March 25, 1947. W. M. WINSLOW 2,417,850

METHOD AND MEANS FOR TRANSLATING ELECTRICAL IMPULSES INTO MECHANICAL FORCE

Filed April 14, 1942

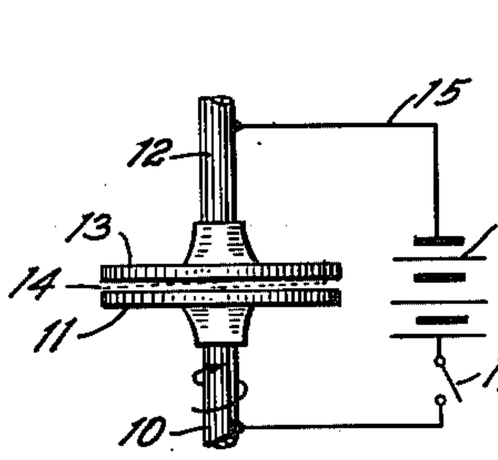

Fig. 1.

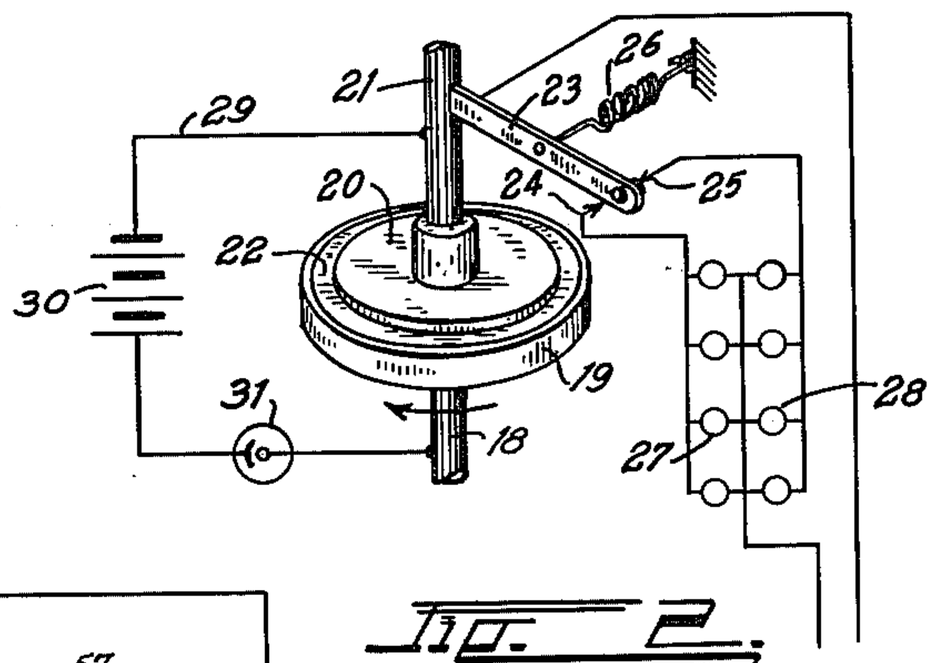

Fig. 2.

