive material but satisfactory results may be obtained by the use of containers of conductive material if the container is electrically insulated from the coils or plates of the magnetic force inducing device by an air gap or other nonconductive shield.

The apparatus schematically shown in FIG. 5 illustrates the use of the invention as a simple form of combined valve and pump wherein there is an intake line 20 to a cylindrical lifting chamber 21 and an outlet 22 spaced vertically above the inlet line 20. The same type of electromagnetically inducing means may be used, as shown in FIG. 1, that is, an induction coil 12 with laminated plates 11 defining the stator 10 to induce a rotating magnetic force to rotate the liquid in the container when alternating current is applied to the coil 12. To use the apparatus shown in FIG. 5 as a pump and valve, the inlet pipe 20 may be connected to a vessel 24 so that liquid in such position flows through the line 20 to a level 23 in the cylindrical lifting chamber 21. The liquid in the lifting chamber 21, when subjected to a rotating magnetic force, is caused to rotate and form a vortex. The liquid adjacent the inside walls of the chamber 21 rises up the walls and flows out through the outlet pipe 22 into another container 25 or to some other discharge point.

It will be understood that such design features, as providing a tangential scoop 26, may be provided to improve delivery through outlet opening 22. Also, the walls of the lifting chamber 21 may be suitably shaped to aid in raising the liquid, e.g., a helix may be formed on the walls for guiding the liquid upward.

It will be noted from the foregoing description of the apparatus shown in FIG. 5 that an effective pump and valve means can be obtained from use of the apparatus and that no moving parts are required to pump, i.e., raise the liquid, from the level 23 in the lifting chamber 21 out through the outlet line 22 and that as a pump and valve arrangement, which effectively prevents flow when the magnetic force ceases, would be highly desirable for use in the handling of corrosive or otherwise dangerous and destructive liquids. For the purpose of illustration, the upper end of the container 21 has been left open. However, in an actual application such opening might well be closed if the liquid was corrosive or otherwise noxious or if the liquid was being treated under other than atmospheric conditions. The true versatility of the device will be un-

derstood when it is appreciated that the device may be operated with the top open for inspection and sampling or sealed against contamination.

FIGS. 2 and 3 illustrate two forms or embodiments of the invention wherein the liquid is held in containers having circular paths for guiding the liquid. In FIG. 2 the container is a toroid or annulus 30 which is mounted in universal gimbals 31 and 32 to permit the toroid to be positioned in any horizon which it seeks to maintain. Induction coils 33 are inducing a rotating magnetic field in the toroid 30 are positioned on the exterior of the toroid and, as shown, are actually laid directly on the surface of the toroid. The coils 33 may be arranged in multiple poles which may be connected together by lines 34. As previously noted, the rotational speed is a function of the voltage and frequency. The rotational speed may also be varied by the number of poles or pairs of coils provided. FIG. 2 illustrates a six-pole arrangement. Alternating current voltage applied to the coils produces a rotating magnetic field whereby liquid in the toroid is caused to rotate at a speed determined by the input and the number of poles. For purposes of using the apparatus of FIGS. 2 for a gyroscope, it has been found effective to use mercury in the toroid because of its mass and favorable electrical qualities. The toroid, itself, may be made of glass, ceramic, or other suitable nonconducting material. The mercury or other fluid may substantially fill the toroid with only sufficient space left to allow for expansion of the fluid.

FIG. 3 shows another form of gyroscope which embodies the invention. In this form, a sphere 40 may be supported on any suitable base 41. A small body of mercury or other suitable electrically conductive liquid is sealed in the sphere and induction coils 43 are laid upon the exterior surface of the sphere in a broad band in the area in which the liquid will rotate. The coils are attached to a suitable source of AC voltage and the liquid is caused to rotate. Upon rotation the liquid tends to form a narrow path about the equator of the sphere in the plane in which it is first induced to rotate. If the base of the sphere moves into a new plane, the path of rotating liquid in the sphere will tend to continue to rotate in its original plane of rotation and thereby may be used for the purpose of a gyroscope. By providing coils 43 in a broad area of the sphere, this spherical type of gyroscope may be used in gyroscopic applications wherein the movement from the original horizon lies within the rotating magnetic field set up by the coils. The angles of operation of the spherical gyro may be increased by providing additional coils, as for example the sets of coils 43a and 43b shown in FIG. 3a, on the spherical surface and providing suitable means, as for example relay 48a, for creating magnetic fields by said additional coils.

