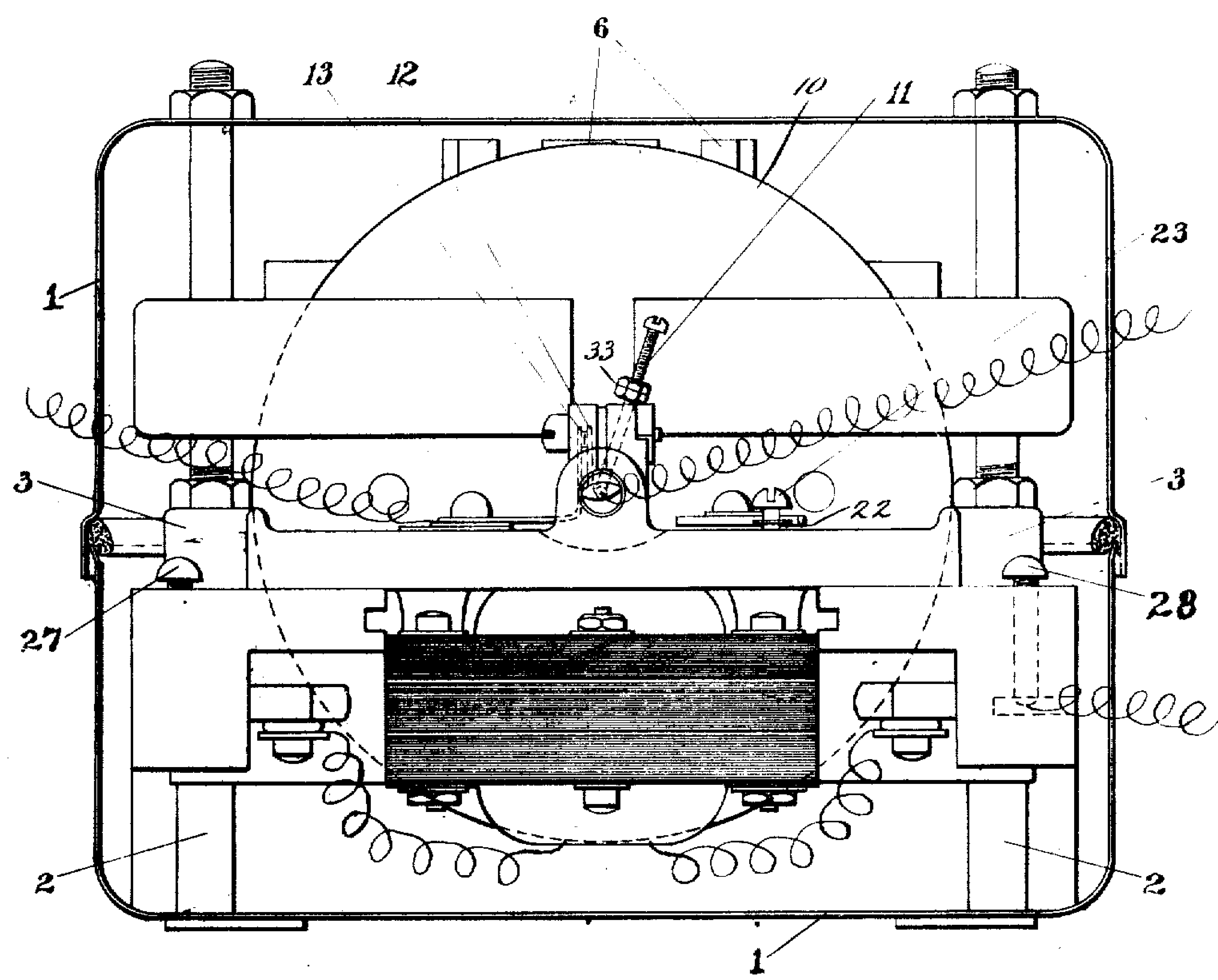
P. O. KEILHOLTZ & F. E. RICKETTS.
OVERLOAD AND REVERSE CURRENT RELAY.
APPLICATION FILED AUG. 5, 1908.

944,040. Patented Dec. 21, 1909.