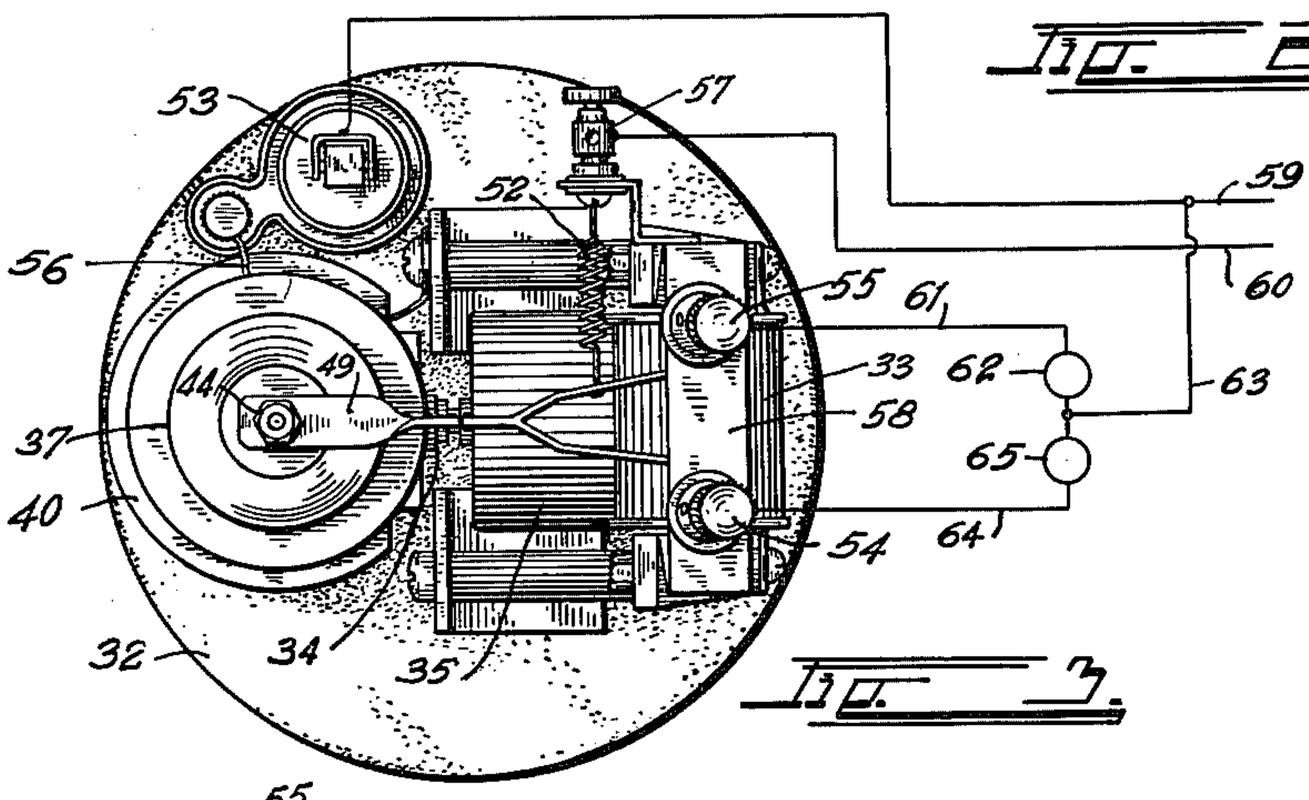

Fig. 3.

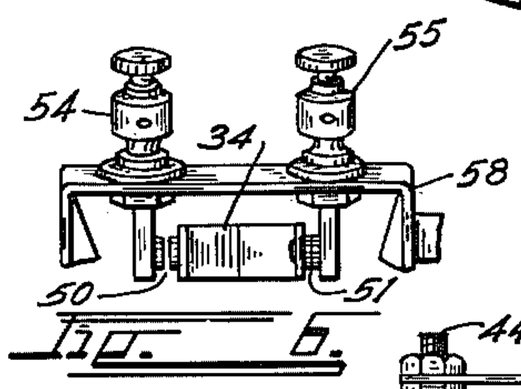

Fig. 6.

