

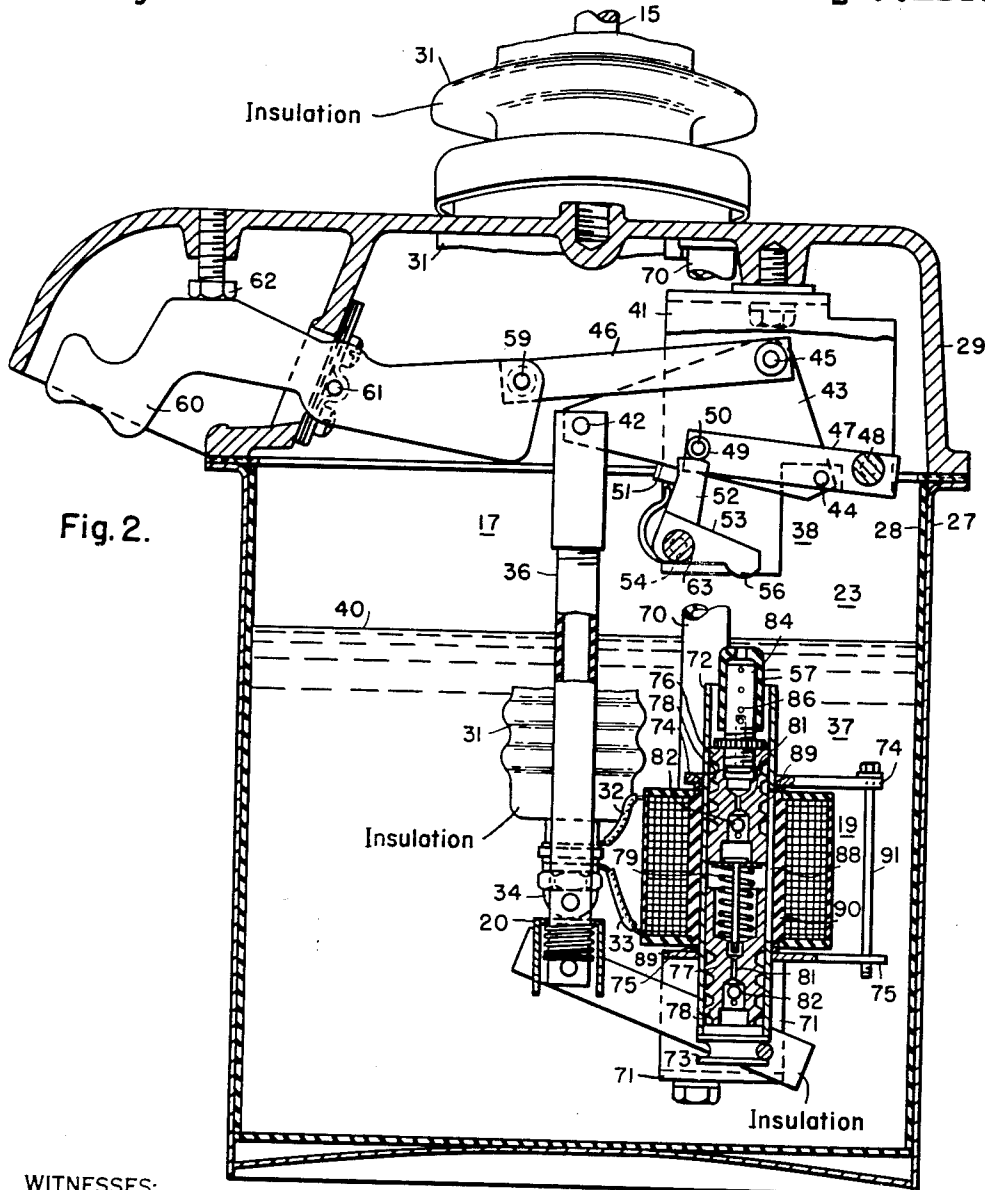
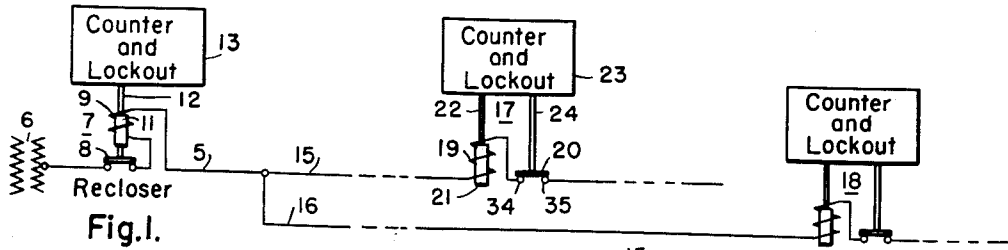
July 31, 1956