4 SHEETS—SHEET 1.

Fig. 1



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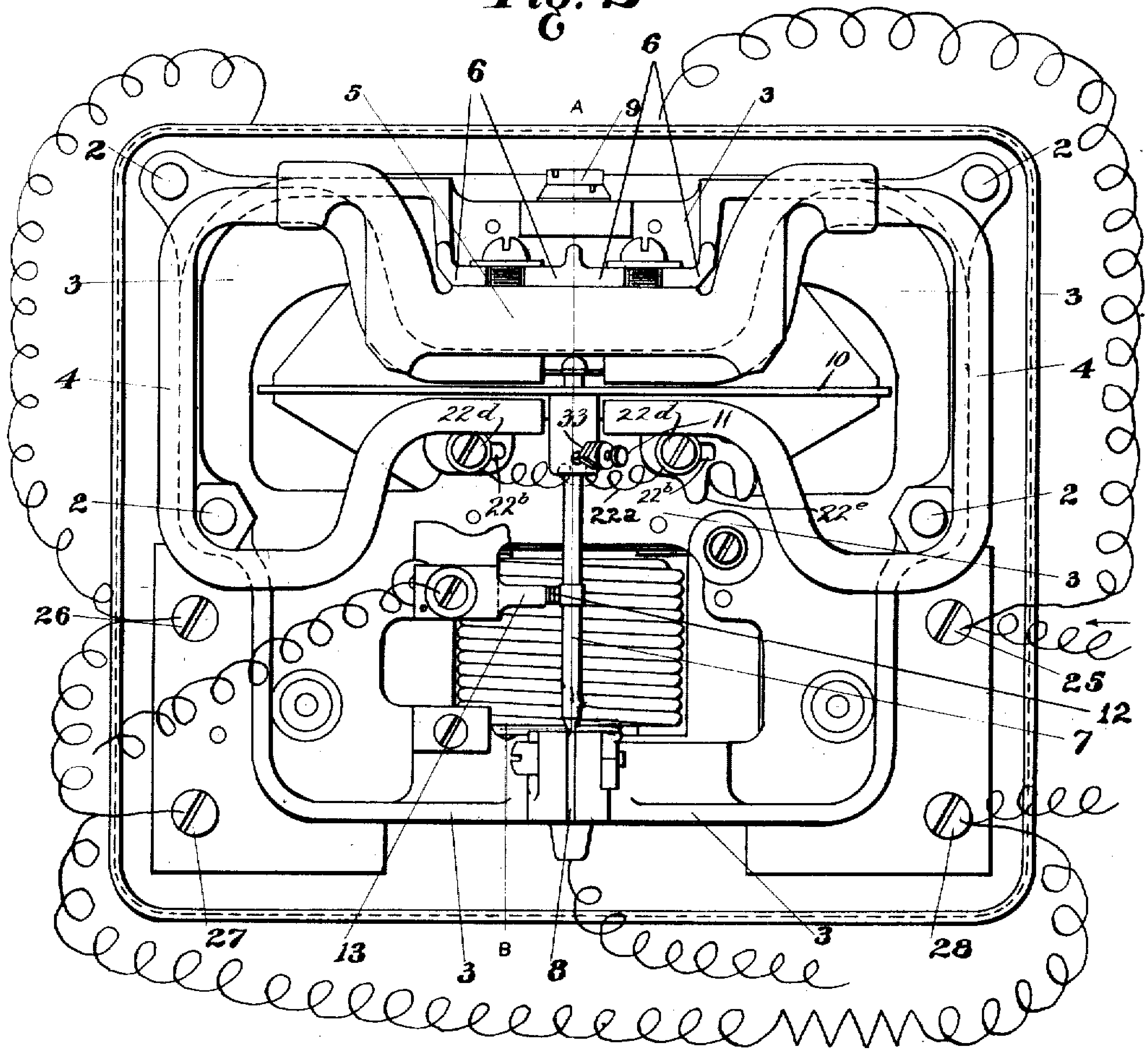
4 SHEETS—SHEET 2.

Fig. 2



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4 SHEETS—SHEET 3.