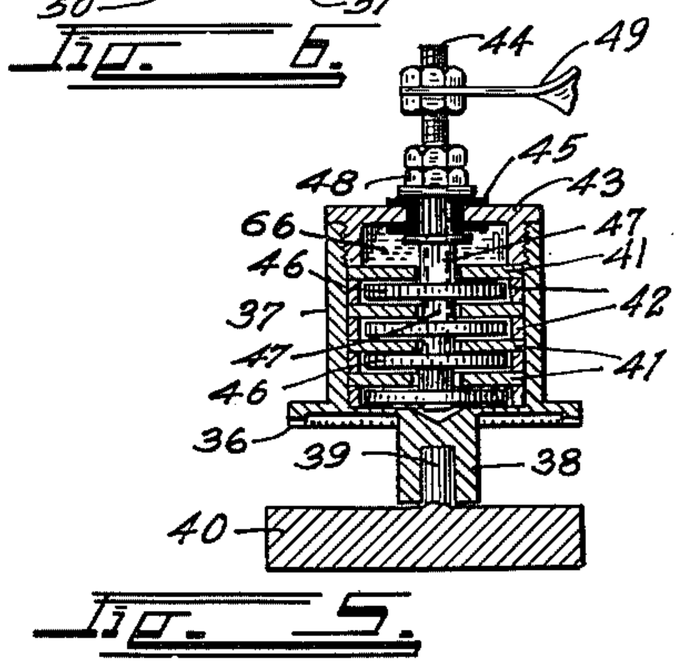

Fig. 5.

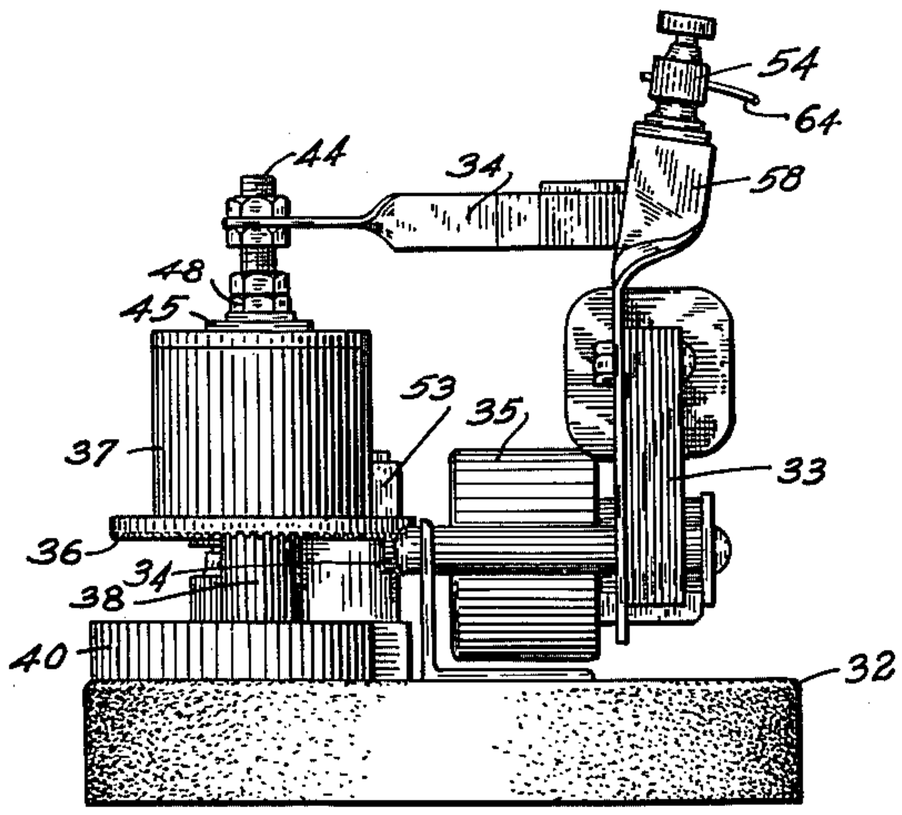

Fig. 4.

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Patented Mar. 25, 1947 2,417,850

UNITED STATES PATENT OFFICE

2,417,850

METHOD AND MEANS FOR TRANSLATING ELECTRICAL IMPULSES INTO MECHANICAL FORCE

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Application April 14, 1942, Serial No. 438,967

22 Claims. (Cl. 175—320)

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This invention relates to a method and means for transmitting a mechanical movement or force in response to an electrical potential.