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2,757,321

CIRCUIT INTERRUPTER

Filed Nov. 18, 1950



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2,757,321

CIRCUIT INTERRUPTER

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Continuation of application Serial No. 106,886, July 26, 1949. This application November 18, 1950, Serial No. 196,508

16 Claims. (Cl. 317-178)

Our invention relates generally to circuit interrupters, and it has reference in particular to circuit interrupters of the line sectionalizing type, such as may be used in conjunction with automatic reclosing circuit breakers on feeders in distribution systems.

This application is a continuation of our copending application, Serial No. 106,886, which was filed on July 26, 1949, and is assigned to the assignee of the present invention. Application Serial No. 364,292, filed on June 26, 1953, is a continuation of this application.

Generally stated, it is an object of our invention to provide a circuit interrupter which is simple and inexpensive to manufacture and is reliable and effective in operation.

More specifically it is an object of our invention to provide a new and novel circuit interrupter structure wherein an operation counter operates to release a lever of the interrupter contact operating mechanism for opening the interrupter, and a handle is provided for manually operating the same lever to open and close the interrupter.

Another object of our invention is to provide in an operation counter of the magnetically operated type, for using ribs of magnetizable material at spaced intervals on a movable core for effecting a magnetic locking action of the core in different stepped operating positions.

Yet another object of our invention is to provide for more accurate operation of a sectionalizer type of circuit interrupter by providing for magnetically locking the armature of an operation counter used therewith in its different operating positions.

It is also an object of our invention to provide a counting-mechanism which makes use of a novel principle of operation, using two armatures inside of a single operating-solenoid, with a compression spring between them for normally holding the armatures separated from each other when the solenoid is deenergized, with special fluid-flow valves and special magnetic interlocks which make the mechanism free of previously experienced difficulties resulting in erratic performance and involving excessive burdens on the solenoid.

With the foregoing and other objects in view, our invention consists in the systems, combinations, structures, parts, and method of design and operation, hereinafter described and claimed, and illustrated in the accompanying drawing, wherein

Figure 1 is a diagrammatic view of circuits and apparatus illustrating the kind of system in which our invention is used, and

Fig. 2 is a simplified cross-sectional view through the counting means and through the operating mechanism of a sectionalizer type of interrupter illustrative of our invention.

In Fig. 1, we show our invention applied to a rural power-line 5 of the type described, which is fed from a power source 6 through a diagrammatically indicated automatic reclosing circuit breaker or recloser 7, having a normally-closed breaker contact 8, and an operating-

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coil 9, both connected in series with the line 5. The recloser has an armature 11 which is mechanically connected, at 12, to a block 13 which represents any suitable counter-and-lockout mechanism, which counts the number of rapidly repeated contact-opening-and-reclosing operations, and after a predetermined number of such operations locks out the recloser by thereafter holding the contact 8 in its open position, until the recloser is manually reset. It will be understood that the recloser contact 8 is normally closed but opens in response to a predetermined overcurrent condition in the coil 9. The opening of the contact 8 deenergizes the coil 9, and when the coil 9 is deenergized, the recloser contact 8 automatically recloses itself, until the counter mechanism 13 becomes effectively operative and holds the contact 8 in its open position. There are a number of such reclosers on the market, and their specific construction constitutes no part of our present invention, unless the mechanism 13 is designed so as to include our counter, which will be subsequently described. It is believed, therefore, that the diagrammatic recloser illustration in Fig. 1 is sufficiently clear without further explanation or illustration.

