H. POTH.

RHEOSTAT.

APPLICATION FILED DEC. 8, 1905.

898,987. Patented Sept. 15, 1908.

3 SHEETS—SHEET 1.

Fig 1

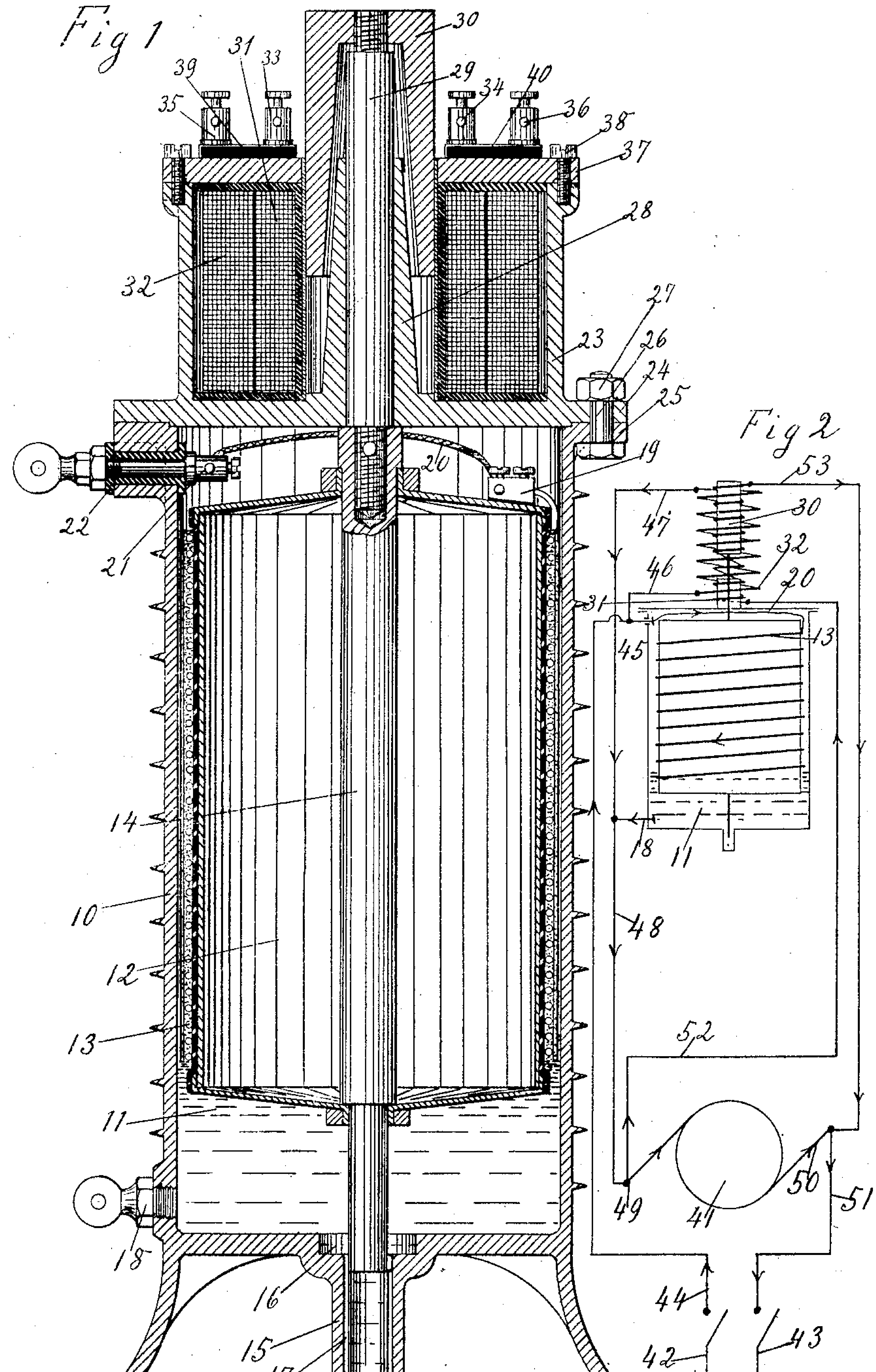

Fig 2

Witnesses

O. Knight Jr.

H. C. Workman

Inventor

Heinrich Poth,

By his Attorneys

Knight Bros.