The principal object of the invention is to provide a device of this character which will operate on exceedingly slight currents without amplification being necessary and without the use of electromagnets.

The invention comprises what might be termed an electro-fluid clutch. While it has been described as particularly applied to the operation of a relay for closing a second circuit in response to an electrical voltage or impulse received over a first circuit it is not, of course, limited to this particular application. It will be found useful wherever it is desired to cause a moving drive member to transmit movement to a driven member in response to very slight electrical currents arising from any source.

In actual practice relays controlling heavy electrical loads have been controlled by currents of such slight intensity as to be immeasurable by the usual instruments such as currents arising from photo-electric cell circuits or electro-static charges, either uni-directional or alternating at any frequency.

Other objects and advantages reside in the detail construction of the invention, which is designed for simplicity, economy, and efficiency. These will become more apparent from the following description.

In the following detailed description of the invention reference is had to the accompanying drawing which forms a part hereof. Like numerals refer to like parts in all views of the drawing and throughout the description.

In the drawing:

Figs. 1 and 2 are diagrams illustrating the basic principle of the invention;

Fig. 3 is a top view of a photo-cell relay constructed to employ the principle of the invention;

Fig. 4 is a side view of the relay of Fig. 3;

Fig. 5 is a vertical section through the operating element of the improved relay; and

Fig. 6 is a fragmentary, detail view of the contacts of the improved relay.

This invention contemplates the use of what is believed to be a novel phenomenon of electricity. I have found that if two plates are separated by certain substantially dielectric fluids containing certain substances the fluid mixture will tend to cause the two plates to act as a unit as long as an electrical potential difference exists between the plates.

This principle may be experimentally demonstrated, as shown in Fig. 1 in which, a power drive shaft 10 is provided with a disc 11 and a driven shaft 12 is provided with a disc 13. The two discs are maintained in closely spaced, parallel relation and are insulated from each other by

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means of a suitable dielectric or substantially dielectric fluid mixture 14 held between them by capillary attraction. The two shafts are in an electrical circuit 15 containing any source of electrical energy 16 and any suitable circuit closing device 17. Electrical potential is applied to discs 11 and 13 by means of the closing device 17. Since the fluid 14 is substantially dielectric, very little current will flow through the circuit.

While the circuit is open there is no noticeable tendency for the disc 13 to rotate with the rotating disc 11 but when the circuit 15 is closed at 17, the disc 13 immediately rotates with the disc 11 as a unit with considerable force and persistence. The instant the circuit is opened the driven disc 13 stops and the drive disc 11 continues to rotate.

Many fluid mixtures have been found to accomplish this result with more or less efficient results. It appears that the fluid must be a dielectric, or substantially non-conducting at all operating electrical pressures, for very little current flows through the fluid between the plates.

Therefore, a low viscosity, non-conducting liquid is preferred as the fluid medium. Fluids which have been found suitable are light weight transformer oil and transformer insulating fluids such as "pyranol," "inerteen," etc., olive oil, mineral oil, etc. A pure fluid or a pure oil alone, however, does not act to tie the plates together under the influence of the electric current to any practical extent. However, when an additional substance, in the nature of a finely divided material, is added thereto the tying effect is very pronounced. Such substances as starch, lime stone, or its derivatives, gypsum, flour, gelatine, carbon, etc. all create the desired effect with more or less efficient results. It is probable that some fluid and/or some additional agent which are still untried will give even better results than any so far experimented with. To date, the applicant finds that a pharmaceutical mixture of refined mineral oil and "lanolin" in which starch granules (approximately 20% by volume) have been placed gives good results. It is believed that the resulting mixture is simply a mechanical one as there does not appear to be any chemical reaction between the elements of the mixture.

Just what takes place in the fluid when the electrical potential is impressed upon the plates is not definitely known. It appears, however, from close observation of the mixture in action that there is a tendency for suspended particles, probably the starch, in the oil to form in an infinite number of strings or lines extending between the plates while under the influence of the potential. These strings or lines immediately disappear when the circuit is broken. Perhaps these strings or lines tend to, in a sense, tie the plates together or increase the sheet stresses be-

tween them by their tendency to prevent relative movement in the strata of the fluid body.