The rural power line 5 may extend out, either in a single branch, or in a plurality of branches 15 and 16, each branch usually supplying a number of customers located at various points distributed along the line. Most of the faults which will occur on such a line are faults which will clear themselves as soon as voltage is removed from the line, although sometimes a fault may require a certain length of time, or a certain number of successive opening and reclosures of the recloser 7, in order to burn off or clear the fault. The recloser 7 protects such a line by more or less rapidly opening and reclosing its breaker contact 8 for a predetermined number of times, such as 4 or 5 times, after which, if the fault has not then cleared itself, the fault is considered to be a permanent fault and the recloser permanently opens its contact 8.

Since a line 5 of the type in question, or its several branch lines 15 and 16, usually serve a considerable number of customers, it has been recognized as being desirable to use one or more circuit interrupters or line sectionalizers for increasing the number of points, along the line, at which the circuit can be disconnected in the event of a permanent fault which will not clear itself, thus limiting the number of customers, or the amount of the circuit, affected by any permanent fault.

Fig. 1 illustrates a typical situation in which a sectionalizer 17 is inserted at some intermediate point along the length of the branch line 15, while a similar sectionalizer 18 is inserted at some intermediate point along the branch line 16. Each sectionalizer, such as 17, comprises a series-connected operating-coil 19, and a normally closed, series sectionalizer contact 20, both of which are connected in series with the associated branch line, such as 15. The current coil 19 operates on an armature 21 which is mechanically connected, as diagrammatically indicated at 22, with a counter-and-lockout mechanism 23, which is indicated by block diagram in Fig. 1. The counter-and-lockout mechanism 23 is mechanically connected, as diagrammatically indicated at 24, so as to trip out the sectionalizer contact 20 after a predetermined number of "counts" of fault current surges followed by interruptions of the current through the coil or solenoid 19, the mechanism thereupon not only opening the contact 20 but also locking it out, or holding it open, so as to disconnect the power service from the rest of the line, extending beyond the location of the sectionalizer (such as 17), until the fault can be located and corrected, after which the sectionalizer will be reclosed or reset by hand.

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A desirable structural form of the sectionalizers, such as 17 or 18, is shown in Fig. 2. The sectionalizer 17 is here shown as being enclosed within a metal tank 27, which is provided with an insulating liner 28, and which is surmounted by a top casting 29. The incoming line 15 enters through a bushing 31 which terminates inside of the tank. The circuit then continues, through a conductor 32, to the sectionalizer coil 19. From the sectionalizer coil 19, the circuit continues through a conductor 33 back underneath the bushing 31 for the incoming lead 15, and thence to the terminal 34 which constitutes one of the stationary contacts of the sectionalizer. Ordinarily, the sectionalizer has two bushings, each with its lead passing through the bushing, and each bushing terminates, at its bottom in one of the stationary contacts of the sectionalizer, but since Fig. 2 shows an approximately central section through the sectionalizer, the second stationary contact is not visible in Fig. 2, but it is indicated in Fig. 1 at 35. The movable contact 20 is shown, in Fig. 2, as a contact bar or bridge which presses up against the underside of the stationary contacts 34 and 35 in the closed position of the sectionalizer, and which is lowered by gravity, to operate the sectionalizer, upon the release of a pull rod 36, which is shown in the form of an upwardly extending insulating tube.

The counter-and-lockout mechanism 23 is segregated in Fig. 2, into its component parts, consisting of the counter 37 and the operating mechanism 38.

The sectionalizer 17 can theoretically operate either in air, or in an insulating oil, or other insulating fluid. It is sometimes desirable for the counter 37 to operate in oil, as it involves dashpot or fluid-flow operation, as subsequently described, which is somewhat more difficult to obtain in air, with the necessary time constants. It is sometimes desirable to have the contacts 34-20-35 also operating in oil. We have consequently illustrated our apparatus, by way of example, as having the counter 37 and the contacts 34-20-35 immersed in oil 40 which is contained in the tank 27.