The fluid ring in the spherical gyro is completely free to remain always in its initial rotating plane. The coils are so mounted that the liquid will rotate in the proper direction and speed regardless of the sphere's position. Pairs of electrical contacts 45 are distributed about the interior wall of the sphere and extend through the wall of the sphere to the exterior. They are mounted so as to make electrical contact with the rotating liquid in the sphere. The electrical contacts will indicate the angle to which the sphere has moved with respect to the original plane of rotation when a circuit is completed between two contacts. For example, contacts 45a and 45b are on diametrically opposite sides of the sphere, are connected to a suitable sensing mechanism when the conducting fluid which is rotating within the sphere makes contact by rotating in an equator which passes into contact with both contact points 45a and 45b. The sensing circuit is completed by the conductive liquid. For purposes of illustration, lines 46 and 47 lead to the sensing mechanism which may be a simple light, relay or directional indicator which is illustrated merely as a coil 48 in the diagram shown in FIG. 3. In line 46 a source of power such as battery 49 is provided.

These same electrical contacts can be used to activate different sets of coils 43 which are mounted on the surface of the sphere to keep the electromagnetic force bound within the initial plane of rotation. Thus, for example, in FIG. 3a the pair of

coils 43 is energized from the AC source indicated through lines 100, 101, and 102 connected in series with normally closed contacts 103 and 104 of relay 48a and through return line 105. When the sphere is tilted such that the rotating fluid connects electrical contacts 45a and 45b relay coil 106 is energized to open contact 103 and close contact 107 thereby deenergizing coils 43 and energizing coils 43a and 43b which lie in the diametrical plane of contacts 45a and 45b. When the sphere is tilted the opposite way to cause the rotating fluid to connect electrical contacts 45c and 45d relay coil 108 is energized to open contacts 104 and close contacts 109 thereby deenergizing coils 43 and energizing coils 43b which are in the diametrical plane of contacts 45c and 45d. It is understood that the number of coils used and the arrangement of the contacts 45 are made suitable to the intended purpose of selectively energizing coils as required to continue a rotating field for the fluid as the sphere is tilted.

It will be noted that by the use of a liquid such as mercury within the toroid type of gyro shown in FIG. 2 or the spherical type shown in FIG. 3, that the usual difficult problem of obtaining a dynamic balance is eliminated because the liquid is by its nature self-distributing and self-balancing.

It will also be understood that there are no bearing required to support the rotor. The liquid is supported in the container and another fluid, if desirable, can be used as a lubricant between the rotating fluid and the inner surface of the container to decrease any frictional losses.

By virtue of these designs, FIGS. 2 and 3, all of the motion is contained within a sealed element which will eliminate many environmental problems encountered in the use of gyroscope apparatus in missiles, aircraft, and nautical applications.

The embodiment shown in FIG. 3 illustrates particularly the usefulness of the invention for a gyroscope in that all bearings needed for the usual gimbals shown in FIG. 2 have been eliminated.

It will also be appreciated that a gyro made in the form shown in FIG. 3, which may be completely sealed and in which all exterior moving parts have been eliminated, can be readily miniaturized for missile applications and for other uses in guidance systems where it is particularly desired to reduce space and weight requirements.

In FIG. 4 a further embodiment of the invention is disclosed wherein a cylindrical conduit 50 of nonconducting material adapted to contain an electrically conductive liquid which is to be moved therethrough is provided with an interior screw thread or spiral 51. On the exterior of the cylindrical conduit 50 coil means 52 are positioned to induce a rotating magnetic field within the conduit 50. Upon applying an alternating current to the coils 52 liquid is made to rotate in the conduit 51 and the screw thread on the interior of the conduit 50 causes the liquid which is contained in the conduit to advance in the direction of the arrows indicated in FIG. 4. The lead or pitch of the threads of screw may be changed to change the speed at which the liquid will be moved axially in the conduit. The mechanical advantage increases with a decrease in the pitch or lead. The rotational speed of the liquid is also a factor in determining the speed of axial movement of the fluid through the conduit. The apparatus of FIG. 4 forms essentially a pump. It has the advantage of being usable in either direction by reversing the rotating magnetic field. The liquid may be caused to rotate in the reverse direction and the liquid will be therefore caused to spiral and move in the opposite direction to the arrow shown in FIG. 4. Furthermore, there are no moving parts required for such a pump.

