No. 816,111. PATENTED MAR. 27, 1906.

R. D. MERSHON.

REVERSE RELAY DEVICE.

APPLICATION FILED NOV. 4, 1904.

3 SHEETS—SHEET 1.

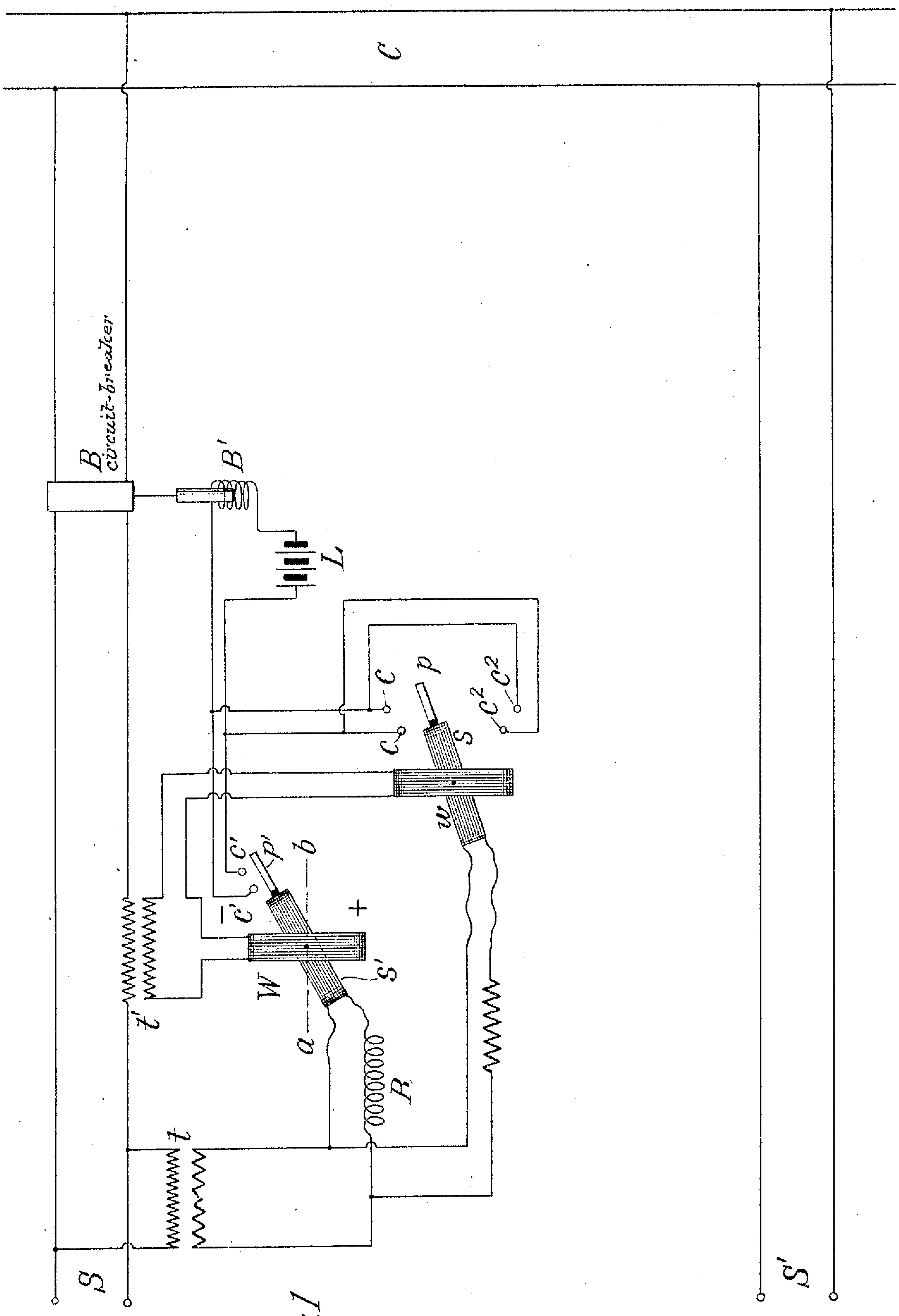

Fig.1

Witnesses
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A. S. Dunham.