Whatever be the full explanation, it is manifest that the viscosity of the fluid is greatly increased in the presence of the electrical field and a homogeneous fluent mechanical linkage, or coupling, is thereby established. This increase in viscosity takes place without a change in temperature.

The effect is clearly not the result of positive and negative electrical attraction of the plates since such attraction would operate only at right angles to the plates tending only to move them toward each other. Since the plates cannot move axially but are only free to rotate, no movement can result from said electrical attraction. The effect can be attained with either direct or alternating currents of any frequency. There is no permanent change in the mixture as it instantly releases and regrips rapidly and indefinitely. Currents of such low values as are carried by the hand of the experimenter without wires serve to cause the two plates to rotate in unison. The body of a person when moving his feet back and forth across a carpet will store an electrostatic charge sufficient to operate the device. The slight current passed by the electrons of a photo-electric cell from a series connected source of supply will also operate the device.

The effect can be put to many uses, for instance a relay structure such as diagrammed in Fig. 2 may be based on the principle of this invention. This relay employes a drive shaft 18 driven from any source of motive power. The shaft 18 supports a fluid cup 19. A driven disc 20 is suspended in the cup 19 out of contact with the bottom thereof on a driven shaft 21. The cup contains a dielectric fluid mixture 22 such as previously described. A relay blade 23 is secured to the driven shaft 21 and projects therefrom between a pair of relay contacts 24 and 25. The blade 23 is constantly urged against the contact 25 by the action of a spring 26.

The direction of rotation of the cup 19 is such as to tend to swing the blade away from the contact 25 and against the contact 24. The contact 24 may control any desired circuit devices such as lamps 27 and the contact 25 may similarly control any desired circuit device such as a second series of maps 28. Electrical voltage is impressed on the cup 19 and on the plate 20 by the terminals of a control circuit 29 containing a source of electrical energy 30 and any suitable condition responsive circuit closer such as a photo-electric cell 31.

Whenever a light beam strikes the cell 31, an electrical potential difference is impressed on both the cup 19 and the plate 20 causing the fluid 22 therebetween to exert a clutching or tying effect between the two. This causes the plate 20 to rotate with the cup so as to swing the relay blade 23 from the contact 25 and against the contact 24, thus extinguishing the lamps 28 and lighting the lamps 27. When the light ceases to impinge on the cell 31 current ceases to be impressed on the cup and plate and the clutching effect instantly ceases. The spring 26 then draws the relay blade 23 back to the contact 25.

A practical construction for such a relay is illustrated in Figs. 3, 4, and 5, mounted on a suitable base block 32. The base supports a synchronous motor 33 of the "telechron" type which drives a bevel pinion 34 at slow speed through suitable reduction gears contained in a

gear box 35. A bevel gear 36 rests upon and is in constant mesh with the pinion 34.

The bevel gear 36 is formed on a fluid cup 37 having a downwardly projecting bearing post 38 which is rotatably fitted over a pivot stud 39. The stud 39 projects upwardly from a base flange 40. Thus it can be seen that operation of the motor will rotate the cup 37 at slow speed. The connections to the motor are usual and are therefore not illustrated.

The cup 37 contains a superimposed series of washer-like plates 41 separated by means of separating rings 42. The series of plates and rings are clamped together by means of a threaded, flanged cap 43 which also seals the top of the cup.

A shaft 44 is journalled in an insulating bushing 45 in the cap 43 and extends downward into the cup through the open centers of the plates 41. This shaft carries a superimposed series of discs 46 separated by separating sleeves 47, the upper one of which extends through the bushing 45 to a clamp nut 48. The entire series of discs and sleeves are clamped together as a unit by tightening the nut 48. The discs 46 and the plates 41 do not contact but are maintained in close parallel relation. The cup is substantially filled with a suitable substantially dielectric mixture 66 of mineral oil and starch as above described and is free to revolve about the shaft 44 without imparting rotation to the latter. The shaft 44 supports a relay arm 49 which is bifurcated at its free extremity and terminates between a pair of spaced relay contacts 50 and 51. A spring 52 constantly urges the relay arm toward the contact 51.