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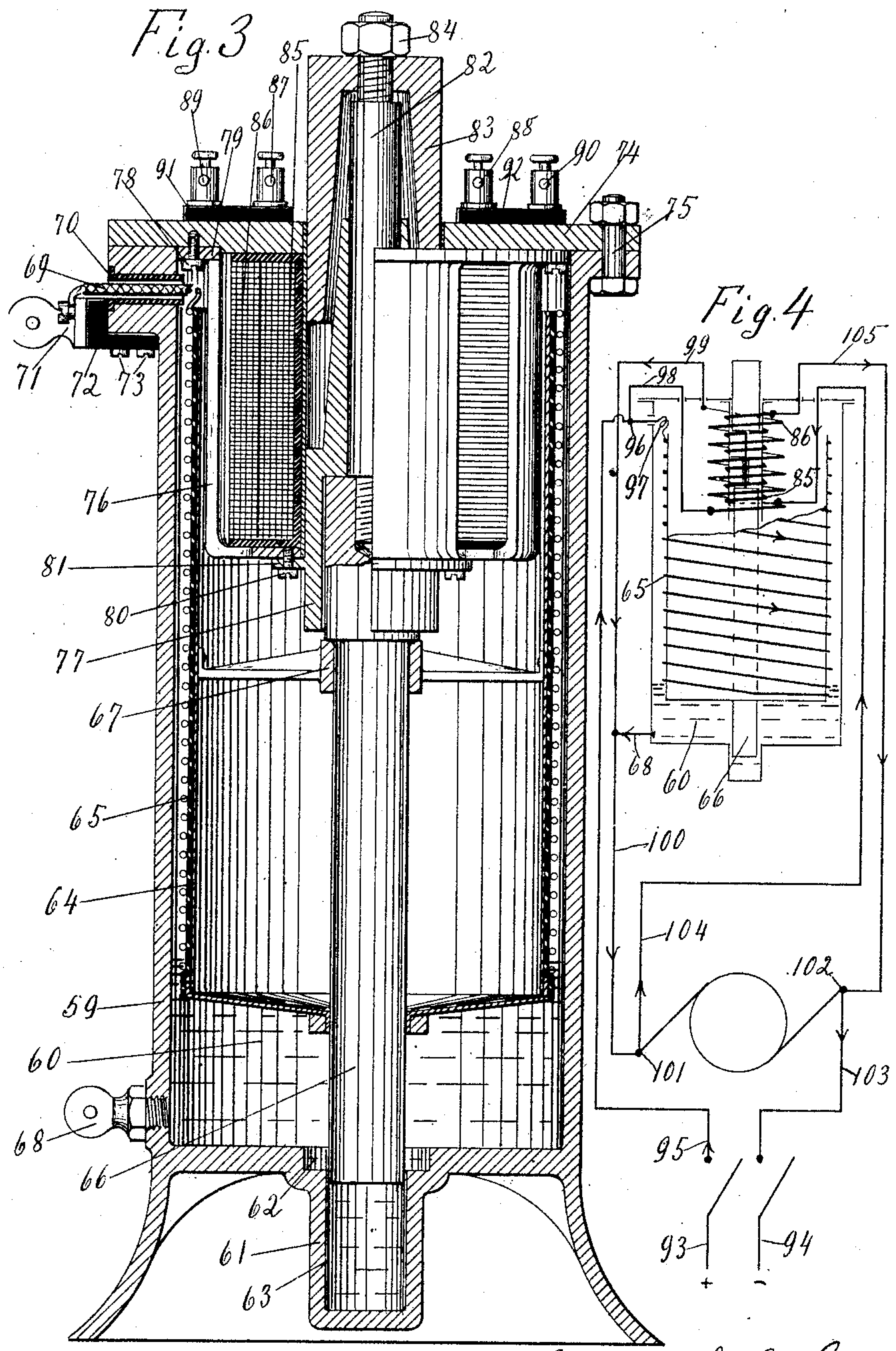
3 SHEETS—SHEET 2.



Witnesses

O. Knight.
H. C. Workman

Heinrich Poth
Inventor,

By his Attorneys Knight Bros.

THE NORRIS PETERS CO., WASHINGTON, D. C.