R. D. Mershon Inventor

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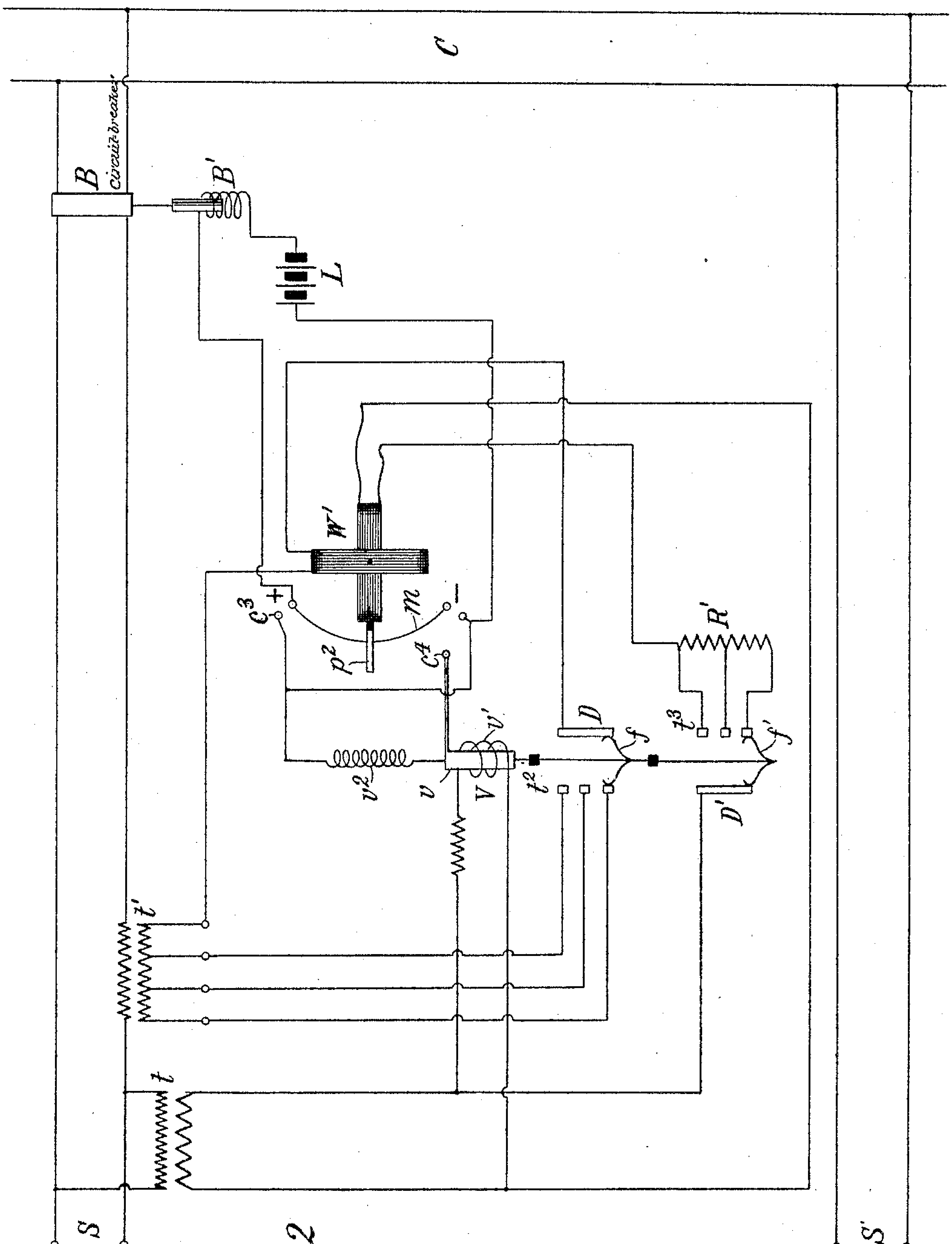