The particular operating mechanism 38 which is shown in the accompanying drawing constitutes the subject matter of a companion application Serial No. 106,886, of J. M. Wallace and A. W. Ogg. In brief, it will perhaps suffice to say that this operating mechanism comprises a triangularly shaped lever 43 to which the pull rod 36 is pivotally connected as by a pivot 42. A lever 47 mounted by a pivot 48 on a frame 41 secured to the casting 29 supports a pivot 44 for one corner of the lever 43. The lever 47 is normally supported by a releasable bellcrank trigger 53 having an arm 52 engaging a roller 49 on a pin 50 at the free end of the lever, and an operating handle 60 pivotally mounted on the casting by a pivot 61 and connected by a pivot 59 so as to provide a toggle arrangement with a lever 46 connected to the other corner of the lever 43 by a pivot 45. An adjustable stop 62 is provided for the handle 60. The trigger 53 has an extending stop lug 51 which engages the frame 41 to locate the trigger in the position shown, and it has a downwardly extending abutment portion 56 which is adapted to be tripped when an upward movement of a trip pin 57 of the counter 37 raises said abutment point 56 of the trigger, whereupon the pivot 44 drops, permitting pivot 45 to fall and the toggle arrangement of the handle 60 and lever 46 to break, so that the linkage of the operating mechanism permits the pull rod 36 and the movable contact member 20 to drop freely in the opening operation of the mechanism. Eventually lever 43 strikes a roller 63 or pivot 54 of the trigger and rotates counterclockwise to raise pivot 44 and relatch lever 47 with the arm 52 of trigger 53.

The counter 37 is suspended from the top of the top casting 29, by means of a plurality of depending insulating supports or tubes 70, which support the base frame 71 of the counter.

The counter 37 proper comprises a vertically disposed tube 72, which is preferably made of brass or other non-magnetizable metal. The lower end of the tube is tightly closed by a plug 73, while the top of the tube 72 is open. The series-current coil 19 surrounds a portion of the tube 72, intermediate between its upper and lower ends. Immediately above and below the coil 19 are two perforated magnetizable plates 74 and 75, respectively, both of which are perforated so as to surround the tube 72. The plates 74 and 75 serve as the two pole pieces of an electromagnetic circuit, the excitation of which is provided by the coil 19.

Inside of the tube 72 are two normally spaced magnetizable cores or armatures 76 and 77, which are slidably movable, with a close fit of say perhaps 3 mils radial clearance, within said tube. The upper armature 76 extends partly above and partly below the level of the upper plate 74, while the lower armature 77 extends partly above and partly below the lower plate 75. Each of these armatures 76 and 77 thus extends partly within and partly without the space between the two plates 74 and 75.

In accordance with an important feature of our invention, at least one of the armatures, such as the upper armature 76, and preferably both of the armatures 76 and 77, are provided with a plurality of annular magnetizable ribs 78 which are vertically spaced from each other by a spacing which is preferably approximately the same distance as the closable distance between the two armatures 76 and 77, or other disposition which will magnetically lock the respective armatures against unwanted vertical displacement or slippage. A compression spring 79 is disposed between these two armatures, so that, when the coil 19 is sufficiently energized, the two armatures are brought together, storing up energy in the interposed compression spring 79, as will be more fully described hereafter.

Each of these armatures 76 and 77 is provided with a central bore 81, and the lower end of each of these bores, is closable by means of a ball valve 82, so that the fluid which is entrapped within the closed lower end of the tube 72 resists any rapid downward movement of either armature, because of the closure of these ball valves 82, while said valves permit the free upward movement of either armature. The entrapped fluid could be any gas or liquid having the required viscosity in comparison with the mechanical clearances which are provided. The idea is to permit the respective armatures to move freely upwardly, in a step-by-step motion, as will be subsequently described, while permitting said armatures to drift back downwardly again, by fluid leakage, at a very slow rate.

At the top of the upper armature 76, we affix an upstanding pin 84, which extends upwardly to a point above the open top end of the tube 72. This pin 84 is surrounded by a tubular tip or trip pin 57, which is capable of serving as an adjustable extension of the pin 84. This vertical adjustment is effected in any one of a plurality of vertically spaced positions corresponding to the spacing between the armatures 76 and 77, by means of a cotter pin 86, so that adjustment may be made for any desired number of "counts," such as 1, 2, 3, or 4, within the range of the counting mechanism 37.