H. POTH.
RHEOSTAT.
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3 SHEETS—SHEET 3.

Fig. 6

Fig. 7

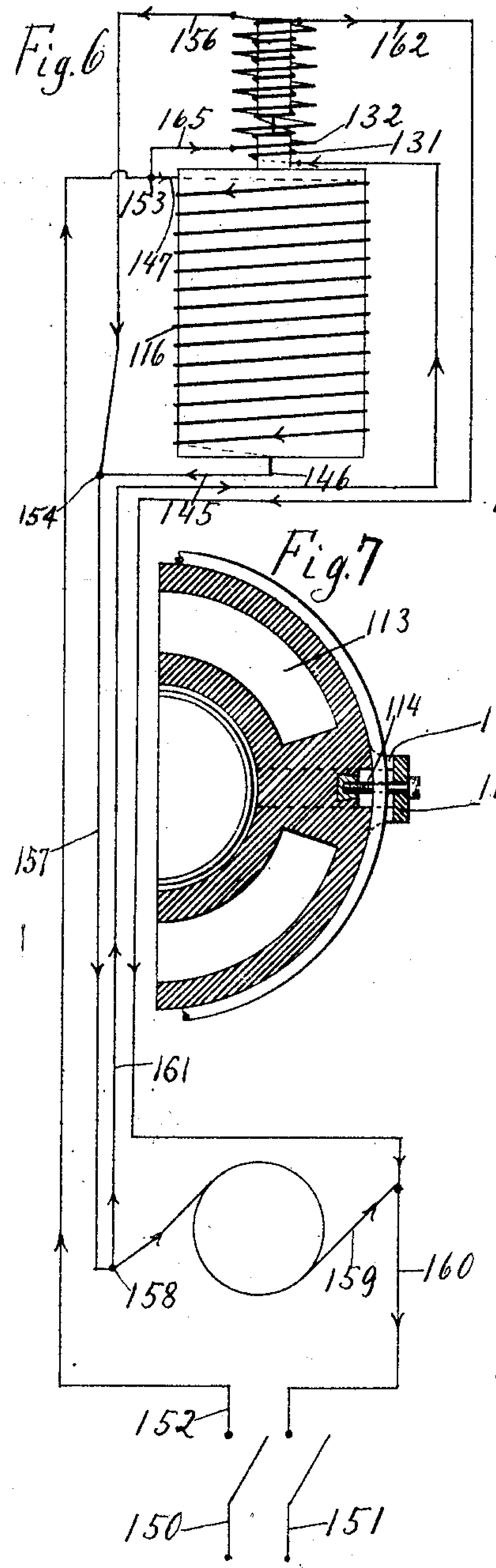
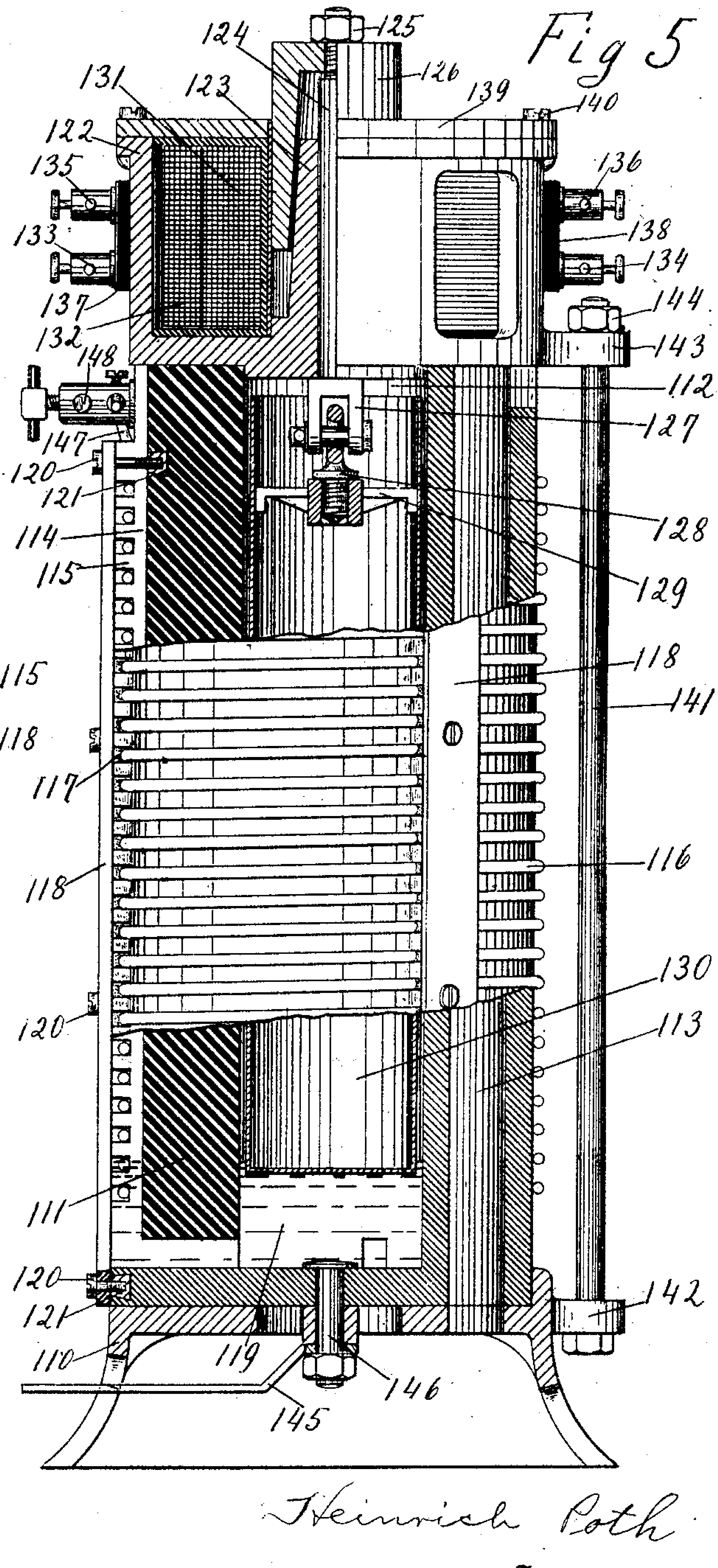


Fig 5



Heinrich Poth
Inventor,

Witnesses
O. Knight Jr.
H. C. Workman

By his Attorneys Knight Bros.

UNITED STATES PATENT OFFICE.

HEINRICH POTH, OF BROOKLYN, NEW YORK.

RHEOSTAT.

No. 898,987. Specification of Letters Patent. Patented Sept. 15, 1908.

Application filed December 8, 1905. Serial No. 290,906.

To all whom it may concern:

Be it known that I, HEINRICH POTH, a subject of the German Emperor, and a resident of Brooklyn, in the county of Kings and State of New York, have invented certain new and useful Improvements in Rheostats, of which the following is a specification.

My invention relates in general to rheostats for all kinds of electric current.

More especially, my invention may be applied to rheostats which are used as motor starters.

Broadly speaking, my invention comprises any apparatus in which there is a resistance medium of which the short circuiting is accomplished gradually without the step by step action by means of a conductive liquid which is caused by any suitable means to gradually come into contact with more and more of the resistance medium and thereby decrease the resistance.

The object of my invention is to do away with certain well known disadvantages which are present in the rheostats now in use. The rheostats now in common use operate by the step by step short circuiting of the resistance medium, and involve the use of a greater or less number of terminals and contact pieces which are subject to wear, owing to friction and the tendency to spark, in addition to being expensive in construction. The step by step short circuiting of the resistance medium is in many cases a great disadvantage, and to decrease this drawback, it has generally been the practice to increase the number of terminals. But this method of avoiding the disadvantages greatly increases the cost of construction, and furthermore does not altogether do away with the step by step action.

I accomplish the objects of my invention by mounting the resistance medium, (preferably a coil in helical form) upon a suitable supporting body, and providing a suitable conductive medium, preferably mercury, which through any suitable means is caused to gradually rise or fall around the resistance coil, one terminal of the resistance circuit being in contact with the conductive liquid while the other is conductively attached to the end of the coil opposite to that which is dipping into the conductive liquid.

My improved rheostat does away entirely with contact pieces, special contact levers, and spark formation, and the short circuiting of the resistance is gradual.

The rise and fall of the conductive liquid may be accomplished by hand, or the device may be provided with means for accomplishing this rise and fall automatically without any attention from the operator.