Fig. 3

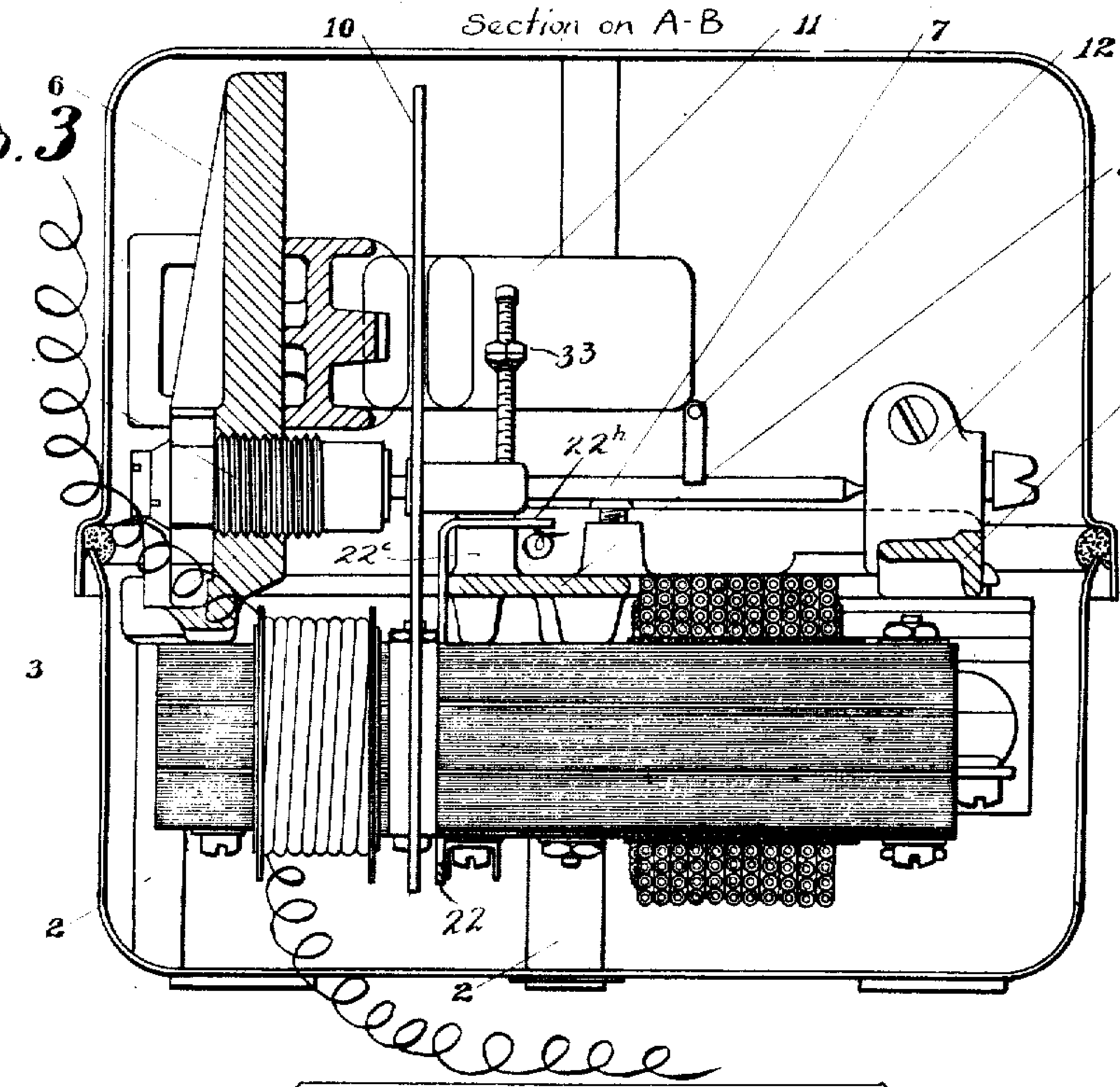
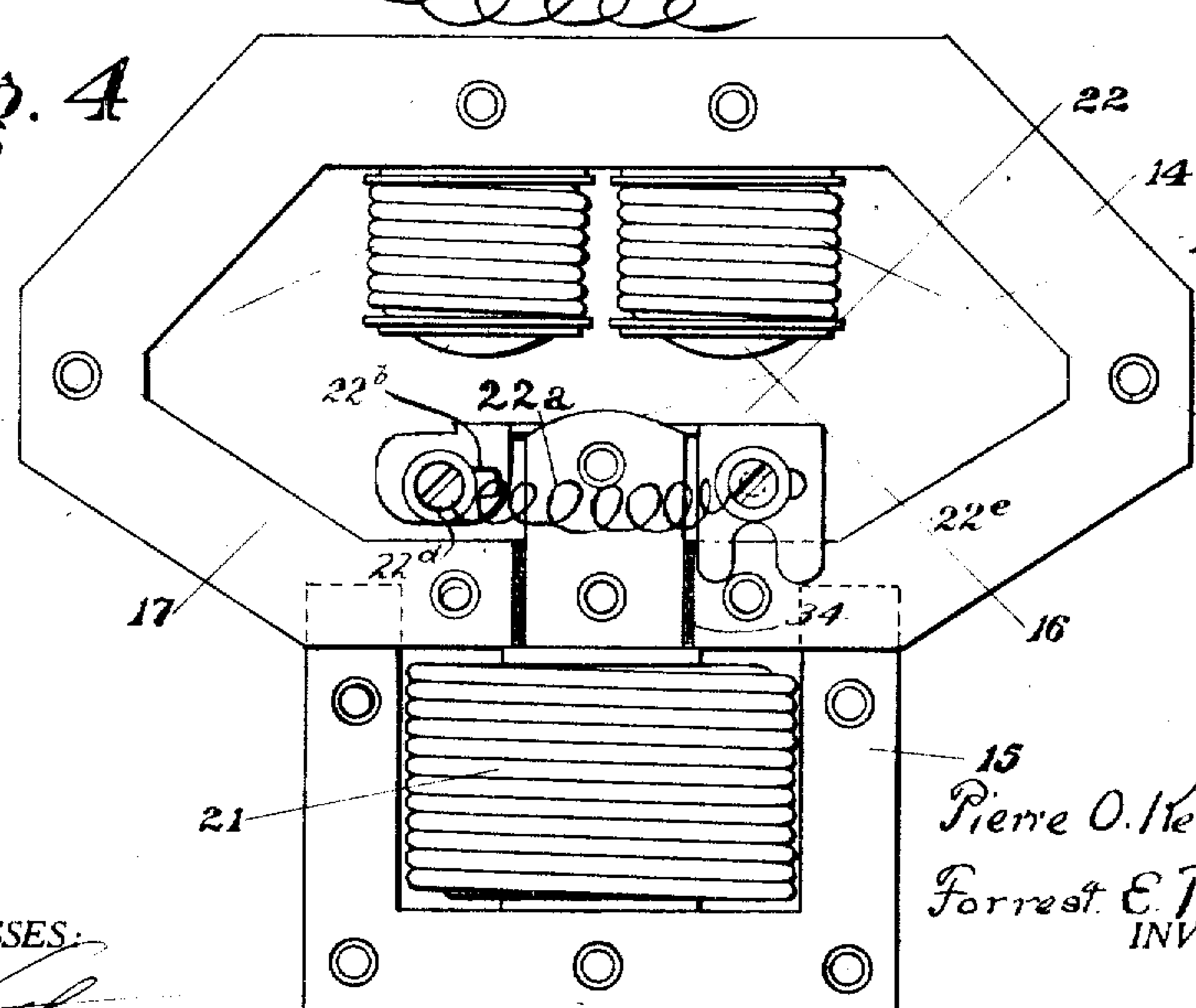


Fig. 4



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4 SHEETS—SHEET 4.