In the operation of the counting mechanism 37, when the coil 19 is first energized, with a current corresponding to the setting of the counter, the two armatures 76 and 77 are drawn together, so as to close the air gap which separates the inner ends of said armatures. The upper armature 76 cannot move downwardly, in order to bring the two armatures together, because of the presence of its fluid-flow valve 82, and hence the lower armature 77 must move upwardly. The attractive force between the two armatures is greater than the attractive force between the lower plate 75 and the corresponding rib 78 of the lower armature 77, which was at first on the same level as said lower plate 75. When the lower armature com-

pletes its upward movement, compressing the spring 79, its next rib 78 comes into a magnetic interlock with the lower plate 75, thus holding said lower armature from drifting or settling downward, due to gravity and the slow leakage of the fluid filling of the tube 72, this holding action being maintained as long as the coil 19 remains effectively energized.

When there is a fault on the distribution line, within the protective reach of the recloser 7 (Fig. 1), the recloser contact 8 quickly opens, and quickly again recloses, but during the movement (12 cycles or more, in a 60-cycle line) when said recloser contact 8 was open, the sectionalizer coil 19 is deenergized, and the compression spring 79 between the two armatures 76 and 77 expands, and pushes the two armatures apart again, to their normal separation distance. During this action, however, the lower armature 77 cannot move downwardly, because of its fluid-flow valve 82, and hence the upper armature 76 must move upwardly, which it is free to do, so far as fluid action is concerned, because its valve 82 will open during such movement. The magnetic attraction between the upper and lower plates 74 and 75 and the corresponding magnetizable ribs 78 of the upper and lower armatures 76 and 77 is now practically non-existent, because of the deenergization of the coil 19, and hence the upper armature 76 is notched upwardly by a distance corresponding to the amount of compression of the spring 79.

If a fault continues on the distribution system, at a point beyond the sectionalizer coil 19, the reclosure of the recloser contact 8 reenergizes the sectionalizer coil 19 and causes a second compression of the spring 79, in a manner already described. If the fault is still on the system, as has just been assumed, the recloser contact 8 again opens, and a second upward stepping movement of the trip pin 57 is obtained. And thus the step-by-step movement of the counter mechanism continues.

When the last upward stepping of the upper armature 76 is obtained, depending upon the vertical positioning of the trip pin or tubular tip 57, this pin 57 comes into contact with the trigger 53 during this last upward movement. The lever 47 is released and falls carrying pivot 44 therewith. The pivot 45 drops also, breaking the toggle arrangement of the lever 46 and handle 60, so the lever 43 rotates in a counterclockwise direction and rod 36 drops and trips out the sectionalizer contact 20. As the pull rod 36 falls, the lever 43 drops and strikes roller 63 on pivot 54 of the trigger. The lever 43 thereupon rotates about the roller 63, raising pivot 44 and lever 47 until the trigger 53 returns to the initial latched position. It will be noted that the last upward movement of the trip pin 57 occurs during a time when the current in the sectionalizer coil 19 is off. In the operation of the recloser 7, the current remains off, that is, the recloser contact 8 remains open, for a minimum of 12 cycles (on a 60-cycle line), before the recloser contact 8 recloses. The opening of the sectionalizer contact 20 requires something like 2 or 3 cycles, so that it is seen that the sectionalizer contact 20 opens during the current-off period, so that the sectionalizer contact 20 does not have to interrupt any substantial current. The sectionalizer may be reclosed by operating the handle 60 to rotate the lever 43 clockwise about pivot 44 and restore the over-center toggle arrangement with lever 46.

By our new counter mechanism, we have thus provided a counter in which the magnitude or distance of the advance-steps, by which the counter is advanced each time it "counts," is fixed. This action is obtained particularly by virtue of the magnetizable ribs 78 of the upper armature 76, which magnetically interlock with the upper magnetizable plate 74 each time the coil 19 is energized, thus accurately lining up the vertical position of the upper armature 76, for each counting operation. In this manner we avoid errors due to slightly different upward lifts, due to various conditions such as the magnitude of the fault current, the dissymmetrical position of the arma-

tures 76 and 77, one of which may be extending further outside of the coil than the other, so that there would normally be a tendency for the two armatures to settle themselves into a central position with an equal amount of extension beyond the confines of the coil 19. Our magnetic interlock also automatically adjusts for small amounts of drift, in case of a timed operation of the recloser contact 8, which is sometimes used instead of the "instantaneous" tripping operations, as is well understood in the art. In short, we have provided a counter mechanism which actually advances the trip pin 57 by a fixed predetermined invariable amount, each time the coil 19 is deenergized, after having been energized sufficiently to compress the spring 79.