For the purpose of setting forth clearly the nature of my invention, I have shown in the drawings, and shall describe, a few forms of the invention as adapted to operate automatically as a motor starter, but I do not limit the invention to the automatic forms or to its use as motor starters only.

In the drawings Figure 1 is a central sectional elevation of a form of the apparatus in which electric magnets, serving to automatically actuate the rheostat, are arranged above the resistance bearing body. Fig. 2 is a diagram of a circuit which might be applied to the form of apparatus illustrated in Fig. 1. Fig. 3 is a central sectional elevation of an apparatus in which electro magnets are situated within the resistance bearing body. Fig. 4 is a diagram of a circuit applied to the apparatus shown in Fig. 3. Fig. 5 is an elevation, partly in section, showing a somewhat different form of the rheostat supporting member. Fig. 6 is a diagram of a circuit as applied to the apparatus shown in Fig. 5, and Fig. 7 is a central sectional plan through the apparatus shown in Fig. 5, illustrating in detail the formation of the resistance coil retaining members and the location of one of the channels for the conductive liquid.

In describing the apparatus shown in these figures, I shall use specific terms but it is to be understood that I do not wish to limit my invention to the use of any particular form of construction or any particular material for accomplishing the desired result, as any analogous form of construction or material might obviously be employed without departing from the spirit of my invention.

Referring now to Fig. 1, 10 indicates a containing vessel which may be of iron, for example provided if necessary on the outside with ribs for radiating whatever heat may be produced in the rheostat. This vessel contains a body of mercury 11 (or other suitable conductive liquid) and within the containing vessel 10, and dipping into the body of mercury 11 is a drum or other suitable body 12, which has wound in helical form around its periphery, the resistance coil 13. The drum 12 may be of iron and covered upon its periphery with a coating of enamel or other suitable substance to insulate from it the resistance coil 13; or this drum may be made of some non-conductive material to accomplish the same purpose. The drum 12 is mounted in any suitable manner upon the central shaft 14, which may also be prevented from turning by suitable means and may also be of iron; and the lower end of the shaft 14 rests in a well 15 formed in the bottom of the containing vessel 10. The bottom of the containing vessel 10 is provided, around the top of the well 15, with an annular recessed portion 16; and longitudinal grooves 17 may be formed in the walls of the well 15. The mercury can thus pass down into the well 15 and get below the lower end of the shaft 14 and thus serve as a cushion for the drum 12 upon its depression in the body of mercury 11 through the means hereinafter described. Of course other additional and equivalent cushioning devices might be employed at any other suitable place without departing from the spirit of my invention.

One terminal 18, in the resistance circuit, is secured upon the lower portion of the containing vessel 10 in constant contact with the body of mercury 11 and the current travels from said terminal through the mercury up to the lower portion of the resistance coil 13 which is dipping into the mercury. A layer of oil may be provided on top of the mercury to keep its surface clean and conduct the heat from the resistance coil to the containing vessel. Passing through the resistance coil, the current leaves the coil at a terminal 19 which is suitably positioned at the upper portion of the drum and insulated therefrom and passes through the flexible conductor 20, to the other terminal 21 of the circuit, which is secured in the upper portion of the containing vessel 10 and insulated therefrom by an insulation 22. It will thus be seen that by causing the drum 12, which bears the resistance coil 13, to sink further into the body of mercury 11, the mercury will rise about the sides of the drum 12 and gradually come in contact with more and more of the resistance coil 13 without any step by step action and thus reduce the resistance in the circuit in a perfectly gradual manner.

For the purpose of causing the drum carrying the resistance coil 13 to rise and fall in the body of mercury 11, and thus vary the amount of resistance in the circuit, I may use any suitable means, whether manually or automatically operated. I have shown, however, in this figure, a means for causing this rise and fall automatically without any attention from the operator. Secured upon the top of the containing vessel 10, is a cylindrical casting 23, which is provided with ear pieces 24, corresponding to ear pieces 25 on the vessel 10; and bolts 26 are passed through these ear pieces and secured in place by nuts 27, whereby the casting is firmly secured upon the vessel 10. The cylindrical casting 23 should be of iron, as it is to serve as a conductor of the magnetic flux of the electromagnets soon to be described. Said iron casting 23 has a central and somewhat tapering or conical core piece 28, which is centrally bored to admit a brass rod 29 to slide vertically through it. The brass rod 29 has its lower end threaded and is screwed into a correspondingly threaded recess in the upper end of the shaft 14 which carries the resistance bearing drum 12. The upper end of the brass rod 29 is threaded and has secured thereon a correspondingly threaded movable iron core piece 30, which is so formed as to be complementary to the core piece 28, referred to. The core piece 28 is made in the conical form referred to for the purpose of coöperating with the complementary core piece 30, which has a conical or tapering recessed portion, to produce a diminution of the gap between the two core pieces upon the lowering of the core piece 30, as will appear hereinafter. Surrounding the core piece 28, in the cylindrical casting 23, are two electromagnet coils 31 and 32, the inner coil 31 having its terminals in the binding posts 33 and 34, while the outer coil 32 has its terminals in the binding posts 35 and 36. These binding posts are mounted upon a cover plate 37 which is secured upon the casting 23 by screws 38. The said terminals are insulated from the cover plate 37 (which should be of iron) by insulation blocks 39 and 40. The purpose of having two electromagnets surround the core pieces 28 and 30 is to provide for a certain coöperation of them which is to economize in the expenditure of electrical energy necessary for causing a depression of the movable core piece 30, as will hereinafter appear from a description of the circuit by which this form of the device is best operated. It will readily be seen that by the depression of the movable core piece 30, under the influence of the electromagnets 31 and 32, a depression of the resistance bearing drum 12 is accomplished, and thereby the resistance in the circuit decreased as above referred to.