Fig. 5

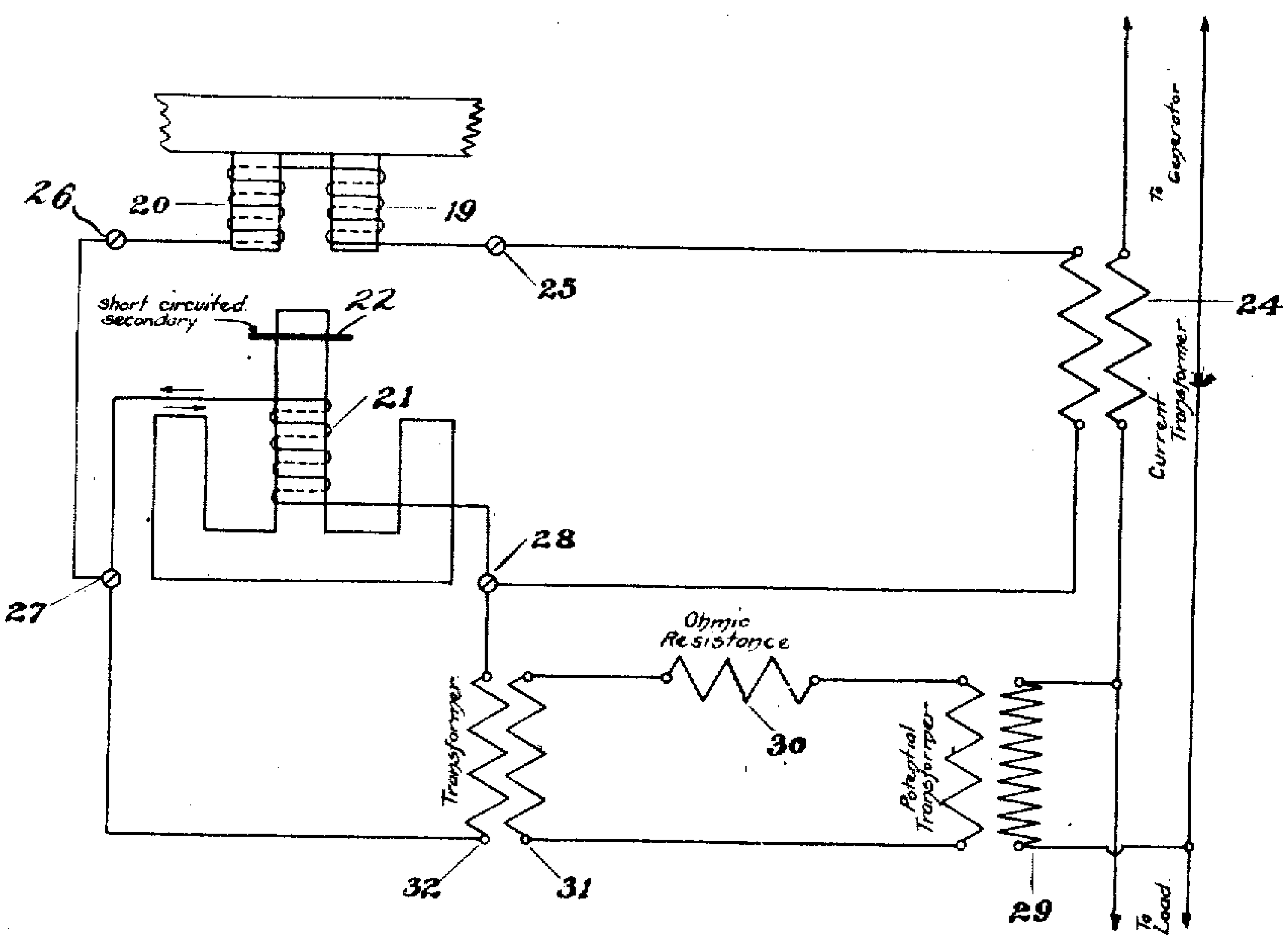
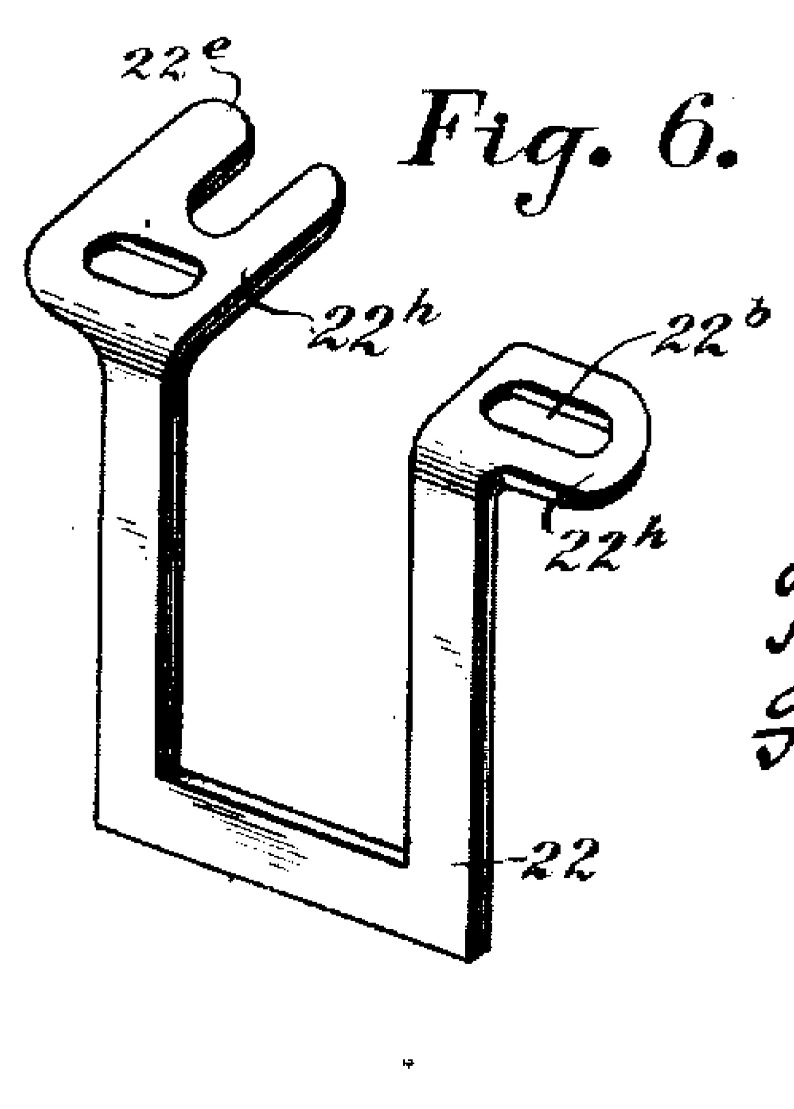