The magnetizable ribs 78 on the lower armature 77 also assist, although they are not by any means necessary, as in the case of the corresponding ribs on the upper armature 76. In the lower armature 77, if said ribs 78 are used, as shown, they obviously serve to help to hold the two armatures in their proper vertical position, without any downward drifting, throughout the time when adequate energizing current is flowing through the coil 19.

The foregoing and other advantages are obtained in a structure which combines great simplicity, freedom from operational difficulties, and low manufacturing costs.

An important feature of our invention is related to the choice of brass or other non-magnetizable metal, as a material of construction for the tube 72. It is desirable to use a metal for said tube so that its bore can be accurately machined so that close radial tolerances may be maintained between said bore and the two armatures 76 and 77. If a metal is used for the tube 72, it has to be non-magnetic in order to prevent sticking of the armatures thereto and to permit the magnetic flux to penetrate to the armatures 76 and 77. But if the tube 72 is of metal or other conducting material, it is sometimes desirable that the central portion of the tube, or more particularly, the portion between the upper and lower magnetizable plates 74 and 75, should have a vertical slit therein, as has been shown at 88. This vertical slit is for the purpose of impeding or breaking up the eddy currents which would otherwise flow around the circumference of the tube, as a result of the axial flow of alternating magnetic fluxes through the center of the tube. The vertical slit 88 extends from a point just below the upper plate 74 to a point just above the lower plate 75.

It is necessary, however, to prevent the flow of oil or other fluid through this vertical slit 88, and hence, in accordance with this phase of our invention, we provide two compressible sealing rings 89, surrounding the tube 72, one above and the other below, said slit 88. The portion of the tube having the slit 88 is further surrounded by a tubular insulating member 90, which is not slit or perforated. The respective sealing rings 89 are compressed between the brass tube 72, the respective ends of the tubular insulating member 90, and the respective plates 74 and 75, thus preventing any leakage of oil or other fluid out of the slit 88.

The coil 19 surrounds the tubular insulating member 90. A return path for the magnetic flux is sometimes provided by one or more magnetizable bolts 91, which join the upper and lower plates 74 and 75, outside of the coil 19.

By using a lever arrangement in which the lever 43 has two pivotal points of support arranged in triangular relation with the point of connection to the contact pull rod, a simple and efficient mechanism is provided. The toggle handle mechanism and the releasable latch operate at different points on the same lever, thus providing an inexpensive and reliable operating mechanism. Since the trigger 53 is reset in the latch position during the opening operation, the sectionalizer is reclosed by reclosing it through operation of the manual operating handle in the same manner as reclosing after a manual opening, merely by replacing the handle and lever 46 in

an over-center toggle arrangement as shown. Manual tripping is effected by simply operating the handle to break this same toggle arrangement, whereupon the lever 43 pivots counter-clockwise, dropping the pull rod and opening the contacts.

While we have illustrated our invention in but a single exemplary form of embodiment, which is now preferred, we wish it to be understood that our invention is susceptible of considerable modification, by way of additions, omissions and the substitution of various equivalents, without departing from the essential spirit of our invention, particularly in its broader aspects. We desire, therefore, that the appended claims shall be accorded the broadest construction consistent with their language.

We claim as our invention:

1. An electromagnetic circuit, a pair of core-members of a magnetic material mounted for axial movement within said electromagnetic circuit, said core-members being freely movable in one direction, means for opposing the sudden movements of the respective core-members in the opposite direction, means for normally biasing said core-members apart so as to normally have a predetermined separation, and means for supporting said core-members in positions in which each core-member at some time extends at least partially beyond its end of said electromagnetic circuit, whereby a predetermined energization of said electromagnetic circuit draws in one of said core-members in said free-movement direction against the bias of said core-separating biasing-means, and whereby a subsequent deenergization of said electromagnetic circuit permits said biasing-means to expel the other core-member a predetermined distance beyond the electromagnetic circuit in said free-movement direction.