In Fig. 2, I have shown one form of the wiring which might be employed for automatically operating the apparatus, shown in Fig. 1. In this figure, 41 is the motor, 42 is the positive switch terminal of the line, and 43 the negative switch terminal. The current enters when the switch 42 and 43 is turned on, and passes along the positive wire 44, to the connection 45, from which one part of it passes through the flexible wire 20 into the resistance coil 13, through the mercury 11, and out by the terminal 18. There is a circuit parallel to the resistance coil, by which the other part of the current leaves the connection 45, and this comprises the conductor 46, the outer magnet coil 32, and the conductor 47, the latter being connected to the terminal 18, above referred to. The united current from there on, passes by the conductor 48 to the brush 49, through the motor 41, out by the brush 50, and returns by the negative conductor 51 to the negative switch terminal 43, already mentioned.

A shunt circuit is led off from the positive brush 49, which conveys a shunted current along the conductor 52, up to the inner magnet coil 31, out of the said coil by the conductor 53, and thence back to the negative brush 50, where it again joins the main current and returns with it by the conductor 51 to the negative switch terminal 43. In the operation of these circuits in the shunted coil 31 the current is very weak, when the motor is first started, owing to the fact that the brush tension of every direct current motor is the smallest at the start. Therefore, the inner magnet coil 31, which is fed by the shunt from the motor, receives very little current. On the other hand, the outer magnet coil 32, which is paralled to the resistance coil 13, and is fed by a portion of the main current, receives a comparatively large proportion of the current at the full tension, less the loss through armature resistance which exists between terminals 18 and 45 of the resistance coil at the start of the motor. Considerable energy is thus expended to operate the rheostat at the start. As the movable core 30 responds to the excitation of the magnet, it operates to depress the drum 12 and thus cause the mercury to gradually creep up the resistance coil and steadily decrease the resistance opposed to the main current. The effect of this is to allow more current to pass through the resistance coil 13. Thus enough current reaches the motor 41 to start it and as the armature tension increases with the number of revolutions, consequently the inner magnet 31, which is shunted through the armature 41, is more strongly excited; that is to say, the inner magnet has its excitation increased. As the motor revolutions increase more and more, due to the constant diminution of the resistance 13, the outer magnet 32 receives less and less excitation as the tension between terminals 18 and 45 will decrease at the same time and finally magnet 32 will be out of action when the resistance coil is short-circuited. The depression of the drum 12 is then maintained entirely by the magnetism of the inner magnet 31. Referring, now, for a moment to Fig. 1, it will be seen that, as the movable core 30 is lowered, the gap between the two core pieces 28 and 30, becomes smaller and smaller. As a result of this I am enabled to maintain the necessary depression of the drum 12 by a smaller magnet, because the two core pieces are then nearer together, and the lines of force exert a greater influence on the iron core pieces. Therefore, as I need now only very little current to generate the necessary magnetic force, I economize in the amount of electrical energy, which must be taken from the operation of the motor. In practice, the parts are all so proportioned that this operation is obtained with perfect regularity.

In Fig. 3, I have shown a form of the apparatus which is slightly modified from that shown in Fig. 1. In this form of apparatus, 59 indicates the vessel which contains the body of mercury 60 and is provided with a well 61, annular recess 62 at the top of the well and longitudinal grooves 63 in the interior walls of the well, in the same manner as the apparatus above described. A metallic drum 64 of somewhat modified form, carries a resistance coil 65 which is insulated from the drum by a coat of enamel. The drum itself may be made of insulating material and the layer of enamel done away with, if desired. This drum 64 is mounted upon a central iron shaft 66, the lower end of which operates in the well 61, which forms a cushion for it in the same manner as the well 15 described above. The said drum is open at the top, and a brace 67 secured to the shaft 66 and to the inner wall of the drum, serves to readily secure the drum upon said shaft. One terminal 68 of the circuit is secured near the bottom of the containing vessel 59 and is in constant contact with the body of mercury 60. Current passes up from the mercury into the resistance coil 65 and leaves the resistance coil by the flexible conductor 69 (shown broken away) which passes through the upper portion of the vessel 59 in an insulating sleeve 70. The flexible conductor 69 is in electrical contact with a terminal 71 which is secured upon the upper portion of the iron vessel 59 and is insulated therefrom by an insulation block 72, secured to the vessel by screws 73. An iron cover plate 74 is secured upon the top of the vessel 59 by means of bolts 75, and depending from this cover plate 74, within the open upper end of the drum 65, is a basket 76, preferably of brass, which has slotted walls and a central recess in which is held a hollow, tapering, iron core piece 77. The basket 76 is secured to the cover plate 74 by screws 78 which pass through the flange 79 at the upper portion of said basket; and the iron core piece 77 is secured to the bottom of the basket 76 by screws 80 which pass through a peripheral flange on the said core piece. The upper end of the drum supporting shaft 66 is enlarged and fits loosely within the enlarged lower end of the hollow core piece 77. A brass rod 82 passes loosely through the hollow core piece 77 and may slide perpendicularly therein. This brass rod has its lower end threaded and screwed into a threaded portion of the enlarged upper end of the shaft 66, and secured upon the upper end of said brass rod 82, by a threaded portion thereof, is movable iron core piece 83, which is complementary to the above mentioned tapering core piece 77. A nut 84 is secured upon the outer end of the brass rod 82. Seated in the basket 76 are two magnet coils, the inner of which is shown at 85 and the outer of which is shown at 86. The inner magnet coil 85 has its terminals at binding posts 87 and 88 respectively, and the outer magnet coil 86 has its terminals at binding posts 89 and 90, respectively. The terminals 87 and 89 are secured upon the cover plate 74 and insulated therefrom by an insulation block 91; and the terminals 88 and 90 are secured upon said cover plate and insulated therefrom by an insulation block 92. Upon the excitation of these magnets, the movable iron core piece 83 is depressed, and through its supporting rod 82, it depresses the shaft 66 which carries the drum 64, thereby causing the mercury to rise and gradually short circuit the resistance coil in the same manner as already described with reference to the apparatus shown in Fig. 1.