Fig. 6.



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UNITED STATES PATENT OFFICE.

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OVERLOAD AND REVERSE CURRENT RELAY.

944,040. Specification of Letters Patent. **Patented Dec. 21, 1909.**

Application filed August 5, 1908. Serial No. 447,082.

To all whom it may concern:

Be it known that we, Pierre O. Keilholtz and Forrest E. Ricketts, citizens of the United States of America, residing at the city of Baltimore, State of Maryland, and at Derwood, county of Montgomery, State of Maryland, respectively, have invented certain new and useful Improvements in Overload and Reverse Current Relays, of which the following is a specification.

Our invention relates to an overload and reverse current relay which is designed to afford protection to electrical apparatus included in a circuit. It is designed primarily to operate in an alternating circuit. By protection is meant the interruption or opening of the circuit when the electrical conditions upon the line become abnormal, such as the increase of current beyond a predetermined amount or the reversal of the direction of the current. The device is not intended to open or interrupt the circuit, but it is designed to set in action suitable auxiliary devices which will cause such opening or interruption by proper switches.

Referring to the drawings,—Figure 1 is a vertical elevation of our relay assembled and in operative position. Fig. 2 is a plan view of the same. Fig. 3 is a vertical section upon the line A—B Fig. 2. Fig. 4 is a plan view of the magnets and laminated frame upon which the magnets are supported. Fig. 5 is a diagrammatic view of the wiring. Fig. 6 is a perspective view of the short-circuiting secondary.

Referring to the drawings,—1 is a casing designed to contain the device, divided into two parts, a lower part in which the apparatus is located, and a cover. These two parts are provided with a cushion seat at their contacting edges to secure a dust-proof joint.

2—2—2 are 4 legs upon which the apparatus rests within the case. These legs are made integral with the case and the device is screwed down to them.

3—3 is a frame made integral, of any suitable material, and secured to the legs 2—2.

4—4 are a pair of permanent magnets, bent as shown in Fig. 2, and located with the ends of their poles opposite each other.

5 is a yoke secured to one of the magnets at each end and adapted to be secured to the posts 6—6 of the bed 3. The posts 6—6 are integral with the bed 3 and are located in the position shown in Fig. 2. The slots between the posts serve to permit screws attached to the yoke 5 to pass and to allow for vertical adjustment of the yoke.

7 is a horizontal shaft mounted at its ends in jewel bearings, one end in the stationary bearing 8, and one end in the movable bearing 9. The movable bearing consists of a screw threaded into a hole in the base of the center one of the three posts marked 6, and provided with a lock nut for securing it in an adjusted position.

10 is a disk made preferably of aluminum, so as to be light, and secured to the shaft 7.