Referring to FIG. 6 the apparatus shown is a toroid 70 or other convenient suitable container which, for purposes of illustration, may be used as a rotor having suitable supporting spokes or other supporting means 71 to support the rotor on its axis 72. The toroid 70 is filled with suitable electrically non-conducting liquids and the toroid itself is made of suitable non-conducting material. In the cutaway portion of FIG 6 it will be noted that on the interior wall of the toroid is provided fins or blades 73 which may be fixed to the walls of the toroid either

on the larger or smaller diameters depending upon the use to be made of the rotor. In the form shown in FIG. 6 the electromagnetic force imposed on the liquid is that known as the Lorentz force which results in a force to move a conducting fluid in a direction normal respectively to a direct current flow and to an applied magnetic force.

In FIGS. 6 and 6A several coils 74 are fixed to the exterior of the toroid 70. These coils are adapted to carry direct current and for that purpose are connected to suitable DC sources. The coils 74 produce a magnetic force of fixed polarity acting upon the fluid in the toroid. These coils may also be replaced by permanent magnets. Associated with each coil 74 are the contact elements 75-76 which extend through the wall of the toroid to make electrical contact with the liquid contained in the toroid. The contacts 75 and 76 are connected to a suitable source of direct current which provides a current flow as indicated by the arrows. As a result of the magnetic force of fixed polarity and the flow of current via the electrically conducting fluid between the points 75 and 76, the electrically conducting fluid will be moved in a direction at right angles to the flow of the current between 75 and 76 and at right angles to the polarity of the coils which for the purpose of illustration, is indicated at each coil in the diagram in FIG. 6 as well as in FIG. 6d. Arrows have been placed in FIG. 6 and FIG. 6A to indicate the flow of the liquid in the container 70 which in FIG. 6 is counterclockwise. It will be understood that by placing the liquid in a curved toroidal chamber and that by placing magnetic coils 74 and electrical contacts 75 and 76 at points around the toroid, that the unidirectional movement caused by the Lorentz force induced at each device around the toroid results in a combined movement of liquid which is rotational in nature. To obtain the most desirable results and to achieve what is known as a coupling force, each coil 74 with its related contacts 75 and 76 should be placed in diametrically opposed relationship around the toroid, which, for the purpose of acting as a rotor, should be substantially circular. In this particular application in which the toroid is used as a rotor, it may be accelerated and decelerated by the amount of current imposed through the coils 74 and the current contact points 75 and 76. Electrical connections may be made and maintained through suitable brush contacts to the several coils 74 and contacts 75 and 76.

By controlling the viscosity of the liquid, the speed and mechanical advantage of the system may be controlled. Heat may be one means of changing the viscosity of the fluid during operation of the device.

It will be understood that the Lorentz force can be used in the other types of applications for achieving rotation as in FIGS. 1 through 4, and also it will be understood that the use of a rotating container as a turbine rotor, as illustrated in FIG. 6, may be rotated by means of the rotating electromagnetic force in connection with the illustration in FIGS. 1 through 4.

FIG. 7 illustrates a toroidal container 80 which is provided with an electrically conducting fluid.

Coils 81 for inducing a rotating magnetic field in the fluid are linked by lines 82 to form a six-pole arrangement similar to that described in FIG. 2. The coils 81 induce a rotational motion in the liquid contained in the toroidal element 80 when alternating current is applied through the lines 83 and 84. Also arranged on the exterior of the toroid so as to apply a Lorentz force at various locations around the toroidal container 80 are DC coils 85 to produce a fixed polarity magnetic field, and associated contact points 86 and 87 for directing a current through the toroidal container in the same manner as described with regard to the apparatus in FIGS. 6 and 6a. It will be understood that by applying the rotating magnetic force and the unidirectional force at various locations around the toroidal container that the liquid is caused to rotate by both electromagnetic forces.