In Fig. 4, I have shown the circuit which may serve to operate the rheostat shown in Fig. 3 automatically as a motor starter. 93 is the positive terminal and 94 the negative terminal of the switch from the main, and when the switch is turned on current enters through the positive terminal 93 and passes along the positive wire 95 to the connection 96. From the connection 96 one circuit leads through the wire 97 to the resistance coil 65, through the body of mercury 60 and out by the terminal 68. The other circuit which is in parallel with the resistance coil leads by the wire 98 to the outer coil 86 from which the current passes by the conductor 99, down to the terminal 68 where its current unites with the current from the resistance coil and the united currents together pass down the conductor 100 to the positive brush 101 of the motor. The current passes from the brush 101 through the motor out through the brush 102 and back by negative wire 103 to the negative switch terminal 94 above mentioned. A shunt leaves the positive brush 101 by the conductor 104, enters the inner magnet coil 85, leaves the inner magnet coil by a conductor 105 and returns to the primary circuit at brush 102, from which point it passes by the wire 103 with the main current from the motor back to the negative switch terminal 94. The operation of the circuit in this case is in every way similar to that described with reference to the circuit shown in Fig. 2, and therefore need not be here repeated. One point may be mentioned in regard to the magnetic flux in which the Figs. 1 and 3 are different from each other and which is caused through the different arrangement of the magnet coils. While in Fig. 1 the magnetic flux passed from the movable core 30 through cover 37 thence through the cylindrical casting 23 to core 28 back to core 30 the flux in Fig. 3 passes from core 83 through cover 74 thence through the vessel 59 over to the iron shaft 66 over to core 77 and through the gaps back to core 83. In the latter case I am enabled to use at the same time the resistance coil 65 besides magnet coil 86 for excitation, thus lessening considerably the ampere turns of coil 86.

In both forms of the apparatus already described, the resistance bearing drum or cylinder has been caused to move by the electromagnet depressing the movable core piece. The rise and fall of the mercury or other conductive liquid in the retaining vessel has thus been caused by the depression or elevation of the drum. In such forms not only does the conductive liquid rise around the resistance coil but at the same time the resistance coil is lowered, and therefore greater relative movement between the resistance coil and the conductive liquid is accomplished, than if the resistance coil were maintained in a stationary position, and the relative movement between it and the conductive liquid produced entirely by the movement of the conductive liquid. There are, however, numerous ways in addition to these, for obtaining a considerable rise or fall of the conductive liquid by relatively smaller movements of the body causing such rise or fall. One other way (for example) by which this may be accomplished will be seen from the description of the apparatus illustrated in Fig. 5.

In Fig. 5, I have shown, partly in section, a form of the apparatus in which the separate containing vessel for holding the conductive liquid is done away with and the body which supports the resistance coil serves the purpose.

The apparatus shown in Fig. 5 may also serve as an illustration of one method of securing the resistance coil upon its supporting body in such a manner that the adjacent turns of the coil are effectually prevented from contacting with each other and causing short circuiting. This form of the apparatus is also designed to decrease the necessary quantity of the conductive liquid rising and falling about the resistance coil for varying the resistance.

Referring now specifically to Fig. 5, 110 designates a supporting base of suitable material upon which is resting the resistance bearing body 111 preferably of porcelain, china, plaster, or some other similar nonconductive material. This resistance bearing body 111 is provided with a central longitudinal, hollow or well 112, and between the periphery of the body and the central well 112, are hollow portions 113, which decrease the weight. At suitable intervals in the periphery of the body 111, are a number of longitudinal channels 114 (see Fig. 7), and at the sides of these channels the periphery of the body is extended radially to form longitudinal ribs 115. These longitudinal ribs 115 are recessed approximately horizontally at short intervals in such a manner that the resistance coil 116 may be wound about the periphery of the body 111 and fit into them, so that the adjacent turns of the resistance are thus separated from each other. This construction is plainly shown in Fig. 5. The horizontal slots in the longitudinal ribs 115 are then filled in around the wire with a suitable plastic material 117, as shown in Fig. 5, and an insulating cover 118 secured upon the outer edges of the ridges so that there is thus formed between the two ridges a channel which is in communication at the bottom by suitable passages with the central well 112, which contains the body of mercury or other conductive liquid 119, and in this channel the mercury can rise and short circuit the turns of the resistance coil which cross the channel at intervals. Thus the short circuiting of the resistance coil by the rise of the conductive liquid takes place.

The insulating cover plate 118 may be secured and tightened upon the ribs 115 in any suitable manner but I have shown it as being secured thereto by passing screws 120 through the same at suitable intervals and fastening them in receiving sockets 121 which are embedded in the body 111.

Mounted upon the top of the body 111 is an iron casting 122 having a hollow central core piece 123. The core piece 123 has passed loosely through it, a brass rod 124, which has secured upon its upper end by nuts 125, a movable iron core-piece 126, which is complementary to the above mentioned hollow core-piece 123. The hollow core piece 123 is tapering or conical in form, and the cavity in the movable core-piece 126 has tapering walls to correspond with it so that upon depression of the latter core-piece the gap between the two core-pieces is diminished, for the purposes already described with reference to the apparatus shown in Fig. 1. The lower end of the brass rod 124 terminates in a clevis 127, the bolt of which passes through a screw-eye 128, which is screwed into a frame 129. A plunger 130 is suspended from the frame 129 by riveted connection, and dips into the mercury at the bottom of the well 112. Movement of the core-piece 126 therefore operates the plunger 130 and causes a rise or fall of the mercury in the longitudinal channels 114 in the periphery of the body 111. This movement of the core-piece 126 may be accomplished by two electro-magnet coils, one of which is shown at 131 and the other of which is shown at 132.