Fig. 2

Witnesses
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3 SHEETS—SHEET 3

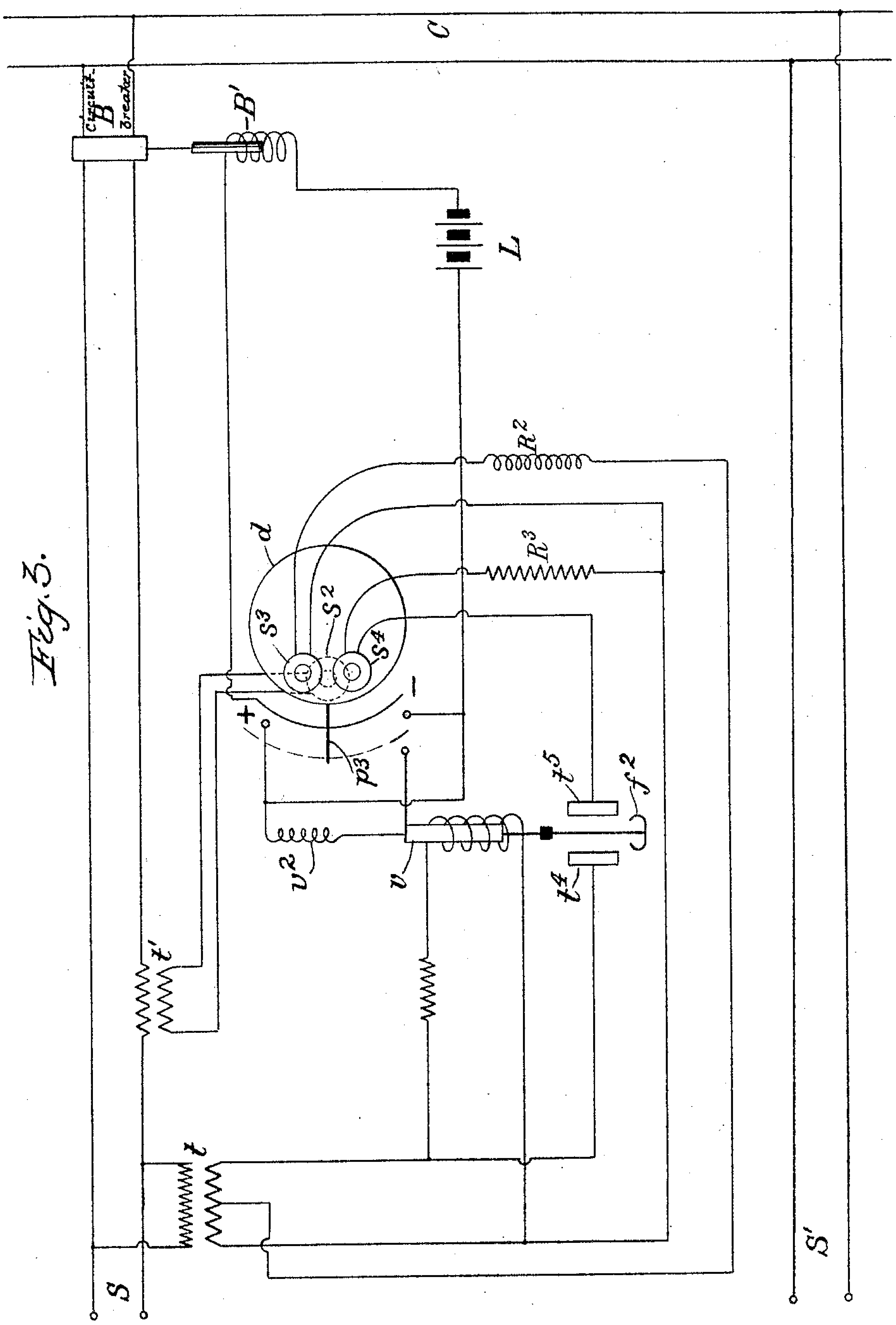

Fig. 3.

Witnesses
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UNITED STATES PATENT OFFICE.

RALPH D. MERSHON, OF NEW YORK, N. Y.

REVERSE-RELAY DEVICE.

No. 816,111. Specification of Letters Patent. Patented March 27, 1906.

Application filed November 4, 1904. Serial No. 231,331.

To all whom it may concern:

Be it known that I, Ralph D. Mershon, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Reverse-Relay Devices, of which the following is a specification, reference being had to the drawings accompanying and forming part of the same.