The cup 37 is connected through the base flange 40 to the base of a standard photo-electric cell 53 through a conductor 56. The contact 50 is connected to a binding post 55. The spring 52 is connected to a similar binding post 57. The contacts 50 and 51 and the posts 54, 55, and 57 are supported on and insulated from a frame member 58.

Two electrical supply mains 59 and 60 lead to the relay. The main 59 leads to the upper terminal of the photo-electric cell 53 and the main 60 leads to the post 57. A first controlled circuit wire 61 is connected to the binding post 55 and through any electric apparatus which it is desired to control such as a lamp 62 to a return lead 63 connected with the main 59. A second controlled circuit wire 64 is similarly connected to the binding post 54 and to a lamp 65 which is also connected to the lead 63. While the photo-electric cell has been illustrated as mounted on the base 32, it could, of course, be mounted in any place convenient for the use to which it is to be placed.

The synchronous motor 33 may operate continuously, since it is one of the small electric clock types and requires but very little current. The speed of the motor is reduced through the gears in the box 35 and the pinion 34 to slowly rotate the cup. In actual practice the cup was rotated once in eight minutes with very satisfactory results.

Whenever a light beam strikes the photo-elec- cell 55, a small electric pressure will be impressed upon the plates 41 and the opposed discs 46 which creates the phenomenon in the fluid mixture of the cup previously described causing the discs to immediately rotate with the plates. This swings the relay arm 49 against the action of the spring 52 so that the circuit 61 is broken at the

contact 51 and the circuit 64 is closed at the contact 50. As soon as the light beam ceases to strike the photo-electric cell, the discs 46 are instantly released and the spring 52 again acts to close the contact 57. The action of the fluid is instantaneous and the gripping effect even with a current of the order of a microampere has been sufficient to flex or bend the relay arm 49.

It is desired to call attention to the fact that the relay is operated direct from the small current flow of the photo-electric cell. There is no amplification of the control current as is now necessary with the usual electro-magnetic relays.

The invention is adaptable to many uses, in fact to substantially all uses for which relay tubes or electro-magnets are now being used, such as for controlling circuits, operating speakers and signal devices, clutching power shafts, etc. especially where very low current values are involved in the control circuits.

It will be noted that any desired delay in closing may be had by simply lowering the speed of rotation of the cup or varying the spacing between the contacts 50 and 51. The speed of release may be controlled electrically through condensers and resistances arranged to provide a definite time delay in the voltage drop of the control circuit.

The sensitivity of this relay is such that it can be operated in an open electrical circuit, under conditions where, due to atmospheric charge, charge due to relative movements, or potential gradients of location, there is created a potential difference between the two electrodes or plates. Under such conditions simply short circuiting the plate elements will restore the relay to initial position.

The term "fluid mixture" as used in this specification and in the appended claims is defined as a mixture, between a liquid or liquids and another substance or substances suspended therein. The term "dielectric" as used herein is defined as "substantially dielectric" that is, a relatively poor electrical conductor such as an oil or the like.

While preferred forms of the invention have been described in some detail together with the theories which it is believed best explain its success, it is to be understood that the invention is not limited to the precise procedures described nor is it dependent upon the accuracy of the theories which have been advanced. On the contrary, the invention is not to be regarded as limited except in so far as such limitations are included within the terms of the accompanying claims in which it is the intention to claim all novelty inherent in the invention as broadly as is permissible in view of the prior art.

Having thus described the invention, what is claimed and desired secured by Letters Patent is:

1. A method for transmitting the movement of one element to a closely spaced adjacent element comprising placing a substantially dielectric liquid mixture between said elements thence placing said two elements in a closed electric circuit.