The terminal of the magnet coil 131 may be at the binding posts 133 and 134 respectively, and the terminals of the magnet coil 132 may be at binding posts 135 and 136 respectively. The binding posts 133 and 135 are secured upon the outer wall of the casting 122 in any well known manner, and insulated therefrom by insulation block 137. The terminals 134 and 136 are similarly mounted upon and insulated from the casting 122 by insulation blocks 138. An iron cover plate 139 may be fastened upon the casting 122 over the magnet coils by screws 140. For the purpose of securing all parts of the apparatus rigidly together, securing bolts or rods 141 may be passed through ear pieces or lugs 142 and 143 of the base 110 and casting 122 respectively, and the two latter parts drawn tightly toward each other and clamping between them the body 111, by tightening the nuts 144. The conductor 145 is connected with the terminal 146 which is in constant contact with the mercury or other conductive liquid at the bottom of the well 112, and thus serves as one side of the circuit leading to or from the resistance coil. The current thus passes through the mercury, through channels 114 into the resistance coil, leaves the resistance coil by a conductor 147 which is secured in a binding post 148, to which latter the other side of the circuit leading to or from the resistance coil may be attached. In the operation of this form of the apparatus, the mercury rises simultaneously in all of the longitudinal channels 114 short circuiting the resistance coil first in one channel, then in the next, and so on around the coil section by section according to the number of the channels 114. While this manner of operation is, to be sure, a step by step short circuiting of the coil, nevertheless the section of the coil which is cut out step by step in each successive channel in this manner is so very small and the change in resistance as each section is cut out is so slight that the short circuiting in my improved rheostat as compared with that in other rheostats is gradual.

In Fig. 6 I have shown diagrammatically a circuit by which this form of apparatus may be made to automatically operate as a motor starter. The positive and negative switch terminals are shown at 150 and 151 respectively. When the switch is turned on, the current passes along the wire 152 to the connection 153. At 153 the current branches and passes through parallel circuits, one going by wire 147 through the resistance coil 116 out by the terminal 146 and the conductor 145 to the connection 154. The other parallel circuit comprises the conductor 155, outer magnet coil 132, and conductor 156, which latter leads the current back to the connection 154, where the two currents are united and from which the united current travels by the conductor 157 to the positive motor brush 158. From the positive brush the current passes through the motor out by the negative brush 159 and returns by conductor 160 to the negative switch terminal 151. Leading from the positive brush 158 a shunt circuit carries a portion of the current by a conductor 161 to the inner magnet coil 131 and back by the conductor 162 to the brush 159. The operation of the circuit in this form is exactly the same as that already described in the other examples, that is, the magnet coil, which is in parallel with the main circuit at first gets much more current than the magnet coil which is in shunt with the motor, but as the resistance coil becomes shortened more current passes through it and the magnet coil 132 which is in parallel with it receives proportionately less current. When the motor is running at full speed the shunt magnet is doing all of the work in keeping the movable core-piece depressed and thus keeping the resistance coil short circuited.

While in the forms illustrated a depression of the drum or other body is accomplished by the excitation of electro-magnets, I do not wish to limit my invention to this construction only. The raising and lowering of the drum or other body may be accomplished by a special motor which would operate through suitable mechanism to raise or lower the drum when the current is turned on or off. Besides the above arrangement, one can also modify the device by making the drum or other plunger so heavy that it sinks of its own weight into the liquid. In that case a special switch device is necessary for the automatic operation of the rheostat. The operation in this case, might be about as follows. A magnet with comparatively great resistance is at first employed for raising the drum or plunger out of the liquid before the motor is switched in. This takes place by the turning on of the main switch. When the drum or plunger has thereby reached the highest point, a rod secured on the plunger shaft strikes against a lever which closes this special switch above-mentioned. By this special switch, the circuit through the starting resistance and the motor, is then closed. A small auxiliary electromagnet holds the lever which operates the special switch, closed as long as the motor current remains switched in. With increasing speed of the motor, the tension in the starter falls and likewise in the main magnet coil which lies in parallel to the starter and therewith the drawing power of the magnet. Thus the drum or plunger sinks gradually again into the liquid and the resistance decreases until it is finally short circuited as the motor reaches full speed. When the motor is cut out, then the auxiliary electromagnet becomes also deënergized and a spring draws away the lever for operating the special switch and thereby sets the apparatus for a new operation.

In the forms shown, the plunger has been centrally located and the conducting liquid has been caused to rise at the periphery. The same result can, however, be accomplished by having the plunger operate around the periphery and the rise in the conducting liquid takes place in a central channel or well in which the resistance may be located.

In the use of my rheostat with alternating currents, it is of course necessary to laminate the iron parts which are subject to heating.

It is obvious that the rheostat might be put in circuit with the field coil of a motor or other machine, instead of in circuit with the armature as herein shown.

The dipping of the resistance medium into the conductive liquid may take place by having the resistance medium at first out of contact with the conductive liquid and then moved into the liquid as it dips. Such an arrangement would serve especially well in the operation with a shunt wound motor. Furthermore, some fluid other than a liquid might be used instead of the conductive liquid, without departing from the spirit of my invention.

Claims.