This is an example in which both of the foregoing electromagnetic forces are utilized to cause rotation of the liquid. This is a method of advantage where great velocities or masses of fluid have to be rotated. For purposes of illustration, FIG. 7

is shown as a gyroscope rotor mounted in gimbals as in FIG. 2. The combined method shown in FIG. 7 for causing rotation is of advantage during the initial starting of the fluid in motion and one of the two methods may be switched off after a fluid has reached its desired velocity. The decreased load at that time may be handled by either of the two methods shown. The provision of the two means of rotating the liquid may also be incorporated for safety purposes where it is necessary to have a secondary means to rotate the fluid in the event of breakdown of one of the methods, such as an alternating current failure having standby direct current batteries which would produce the Lorentz force.

FIG. 8 is a nonconducting pipe element 90 on the surface of which are mounted permanent magnets 91, and containing two contact elements 93 and 94 mounted upon the inner surface of the pipe 90. Upon application of direct current to the contact elements 93 and 94, current will flow from 93 to 94 through the conducting fluid contained within the nonconducting pipe 90. This current flow will cause a Lorentz force resulting in motion in the upward direction, as shown in FIG. 8. If at the same time an alternating current is applied to coils 92 creating a rotating magnetic field in the same manner as described for example in FIG. 1, the induced electromotive force causes the fluid to rotate circularly within the pipe element. The resultant motion of the fluid acted upon by the two forces will be spiralling upward movement. It will be appreciated that the use of these combined forces may be utilized as a pump or valve or in other applications in which it is necessary or desirable to raise and/or rotate fluids. The shape of the walls of the container may be designed as suggested in FIG. 4, to provide suitable mechanical advantage.

It will be appreciated that the lifting force exerted by the permanent magnet (which may be an electromagnet of fixed polarity) may be applied usefully in an apparatus such as the spherical gyro of FIG. 3 to initially lift the liquid into its rotational equatorial path.

It will also be understood that this invention can be employed in certain centrifugal applications because the rotational speeds can be readily controlled and raised and lowered and the direction of rotation can be changed readily. The invention may be applied for the treatment of molten metals as well as other electrically conductive materials at high temperatures as well as very low temperatures. The application of the invention for the handling of molten metals and for the centrifugal casting of such metals will be well appreciated. It will be understood that by moving liquids axially in containers such as cylinders, it can be made to operate pistons or other physical means disposed in the path of the moving liquid.

Also, if electrical contacts are placed in a container above

the liquid level and the liquid is caused to rotate and rise to the contact, a suitable switch means may be had. The foregoing are merely to indicate the various means to which the applicant's invention can be applied. The description has sought to suggest that certain of the applications are to indicate certain presently preferred forms of applying the invention but it will be appreciated that the invention can be carried out by other means and may be used to accomplish the various operations within the scope of this invention.

The scope of the invention is defined in the following claims:

I claim:

1. Apparatus for effecting a selectively directed flow of electrically conducting fluid comprising:
 - elongate conduit means of substantially circular cross section adapted to contain said conducting fluid,
 - means for establishing a rotating magnetic field transverse to the longitudinal axis of said conduit to rotatably displace said fluid therewithin,
 - means for applying a selectively directed Lorentz force to said confined fluid to effect a directional rectilinear displacement thereof, and
 - a helically shaped wall member protruding from the inner surface of said conduit for converting said electromagnetically induced rotative displacement into selective rectilinear displacement supplementing that induced by said Lorentz force.
2. Apparatus for effecting a selectively directed flow of electrically conducting fluid comprising:
 - elongate conduit means of substantially circular cross section adapted to contain said conducting fluid,
 - means for establishing a rotating magnetic field transverse to the longitudinal axis of said conduit to rotatably displace said fluid therewithin,
 - means for applying a selectively directed Lorentz force to said confined fluid to effect a directional rectilinear displacement thereof, and
 - means disposed within said conduit for converting said electromagnetically induced rotative displacement into selective rectilinear displacement supplementing that induced by said Lorentz force.
3. Apparatus as set forth in claim 2 wherein said last mentioned means comprises:
 - wall means protruding from the inner surface of said conduit.
4. Apparatus as set forth in claim 2 including aperture means disposed at a predetermined location in the wall of said conduit for effecting the delivery of moving fluid therefrom.