2. A method for translating electrical voltage impulses into mechanical force comprising moving a first metallic element in contact with a substantially dielectric fluid suspension in juxtaposition to a second element; and impressing said impulses on said elements to cause the fluid to transmit force from the first element to the second.

3. A method for translating an electrical impulse into a mechanical force comprising: rotating a first member in contact with a substantially dielectric fluid suspension in relatively closely spaced, parallel relation to a second member; and thence impressing an electric potential on the two members by closing a circuit therebetween.

4. Means for causing a power driven disc to rotate a second free disc comprising: a dielectric fluid between said discs; a finely divided substance suspended in said fluid; and an electrical circuit including the two discs, said circuit being broken by the dielectric fluid between said discs.

5. An electro-fluid clutch device comprising: a power drive shaft; a driven shaft in axial alignment with said drive shaft; a drive disc on said power shaft; a driven disc on said driven shaft; a fluid receptacle about said discs; a dielectric fluid mixture in said receptacle, said mixture entering between said discs, said discs being electrically insulated from each other; an electrical control circuit including said discs and the dielectric fluid mixture therebetween; and means for closing said circuit to impress a voltage upon said discs.

6. An electro-fluid clutch device comprising: a power drive shaft; a driven shaft in axial alignment with said drive shaft; a drive disc on said power shaft; a driven disc on said driven shaft, said discs being electrically insulated from each other; a substantially dielectric fluid mixture; means for maintaining said mixture between said discs; and means for impressing an electrical potential on said discs to cause the fluid mixture to act as a coupling between the discs to transmit the rotation of the first disc to the second disc.

7. An electro-fluid relay comprising: a fluid cup; a first disc in said cup; means for rotating said first disc; a second disc in said cup in close proximity to said first disc and electrically insulated therefrom; a dielectric fluid mixture in said cup; and means for impressing an electric potential on said discs in response to the closing of a control circuit.

8. An electro-fluid relay comprising: a fluid cup; a first disc in said cup; means for rotating said first disc; a second disc in said cup in close proximity to said first disc and electrically insulated therefrom; a dielectric fluid mixture in said cup; a shaft extending from said second disc; a relay arm carried by said shaft; a contact positioned to be closed by said relay arm; a spring for swinging said arm in one direction; and means for impressing an electrical potential on said discs to cause a clutching effect in the fluid between the discs to swing the arm in the other direction.

9. An electro-fluid relay comprising: a fluid cup; a first disc in said cup; means for rotating said first disc; a second disc in said cup in close proximity to said first disc and electrically insulated therefrom; a dielectric fluid mixture in said cup; a shaft extending from said second disc; a relay arm carried by said shaft; a contact positioned to be closed by said relay arm; a spring for swinging said arm in one direction; a control circuit including said discs; and means for closing said latter circuit to impress an electrical potential on said discs to cause said fluid to exert a clutching effect between the rotating disc and the second disc to swing the relay arm in the other direction.

10. An electro-fluid relay comprising: a fluid cup; a first disc in said cup; means for rotating said first disc; a second disc in said cup in close proximity to said first disc and electrically in-

sulated therefrom; a dielectric fluid mixture in said cup; a shaft extending from said second disc; a relay arm carried by said shaft; a contact positioned to be closed by said relay arm; a spring for swinging said arm in one direction; a control circuit including said discs; and a photo-electric cell in said circuit for passing a current in the latter at desired times for energizing the fluid between the plates to exert a clutching effect with the rotating disc to swing the relay arm in the other direction.