2. The invention as defined in claim 1, characterized by resetting-means tending to force both core-members in said opposite direction, and fluid valve means for permitting said core-members at times to drift slowly in said opposite direction under the influence of said resetting-means.

3. A resetting electromagnetic counter comprising: a tube which is closed at one end and open at its other end; an electromagnetic circuit having two spaced magnetizable pole-piece plates, each having an opening at least partially surrounding said tube; two normally spaced armatures which are slidably movable, with a close fit, within said tube, each of said armatures at some time extending partly within and partly without the space between the two plates, each of said armatures having a fluid-flow passage therethrough and each having a valve for closing said passage so as to resist rapid fluid-flow through said passage in a direction out of the closed end of the tube; a compressible spring between the two armatures; and biasing-means tending to force the armatures toward the closed end of the tube for resetting said armatures so as to be ready for another counting-operation.

4. The invention as defined in claim 3, characterized by said tube being made of substantially non-magnetizable metal and having a longitudinal slit therein, extending nearly the length of the space between the two plates, and within the confines of said space; in combination with a tubular insulating-member surrounding the slit portion of said tube; and two compressible sealing-rings surrounding said tube, one beyond either end of the slit, the respective sealing-rings being compressed between said tube, the respective ends of said tubular insulating-member and the respective plates.

5. A step-by-step movable counter comprising: a tube which is closed at one end and open at its other end; an electromagnetic circuit having two spaced magnetizable pole-piece plates, each having an opening at least partially surrounding said tube; two normally spaced armatures which are slidably movable, with a close fit, within said tube, each of said armatures at some time extending partly within and partly without the space between the two plates, each of said armatures having a fluid-flow

passage therethrough and each having a valve for closing said passage so as to resist rapid fluid-flow through said passage in a direction out of the closed end of the tube; at least one of the armatures having a plurality of annular magnetizable ribs which are vertically spaced from each other; a compressible spring between the two armatures; and biasing means tending to force the armatures toward the closed end of the tube for resetting said armatures so as to be ready for another counting-operation.

6. The invention as defined in claim 5, characterized by an adjustable pin attached to the end of the armature at the open end of the tube.

7. The invention as defined in claim 5, characterized by each of said armatures having a plurality of magnetizable ribs.

8. The invention as defined in claim 5, characterized by a liquid filling within said tube.

9. The invention as defined in claim 5, characterized by said tube being made of a substantially non-magnetizable metal and having a vertical slit therein, extending from a point below the upper plate to a point above the lower plate; in combination with a tubular insulating-member surrounding the slit portion of said tube; and two compressible sealing-rings surrounding said tube, one above, and the other below, said slit, the respective sealing-rings being compressed between said tube, the respective ends of said tubular insulating-member and the respective plates.

10. A fluid-controlling electromagnet comprising: a tube; a coil surrounding a portion of said tube; two perforated magnetizable plates surrounding said tube, one beyond the front end of the coil and the other beyond the rear end of said coil; and a movable armature which is slidably movable, with a close fit, within said tube, and which at some time extends partly within and partly without the space between the two plates; characterized by said tube being made of substantially non-magnetizable metal and having a longitudinal slit therein, extending nearly the length of the space between the two plates and within the confines of said space; in combination with a tubular insulating-member surrounding the slit portion of said tube between the tube and the coil; and two compressible sealing-rings surrounding said tube, one beyond either end of the slit, the respective sealing-rings being compressed between said tube, the respective ends of said tubular insulating-member and the respective plates.