11 is a screw inserted in the hub of the disk 10, and provided with a pair of nuts which may be moved back and forward upon the screw. This screw and its nuts constitute what will be called the overbalance device of the disk, and the nuts are adjustable so as to change the amount of weight necessary to overbalance the disk.

12 is a contact device secured to the shaft 7, and adapted to contact with another contact point 13, which is secured to the bed 3, and in circuit with a switch-operating mechanism for controlling the line. The shaft 7 is also in circuit with a source of current. The contact device 12 is located close to the axis of the shaft, that is to say, it has a very short radius so as to permit the contact points to be pressed together with the greatest degree of force with any given amount of power exerted upon the disk to cause its rotation. These parts are all mounted above the bed 3. Below the bed and secured to it upon the under side are two laminated iron frames 14 and 15, made of numerous sheets of the same shape, which are superimposed and bolted together. The frame 14 is provided with two pole pieces, 16 and 17, and the frame 15 is provided with one pole piece 18. Upon the pole pieces 16 and 17 are wound in series two coils, 19 and 20, and on the pole piece 18 is wound a coil 21. The coil 21 is in series with the coils 19 and 20. The system of electro magnet is centrally arranged as to their poles, and the single electro magnet has its magnetic circuit insulated at the points 34 by non-magnetic conducting material such as brass from the twin electro magnets. The object for so doing is to prevent the lines of magnetic force from passing from the structure 15 to the pole of the single magnet 18.

Surrounding the pole piece 18 of the electro magnet 21 is a single turn of non-magnetic material 22, having a low resistance, such as copper. This piece of non-magnetic material 22 consists of a plate of copper or brass, or other material having similar properties, in the form of a U, the loop of the U being preferably rectangular and of suitable size to receive the end of the single magnet 18. The U-shaped plate has upon its upper end two flanges 22^h turned at right angles to the plate. The plate 22 stands vertical, opposite the pole piece 18, and in line with the face of the pole piece, the end of the pole piece projecting through the loop of the U. The plate is supported by the horizontal flanges 22^h upon its ends upon bosses 22^c which are integral with the frame 3. 22^b are slots in the horizontal flanges 22^h parallel to the vertical portion of the plate and to the plane of the rotor. 22^d are screws by which the plate is secured to the bosses 22^c. 22^e is a fork on one end of one of the horizontal portions of the plate adapted to receive any suitable adjusting means. This adjustment, however, may be made by hand and the latter has not been illustrated because it is merely a means of effecting final adjustment. The plate 22, through its slots 22^b, is susceptible of transverse adjustment relative to the pole piece 18 and the single magnet, and it may thus cut off some of the lines of force of this magnet and centralize the magnet in relation to the fields of the two opposite magnets 16 and 17. Forming a part of the circuit of this non-magnetic material having low resistance is an adjustable resistance 22^a provided with a loop of German silver wire which may be lengthened or shortened so as to vary the resistance. The object of this adjustment is to adjust the impedance of the single coil electro magnet 21 by varying the ohmic component of its impedance. The reactive component of its impedance may be varied by moving the non-magnetic short-circuiting secondary relatively to the primary coil. The short-circuited secondary 22 and 22^a, around the pole piece 18, is to cause the magnetism of the pole piece 18 to lag behind that of 16 and 17 which produces a shifting field. The reaction of this shifting field produces rotation of the rotor. The disk 10 stands vertically between the poles of the twin magnets 19 and 20, and the single pole of the magnet 21, and rotates between them. The overbalance pin 11 is so located in the hub of the disk as to lie normally when the apparatus is not in use upon the stop 23, from which it is raised when torque is given to the disk. As it rises, the resistance to the torque diminishes, because the resistance is maximum when the pin is in a horizontal position and zero when it is vertical. The contacts 12 and 13 are so located that they will come together before the pin 11 reaches the vertical, and consequently the pin will always retain its power to return the disk to its primary position and open the contact. When the overbalancing weight has been raised far enough to permit contact the minimum of resistance of the moving element becomes the moment of the contact and the full torque of the moving element is exerted in making the contact. After the contact is made the devices in the auxiliary circuit, not shown, together with the switch controlling the circuit, perform their proper functions, and the moving element rotates in a backward direction to its first position and is in readiness to operate again.

Referring to Fig. 5, the two lines on the right of the figure represent the main feeders of a circuit.

24 is a current transformer located in the main circuit and having its secondary in the circuit of the magnets 19 and 20 and 21. The binding post 25 is found also upon Fig. 2, and from that binding post a circuit passes through the magnet 19, thence to magnet 20, thence to binding post 26, thence to binding post 27, from which one wire passes to the coil of magnet 21 and thence to binding post 28 and thence back to the secondary of the current transformer.

29 is a potential transformer bridged across the main line, the secondary of which is in a closed circuit in which is located an ohmic resistance device 30 and a second transformer 31.

32 is the secondary coil of the second transformer located in a tertiary circuit which is connected between the posts 27 and 28. The transformer 29 reduces the voltage to a desired amount. The resistance device 30 is capable of adjustment to greatly reduce the flow of current and to secure proper phase relation between current and voltage, and the transformer 31 and 32 will still further transform the current and produce in the circuit 27, 28, 32 a regulated quantity of current of small magnitude.