11. An electro-fluid relay comprising: a supporting member; an electric motor carried by said member; a fluid cup rotatably mounted on said member; means for rotating said cup from said motor; a super-imposed plurality of annular discs secured in said cup; an axial shaft journalled in and projecting from said cup; a plurality of circular discs secured to said shaft, there being one circular disc positioned between each pair of annular discs; means for electrically insulating said shaft from said cup; a dielectric fluid mixture in said cup; a relay arm secured to and projecting from said shaft; a contact member at each extremity of movement of said arm; a spring urging said arm toward one of said contact members; and means for impressing an electric potential on said annular and circular discs to energize the fluid mixture to exert a gripping action between the two types of discs so that the rotation of said cup will be imparted to said arm to swing the latter against the other contact member.

12. An electro-fluid relay comprising: a supporting member; an electric motor carried by said member; a fluid cup rotatably mounted on said member; means for rotating said cup from said motor; a super-imposed plurality of annular discs secured in said cup; an axial shaft journalled in and projecting from said cup; a plurality of circular discs secured to said shaft, there being one circular disc positioned between each pair of annular discs; means for electrically insulating said shaft from said cup; a dielectric fluid mixture in said cup; a relay arm secured to and projecting from said shaft; a contact member at each extremity of movement of said arm; a spring urging said arm toward one of said contact members; a control circuit including said discs; and a photoelectric cell in said control circuit for passing a current to said discs at predetermined times to energize the fluid into exerting a gripping action between the two types of discs to cause the rotative movement of said cup to swing the arm into contact with the other contact member.

13. Means for transmitting force between two closely spaced independent elements in consequence of an electric voltage impressed on said elements comprising a dielectric liquid positioned between said elements and particles of foreign material suspended in said liquid so that the particles will be affected by said voltage to cause said elements to tend to move in unison while under the influence of said voltage, whereby the liquid will act as a coupling between the elements, and means for placing said elements in an electrical field.

14. A method for translating an electrical impulse into a mechanical movement comprising: moving a first element in a substantially dielectric fluid mixture in closely spaced relation to a second free element therein; and thence impressing an electric potential on the two elements by closing a circuit therebetween.

15. The method of controlling the transmission of mechanical force through a homogeneous viscous dielectric fluid suspension which includes the step of increasing shear stresses transmitted in the fluid by applying an electric field in a direction at right angles to the direction of shear.

16. A clutch comprising a pair of spaced metallic walls mounted for relative movement, a substantially dielectric fluid suspension between said walls characterized by an increased viscosity when subjected to an electric field, an electric circuit including said walls for applying a difference of potential therebetween, and a condition responsive device in control of said circuit.

17. A clutch comprising a pair of spaced metallic walls mounted for relative movement; a homogeneous dielectric fluid suspension bridging the space between said walls, said fluid suspension characterized by an electrically alterable viscosity at constant temperature; an electric circuit including said walls for applying a difference of potential therebetween, and a condition responsive device in control of said circuit.

18. A method for transmitting motion from one rotatable member to another rotatable member, comprising placing a substantially dielectric liquid mixture between the members to act as a coupling therebetween and placing said members in an energized electric circuit.

19. A method of translating electrical impulses into mechanical movement comprising rotating a member that is arranged in juxtaposition to a normally non-rotating second member, with a substantially dielectric liquid mixture interposed between the members, and impressing electrical impulses on the members to cause the liquid mixture to act as a coupling between the members and transmit motion from the first mentioned member to the second mentioned member.

20. Means for causing a rotatable member to drive another rotatable member arranged in closely spaced parallel relation to the first mentioned rotatable member, comprising a substantially dielectric liquid having a finely divided substance suspended therein and arranged between the members, and means for electrically increasing the viscosity of the liquid and the substance suspended therein whereby the latter will act as a coupling between the rotatable members.

21. A coupling for two rotatable members comprising a substantially dielectric liquid containing a finely divided substance suspended therein, said mixture being normally incapable of operatively connecting the members together, and means for electrically increasing the viscosity of the mixture to cause the same to operatively connect one member to the other member.

22. The method of instantaneously increasing the viscosity of a force transmitting fluid composed of a dielectric liquid and a finely divided substance suspended therein; which consists in applying an electric field to the fluid.

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