My present invention relates to a class of apparatus known generally as "reverse-relays," used in connection with a system comprising two or more sources of current feeding into the same circuit for the purpose of operating a circuit-breaker or performing other desired functions when certain abnormal conditions occur in the system, such as a short circuit of one of the sources of current.

Reverse-relay devices are usually made in the form of a relay operating on the wattmeter principle, having devices for closing a local circuit when the abnormal conditions occur, which local circuit operates or controls the operation of a circuit-breaker in the main circuit. Such devices have been found to operate more or less satisfactorily when the abnormal conditions do not depart far from normal; but they have not proved satisfactory in the extreme conditions which may be and not infrequently are met in practice. For example, assume two circuits or sources of current feeding into the same bus-bars, each circuit being provided with a switch and a reverse-relay for opening the same operating on the principle of the wattmeter. Upon one of the circuits being short-circuited near the bus-bars the wattmeter-relay would, if it operated properly, reverse its reading and, swinging back of zero, would close its local circuit, which would in turn open the switch. As a matter of fact, however, the reverse-relay devices now ordinarily used will not operate as just described for either or both of two reasons: First, when a short circuit occurs the voltage at the bus-bars is lowered to a greater or less degree, and the component of wattmeter torque due to voltage is therefore reduced; second, in case of short circuit the power factor of the current is very low, which also reduces the wattmeter torque. The result is that in the case of a severe short circuit the reduction of torque from one or both of these causes is so great that it is not sufficient to carry the reverse-relay far enough beyond its zero-point in the negative direction. The object of my invention is, therefore, to provide reverse-relay apparatus which will operate successfully under all conditions which may occur in practice, no matter how severe.

In carrying out my invention I may employ for each piece of apparatus a relay device which will operate under what may be described as slightly abnormal conditions—that is, when the voltage is not greatly reduced—and in connection therewith one which will not operate under the slightly abnormal conditions, but only under severely abnormal conditions, or I may employ a single device which will operate under all conditions. The instrument or instruments may be electrostatic or electromagnetic, and either kind may be constructed to operate on the dynamometer principle or on the rotating field principle. However, for the purpose of simplifying the description I shall confine the same to electromagnetic instruments, describing specifically two operating on the first-mentioned principle and one on the latter.

The essence of my invention resides in obtaining in the instrument under abnormal conditions of low voltage and low power factor in the circuit in which the device is connected a torque high enough to enable it to perform the desired function. This principle may be carried out in any one or more of a variety of ways—as, for example, first, by having such a fixed phase relation between the current and the electromotive force of the shunt-circuit as will produce as great a torque as possible under the abnormal conditions mentioned; second, by causing the voltage effective on the shunt element of the instrument to be increased over what it otherwise would be when the abnormal conditions arise; third, by causing the current in the series coils or the effect in the instrument due to the main current to be increased over what it otherwise would be when the abnormal conditions exist, or, fourth, by changing the phase relation of the current and electromotive force in the shunt-circuit. The first will cause the instrument to have a greater torque than an ordinary wattmeter would have under the condition of low power factor, because at that time the ampere-turns of the shunt and series fields will have a better phase relation for producing torque than in the case of the ordinary wattmeter. The second will increase the torque, because the shunt field is strengthened. The third will increase the torque, because the series field is strengthened. The forth will also increase the torque, for the reason that the conditions which produce the low voltage will be accompanied by low power factor, which in the ordinary wattmeter would mean that the shunt and series magnetizations were in the wrong phase to produce torque, so that changing the phase relations in the proper way to produce a rotation like that of the first-mentioned method would increase the torque above what it would be if the abnormal phase relation persisted. The voltage effect on the shunt element may be increased by changing the ratio of the transformer feeding the shunt-circuit or by varying the resistance, reactance, or capacity external to the shunt element or by other well-understood means. The current effect on the series element may be increased by changing the ratio of the series transformer used in connection with the instrument or by other well-understood means. These operations may be effected automatically by a device operating on the voltmeter principle, as the voltage falls or when it has fallen below a certain predetermined value, or by a device which depends upon the variation of other quantities, which in case of short circuit vary characteristically. For example, this automatic action may be brought about by a device operating on the ammeter principle, dependent upon the fact of a large current flowing when a short circuit occurs. However, for this purpose I prefer the voltmeter device. The phase relation of the series and shunt fields may be changed by cutting into circuit with the shunt element a resistance, reactance, or capacity as may be needed. In the case of a wattmeter operating on the ordinary dynamometer principle, and in which, therefore, the shunt-current is as nearly as possible in step with the electromotive force, it is desirable when the voltage is lowered to have the current in the shunt-circuit lag, thus bringing it more nearly in step with the lagging current taken by the short circuit. As stated, this may be done by cutting reactance into the shunt-circuit. The same result may be secured to a greater or less extent by cutting resistance out of the shunt-circuit, thereby changing the ratio of the reactance and resistance in that circuit. In the case of a wattmeter operating on the electromagnetic inductive principle, in which the shunt-current is made as nearly as possible ninety degrees away from the electromotive force, the phase relation of current and electromotive force in the shunt-circuit may be changed by cutting resistance or capacity into the shunt-circuit.