11. A resetting electromagnetic counter comprising: a tubular member which is closed at one end; a magnetizing coil for causing a magnetic flux to flow axially in an intermediate portion of said tubular member; two normally spaced armatures which are axially movable within said tubular member; a compressible spring between the two armatures; biasing means tending to move both armatures in the same axial direction for resetting the counter; dashpot-means associated with each armature within said tubular member for resisting rapid axial movement of that armature in the biased direction; the initial biased position of the armatures being such that a first one of the armatures extends materially beyond the axial-flux region in its biased direction, whereby, when said coil is sufficiently energized, that armature will be drawn partway into said axial-flux region in an advancing direction opposite to said biased direction, while, at the same time, the two armatures will be attracted together, compressing said compressible spring; and whereby, when the coil is thereafter deenergized, said compressible spring will advance the second armature while said first-mentioned armature temporarily remains stationary; the proportions of the parts being such that a quickly following second energization of the coil will draw said first-mentioned armature further into said axial-flux region in said advancing direction, followed, on another quickly following deenergization of the coil, by a second advance of the second armature.

12. A resetting electromagnetic counter comprising: a

tubular member which is closed at one end; a magnetizing coil for causing a magnetic flux to flow axially in an intermediate portion of said tubular member; two normally spaced armatures within said tubular member, each of said armatures fitting within said tubular member with a fit which is sufficiently fluid-tight to oppose rapid fluid-flow thorough said fit in the direction of the axis; a compressible spring between the two armatures; biasing-means tending to move both armatures in the same axial direction for resetting the counter; each of said armatures having a fluid-flow passage extending therethrough in the direction of the axis, and each having a valve for closing said passage so as to resist rapid fluid-flow through said passage when that armature moves in the biased direction; the initial biased position of the armatures being such that a first one of the armatures extends materially beyond the axial-flux region in its biased direction, whereby, when said coil is sufficiently energized, that armature will be drawn partway into said axial-flux region in an advancing direction opposite to said biased direction, while, at the same time, the two armatures will be attracted together, compressing said compressible spring; and whereby, when the coil is thereafter deenergized, said compressible spring will advance the second armature while said first-mentioned armature temporarily remains stationary; the proportions of the parts being such that a quickly following second energization of the coil will draw said first-mentioned armature further into said axial-flux region in said advancing direction, followed, on another quickly following deenergization of the coil, by a second advance of the second armature.

13. An operation counter comprising, a magnetic circuit including two spaced plates of magnetic material having aligned openings therein, a tube of non-magnetic material disposed in said openings, a pair of relatively movable core members of magnetic material disposed at least partly within the tube, biasing means disposed between the core members to provide a predetermined normal separation therebetween, a coil disposed around the tube for effecting a magnetic attraction between the core members, each of said core members having a one-way fluid valve, and one of said core members having a plurality of peripheral ribs at spaced intervals corresponding to a stepping operation of the core member to effect a magnetic locking action with one of the spaced plates.

14. A counter comprising, an electromagnetic circuit including a solenoid, a tube of non-magnetic material containing a fluid, said tube being coaxial with a portion of said electromagnetic circuit, relatively movable core mem-

bers of magnetic material disposed adjacent each other in said tube in said magnetic circuit, one-way valve means in each of said core members for advancing a predetermined amount of fluid against a movable one of said core members to advance it from a normal position when the solenoid is deenergized following an overcurrent, at least said movable one of said core members having a plurality of spaced apart magnetizable ribs disposed to definitely locate said core member in the magnetic circuit, and means biasing said core members apart to a normal position.

15. In an operation counter, an electromagnetic circuit including two spaced perforated plates of magnetic material having aligned openings therein, a tube of non-magnetic material containing a fluid disposed in said openings, a solenoid disposed about said tube between said plates, a pair of relatively movable core members of magnetic material disposed in said tube adjacent each other to be attracted to each other upon predetermined energization of the solenoid, each of said core members having a fluid passage with valve means to resist passage of a fluid therethrough in one direction for advancing a predetermined amount of fluid upon deenergization of the solenoid, biasing means between the core members, and an adjustable operating member mounted on a movable one of said core members.

16. A counter comprising, an electromagnetic circuit, a tube of non-magnetic material containing a fluid disposed in said circuit, relatively movable core members of magnetic material disposed adjacent each other in said tube in the magnetic circuit, means biasing said core members to provide a predetermined normal separation thereof, solenoid means providing a magnetic flux in said circuit to draw said members toward each other, valve means in each core member providing a one way fluid passage therethrough to advance a predetermined amount of fluid when the solenoid is deenergized, and an adjustable extension mounted on a movable one of the magnetic core members.

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