It will be observed that if just sufficient torque is supplied to raise the adjustable weight from its stop the disk will rotate very slowly at first but increase its rotation as its moment of resistance becomes less, that is, as its adjustable weight approaches the vertical; and if greater torque is supplied, its rate of rotation will be correspondingly increased. This is what is known as the principle of inverse time element. The time of the operation of the disk is also controlled by the action of the permanent magnets 4—4, between the poles of which the disk rotates, and by which its rotation is retarded. The rotating disk with its shaft, overbalance weight and contact device, are the only moving parts of the apparatus, and are so designed as to reduce their weight to a minimum in order that their friction may be small. The torque of the moving element is supplied by the magnetic field of the system of electro magnets which are shown.

The windings of the twin magnets are connected in series, and if an alternating electric current is made to flow through them, the polarity of their poles will have the same cyclic variation as the current, that is to say, the lefthand one will have, say, a north polarity, and the righthand one a south polarity; and their polarities will rapidly alternate. A similar current passing through the single coil magnet will also cause its pole to rapidly change its polarity. If now the circuit containing the twin electro magnets be connected in series with the single coil magnet and an alternating current be passed through them, the polarity of the poles will have a definite relation, that is to say, if the lefthand pole of the twin magnet is north and the righthand one south, the single coil magnet will be north. If now reversal takes place, the poles of the twin magnets will be south-north and the single coil magnet will be south. If now the connection of the single coil magnets be reversed, the polarity of the single coil magnet will be like the righthand pole instead of the lefthand pole as before. If a disk free to rotate is placed in such a magnetic field, it will rotate in a definite direction, which direction can be readily reversed by changing the polarity of the single coil magnet relatively to the others. Furthermore, if the single coil magnet is energized and the twin magnets are not energized, the disk will not rotate, and vice versa. By energizing is meant causing a current of electricity to flow through the windings. The magnetic effects above described are secured by a system of transformers, resistances, re-actances and connections as shown in Fig. 5.

The operation of the device may be described as follows: Assume potential on the circuit, but no power delivered from the generator to the load. Current will flow in the secondary circuit of the potential transformer 29 in a definite amount. In the tertiary circuit 27, 28, 32 the current will flow through the coil of the single coil magnet and not through the coils of the twin magnets, owing to the high reactance of the current transformer. Consequently only the single coil magnet will be energized and the disk will not operate. Let us call this current flowing from left to right. If, now, the generator is caused to deliver power to the line, current will flow in the main circuit and a definite amount will flow in the secondary of the current transformer. Call this current flowing from right to left. The coils of the twin magnets will be energized and the current in the coil of the single magnet will be decreased by the amount of current flowing in the coils of the twin magnets. The field produced by these currents will tend to rotate the disk in the direction of the hands of a clock, which rotation is prevented by a stop as before mentioned (Fig. 1). As the generator delivers more power to the line, more current will flow through the coils of the twin magnets and less will flow through the coil of the single coil magnet. We will assume that sufficient current will be delivered from the current transformer to balance the current from the potential transformer flowing in the coil of the single coil magnet. In this case the magnet is not energized and the disk will not rotate. To this point the disk has had a decreasing torque from a maximum, tending to rotate the disk in a direction, which is prevented by its stop, to zero torque, with no tendency to rotate. As the generator delivers more power to the line, more current will flow in the secondary of the current transformer until the direction of flow through the coil of the single coil magnet will be from right to left and a torque will be supplied to the disk to rotate it forward, depending upon the amount of its unbalancing. If the current supplied is sufficient to give enough torque to overcome the moment of resistance of the disk, it will rotate in a direction opposite to that of the hands of a clock. This result will be produced by an overload of current without diminution of potential. If the potential diminishes, the current balance is disturbed and the relay will operate with less current from the line. This constitutes the overload operation with loss of potential. By suitable adjustment of reactances of the coils 21 and 32 the relative rate of rotation of the disk can be controlled. It is observed that the coils of the single coil magnet and the secondary of the second transformer form a multiple connection and currents will divide between the two branches in proportion to their relative conductances. The short-circuited secondary 22^a affords means of varying the reactive and ohmic components of the single coil magnet and thereby alters its conductance, and changes the relative flow of current in this divided circuit. The reactive component is altered by changing the relative position of the short circuited secondary 22^a to the single coil, and the ohmic component is changed by varying the resistance of the short circuited secondary. If the potential remain constant and the current diminishes, becoming zero, which is the first case cited, the relay will not operate at all. If, however, the current should change its direction, as would occur if the apparatus ceased to deliver but received power, or the reverse, the relay will operate with less current from the current transformer. This constitutes the reverse current operation with potential. If, under these circumstances, the potential should diminish, more current would be required from the current transformer than with full potential to cause the relay to operate. This would constitute the reverse current operation with loss of potential. It will thus be seen that our apparatus is designed to protect electrical apparatus against all those accidents on the line which are likely to cause the apparatus to be destroyed by a sudden abnormal flow of current.