The above-mentioned methods are given merely as examples of ways for restoring or partially restoring the torque of the wattmeter to a value high enough for successful operation, and the explanation has been confined more specifically to electromagnetic inductive and dynamometer instruments, for the reason that these are the types now most commonly used; but it will be seen by those skilled in the art that analogous results may be secured in the case of electrostatic instruments also. Likewise I have mentioned only those methods of varying the phase relations which would probably be employed for the purpose; but other methods might be used—as, for example, that of compounding electromotive forces, &c. It is clear, of course, that the torque may also be increased to the desired value by simultaneously increasing the voltage effective on the shunt-coil and changing the phase relation.

For a more detailed explanation of my invention reference may now be made to the accompanying drawings, in which are shown the preferred embodiments.

Figure 1 is a diagram illustrating a system employing two instruments, one for taking care of conditions departing but slightly from normal, the other for more severely abnormal conditions, the phase relation of the shunt and series coils of the latter being fixed at a value suitable for conditions accompanied by low power factor. Fig. 2 is a diagram showing a system in which a single instrument takes care of the abnormal conditions, the torque of the instrument being made high enough for its successful operation by a device operating on the voltmeter principle. Fig. 3 is a diagram also showing a system with a single instrument for all conditions operating on the principle of the induction-wattmeter, with a device operating on the voltmeter principle to make the torque of the wattmeter sufficiently high under severely abnormal conditions.

Throughout the various figures, S and S′ indicate circuits feeding a common circuit C. At B is shown diagrammatically a circuit-breaker, and at B′ a tripping-coil for operating the same. The shunt and series transformers for the reverse-relay apparatus are indicated by t and t', respectively.

Referring now more particularly to Fig. 1, w is a wattmeter operating on the dynamometer principle, in which the current in the shunt-coil s is as nearly as possible in step with the electromotive force. When this phase relation is disturbed only to a comparatively slight degree, as by a short circuit a considerable distance from the instrument, the torque of the wattmeter may be sufficient to carry the pointer p or other device far enough in the negative direction to connect the contacts c c, thus closing the circuit of battery L, energizing the coil B′, and actuating the switch B. When, however, the voltage at the wattmeter is greatly reduced or under the other very abnormal conditions before mentioned, the torque is in-sufficient for the desired purpose and the circuit-breaker B is not actuated I therefore provide, in addition to the wattmeter w, a device W, analogous to a wattmeter, but in which the current in the shunt-coil s' is made as nearly as possible ninety degrees lagging behind the electromotive force, a reactance R being included in the shunt-circuit for that purpose. Such an instrument will therefore take account only of such component of the main current as is ninety degrees or approximately ninety degrees away from the electromotive force producing it. This device on account of the ninety-degrees phase relation just mentioned may for convenience be designated as a "quadrature device." When conditions are such that the source S is supplying a lagging current to the circuit C, the deflection of the quadrature device is positive. As long as the current neither leads nor lags—that is to say, when the power factor is unity—the quadrature device is at zero, (indicated by the line $a\ b$,) or nearly so. When however, the source S is receiving a leading current, as would be the case if a short circuit occurred beyond the instruments in the circuit S, the reversal of the phase relation of the currents in the shunt and series coils will cause the quadrature device to show a deflection in the negative direction beyond the zero-line $a\ b$ and may carry the pointer p' far enough to bridge the contacts $c'\ c'$, thereby closing the local circuit through battery L and actuating the switch B. By proportioning one or more of the various elements of the system, as the reactance R, the position of the contacts $c'\ c'$ relative to the zero-line, the device, (not shown,) as a spring or weight, which opposes the deflection of the pointer or by other means, the quadrature instrument may be made to be inert, so far as affecting the local circuit is concerned, under conditions which cause the wattmeter w to close the local circuit and to be deflected in the negative direction against the local-circuit contacts only when conditions become too severe for the wattmeter to handle. In most instances it will be found advisable to make the quadrature device come into action somewhat before the operative limit of the wattmeter is reached, so that there could be no gap between the upper limit of the former and lower limit of the other. The local circuit may also be provided with contacts $c^2\ c^2$ on the positive side of the wattmeter, so that in case of overload the extreme deflection of the pointer p in the positive direction will also close the battery-circuit and actuate the switch B.