1. In a motor starting device, the combination with a motor, and a rheostat having a resistance medium in series with the motor armature; of an electromagnet adapted to vary the active amount of said resistance medium and having a coil in series with the motor armature and a coil connected directly at the motor brushes in shunt with the motor armature.

2. In a motor starting device, the combination with a motor and a rheostat having a resistance medium in series with the motor armature; of an electromagnet adapted to vary the active amount of said resistance medium and having one coil in series with the motor armature and in shunt to the resistance medium and another coil in shunt to the motor armature.

3. In a motor starting device, the combination with a motor and a rheostat having a resistance medium in series with the motor armature, and a vessel containing conductive liquid in said circuit adapted by its movement to vary the active amount of said resistance medium, of an electromagnet having a coil in series with the motor armature and a coil connected directly at the motor brushes in shunt to the motor armature, and means whereby the electromagnet causes the movement of said conductive liquid.

4. In a motor starting device, the combination with a motor and a rheostat having a resistance medium in series with the motor armature and a vessel containing conductive liquid in said circuit adapted by its move-

ment to vary the active amount of said resistance medium, of an electromagnet having a coil in series with the motor armature and in shunt to the resistance medium and a coil in shunt to the motor armature and means whereby the electromagnet causes the movement of said conductive liquid.

5. In a motor starting device, the combination with a motor and a rheostat having a resistance coil in series with the motor armature and a vessel containing mercury in its circuit adapted by its movement to vary the active length of said resistance coil, of an electromagnet having a coil in series with the motor armature and a coil connected directly at the motor brushes in shunt to the motor armature and means whereby the electromagnet causes the movement of said mercury.

6. In a motor starting device, the combination with a motor and a rheostat having a resistance coil in series with the motor armature and a vessel containing mercury in said circuit adapted by its movement to vary the active length of said resistance coil, of an electromagnet having a coil in series with the motor armature and in shunt to the resistance coil and a coil in shunt to the motor armature and means whereby the electromagnet causes the movement of said mercury.

7. In a motor starting device, the combination with a motor and a rheostat having a vessel containing conductive liquid in the motor circuit, a drum dipping into said conductive liquid and a resistance coil thereon, of an electromagnet moving said drum in said conductive liquid and having a coil in series with the motor armature and in shunt with the resistance medium and a coil in shunt to the motor armature.

8. A rheostat comprising in combination a vessel containing conductive liquid, a shaft within said vessel, a resistance bearing drum fixed on said shaft and dipping into the conductive liquid, a guide for one end of said shaft in the bottom of said vessel, an electromagnet mounted upon said vessel and having a stationary core-piece forming a guide for the other end of said shaft, and a movable core-piece fixed on the upper end of said shaft.

9. A rheostat comprising in combination a vessel containing conductive liquid, a shaft within said vessel a resistance bearing drum fixed on said shaft, and dipping into the conductive liquid, a guide and cushioning device for one end of said shaft formed in the bottom of said vessel, an electromagnet mounted upon said vessel and having a stationary core-piece forming a guide for the other end of said shaft and a movable core-piece fixed on the upper end of said shaft.

10. A rheostat comprising in combination a vessel containing conductive liquid, a guide in the bottom thereof, an electromagnet mounted upon the top of said vessel and having a hollowed stationary core-piece, a shaft having one end resting in said guide and the other end passing loosely through the hollowed portion of said stationary core-piece, a drum on said shaft bearing a resistance medium and adapted by reciprocation of said shaft to displace a variable amount of conductive liquid, and a movable core-piece for said electromagnet fixed on the upper end of said shaft and adapted to reciprocate said shaft when said electromagnet becomes energized.

11. A rheostat comprising in combination a vessel containing conductive liquid, a guide and cushioning device formed in the bottom thereof, an electromagnet mounted upon the top of said vessel and having a hollowed stationary core piece, a shaft having one end resting in said guide and cushioning device and the other end passing loosely through the hollowed portion of said stationary core-piece, a drum bearing a resistance medium and adapted by reciprocation of said shaft to displace a variable amount of conductive liquid, and a movable core-piece for said electromagnet fixed on the upper end of said shaft and adapted to reciprocate said shaft when said electromagnet becomes energized.

12. A rheostat comprising in combination a vessel containing conductive liquid, a shaft within said vessel, a resistance bearing drum fixed on said shaft and adapted by reciprocation of said shaft to displace a variable amount of said conductive liquid, a guide for one end of said shaft in the bottom of said vessel, an electromagnet mounted upon the top of said vessel, and having a centrally perforated and tapering stationary core-piece forming a guide for the other end of said shaft, and a movable core-piece fixed on the upper end of said shaft and having a recessed portion corresponding to the tapering of the stationary core-piece.

13. A rheostat comprising in combination a vessel containing conductive liquid, a shaft within said vessel, a resistance bearing drum fixed on said shaft and adapted by reciprocation of said shaft to displace a variable amount of said conductive liquid, a guide and cushioning device for one end of said shaft in the bottom of said vessel and an electromagnet having a centrally perforated and tapering stationary core-piece forming a guide for the other end of said shaft, and a movable core-piece fixed on the upper end of said shaft and having a recessed portion corresponding to the tapering of the stationary core-piece.

14. In a motor starting device, the combination of a vessel containing mercury in the motor circuit, a shaft within said vessel, a resistance bearing drum fixed on said shaft

and dipping into the mercury, a guide for one end of said shaft in the bottom of said vessel; an electromagnet upon said vessel having a coil in series with the motor armature and in shunt to the resistance medium and a coil in shunt to the motor armature and having a stationary core-piece forming a guide for the other end of said shaft and a movable core-piece fixed on the upper end of said shaft.

HEINRICH POTH.

Witnesses:

WM. G. DECKER,

WILLIAM HEINMUELLER.