The apparatus is simple, durable, has but one moving element, is positive in its action, operates equally well with an abnormal flow of current from the generator or a reverse current from the line produced by a rotary transformer or from any other cause. The currents employed so balance themselves as to require a very small amount of current for the operation of the device, and the fact that the overbalance of the disk is eliminated when the conditions are such as to rotate the disk and close the contacts, produces a positive and effective contact which secures practical and successful operation.

In the structure above described the shaft which carries the disk overbalance and contact is horizontal. This is the preferred form, but it will be understood that the apparatus will operate in any position in which the axis of the shaft is at an angle to the vertical. The setting of the overbalance device requires the action of gravity, which would be destroyed if the axis of the disk were vertical. The nearer the shaft is to the horizontal, the greater will be the action of gravity and the greater the sensitiveness of the device.

Having thus described our invention, what we claim and desire to secure by Letters Patent is:

1. In an overload and reverse current relay, the combination of an unbalanced rotor, a system of electro-magnets and an electrical contact, means for producing a reaction between the rotor and the system of electro-magnets proportional to the resultant phase composition of the current and voltage elements of the circuit to be controlled, which current and voltage elements are in multiple relation to each other.

2. In an overload and reverse current relay, the combination of an unbalanced rotor, a system of electro-magnets and an electrical contact, means for producing a reaction between the rotor and the system of electro-magnets proportional to the resultant phase composition of the current and voltage elements of the circuit to be controlled; which consists of a derived current and voltage circuit encircling the magnets and responding to variations of electrical conditions on the working circuit.

3. In an overload and reverse current relay, the combination of a current transformer in the main line, a pair of twin electro magnets in series with the secondary of the transformer, a single electro magnet having its pole set opposite the poles of the twin magnets and in series with the twin magnets and the secondary of the current transformer, a potential transformer across the main line the secondary of which is in a closed circuit containing an ohmic resistance device, and a second transformer the secondary of which is in shunt relation to the circuit of the current transformer and including the single electro magnet coil, a rotor mounted upon a shaft set at an angle to the vertical and arranged to rotate in the fields of the twin and single magnets, the rotor being unbalanced, and an electrical contact adapted to be closed by the rotation of the rotor.

4. In an overload and reverse current relay, the combination of a current transformer in the main line, a pair of twin electro magnets in series with the secondary of the transformer, a single electro magnet having its pole in magnetic relation to the poles of the twin magnets and in series with the twin magnets and the secondary of the current transformer, a potential transformer across the main line the secondary of which is in shunt relation to the circuit of the current transformer and including the single electro-magnet coil, a rotor mounted upon a shaft set at an angle to the vertical and arranged to rotate in the magnetic field of the system of magnets, the rotor being unbalanced and an electrical contact adapted to be closed by the rotation of the rotor.

5. In an overload and reverse current relay, the combination of a current transformer in the main line, a pair of twin electro magnets in series with the secondary of the transformer, a single electro magnet having its pole in magnetic relation to the poles of the twin magnets and in series with the twin magnets and the secondary of the current transformer, a potential transformer across the main line the secondary of which is in shunt relation to the circuit of the current transformer and including the single electro-magnet coil, a rotor mounted upon a shaft set at an angle to the vertical and arranged to rotate in the magnetic field of the system of magnets, the rotor being unbalanced, and an electrical contact adapted to be closed by the rotation of the rotor, the pole of the single magnet being in such magnetic relation to the poles of the twin magnet as will induce currents in the rotor which will react upon the system of electro magnets and cause rotation of the rotor.

6. In an overload and reverse current relay, the combination of an unbalanced rotor mounted between the poles of a pair of twin magnets and the pole of an oppositely dis-

posed single magnet, and an electrical contact adapted to be closed when the rotor is given a desired direction of rotation, the magnets being in series and in circuit with the secondary of a current transformer in the main line, and a secondary circuit also including the coil of the single magnet and the secondary coil of a potential transformer.

7. In an overload and reverse current relay the combination of an unbalanced rotor mounted between the poles of a pair of twin magnets and the pole of an oppositely disposed single magnet, and an electrical contact adapted to be closed when the rotor is given a desired direction of rotation, the magnets being in series and in circuit with the secondary of a current transformer in the main line, and a secondary circuit also including the coil of the single magnet and the secondary coil of a potential transformer, and means for varying the impedance of the secondary circuit.

8. In an overload and reverse current relay the combination of an unbalanced rotor mounted between the poles of a pair of twin magnets and the pole of an oppositely disposed single magnet, and an electrical contact adapted to be closed when the rotor is given a desired direction of rotation, the magnets being in series and in circuit with the secondary of a current transformer in the main line, and a secondary circuit also including the coil of the single magnet and the secondary coil of a potential transformer, and means for varying the impedance of the single coil magnet.

9. In an overload and reverse current relay, the combination of an unbalanced rotor mounted between the poles of a pair of twin magnets and the pole of an oppositely disposed single magnet, and an electrical contact adapted to be closed when the rotor is given a desired direction of rotation, the magnets being in series and in circuit with the secondary of a current transformer in the main line, and a secondary circuit also including the coil of the single magnet and the secondary coil of a transformer, the primary of which is included in a circuit which also includes an ohmic resistance and the secondary of a potential transformer.

Signed by us at Baltimore, Md., this 3rd day of July 1908.

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