In Fig. 2 a single instrument W′, operating on the dynamometer wattmeter principle, is employed to take care of all conditions. Its arm or pointer p^2 is at all times in electrical contact with a strip or bar m, which is in circuit with the battery L. The local circuit also includes a contact c^3, on which the pointer will impinge when swung to its extreme positive position, as by overload on the circuit C, and a contact c^4, on which the pointer may impinge when carried in the negative direction, as by short circuit in the circuit S beyond the instrument. The latter contact is carried by a movable core v of a voltmeter device V, held normally in the coil v' against the tension of a spring v^2. When the voltage in the instrument falls, the magnetic field of the coil v' is weakened and the core is drawn out by its spring, carrying the contact c^4 nearer the shunt-coil arm p^2. Less torque will then be required to bring the pointer to the negative contact. The device may be so constructed and proportioned that the contact c^4 may be brought very close to the zero-line, near enough for the low torque of an ordinary wattmeter to swing its arm over against the contact without other assistance; but I prefer to use also some means for increasing the torque of the wattmeter under conditions involving low voltage or low power factor, or both. A number of methods for increasing the torque have been described above, and in the present instance, Fig. 2, I employ three of them—namely, increasing the ampere-turns in the shunt-coil and also in the series coil and changing the phase relation between the ampere-turns, thus making the instrument more positive in its action than it might be if the movable contact c^4 alone were used. To effect this increase in ampere-turns and change the phase relation between the same, the voltmeter device may be provided with suitable commutating devices, as D and D′. As the core v is drawn out of the coil the brush f makes contact with the terminals t^2, successively reducing the number of turns of the series transformer t'. At the same time the brush f' makes contact with terminals t^3, successively reducing the resistance R′ in circuit with the shunt-coil.

In Fig. 3 is shown an induction-wattmeter, to which my invention is applied, with a movable negative contact actuated as in the system illustrated in Fig. 2. The disk of the instrument is indicated by d, carrying an arm or pointer p^3. The series coil of the ordinary wattmeter is designated by s^2 and the shunt-coil by s^3, in the circuit of the latter being a reactance R^2. An auxiliary shunt-coil s^4 is provided, connected with the transformer t through a resistance R^3 and having separated contact-plates $t^4\ t^5$ in its circuit. As the core v of the voltmeter device is drawn up the brush f^2 makes contact with the plates $t^4\ t^5$, thus closing the circuit of the auxiliary shunt-coil. In the particular arrangement shown the electromotive force impressed upon the auxiliary shunt-circuit is higher than is at the same instant impressed upon the permanent shunt-circuit. The auxiliary coil takes account of quadrature-current, and its torque assists that of the other coil. Any number of auxiliary coils may be used, as desired, and may be brought into operation successively or simultaneously by the voltmeter device.

The devices shown in Fig. 3 may be readily applied to existing types of wattmeters operating on the rotating field principle.

The advantages incident to the use of a movable or adjustable contact as employed, for example, in Figs. 2 and 3 are of particular value, as will be readily seen. For instance, the moving contact makes the apparatus automatically self-adjusting, so that it may be made to perform its circuit-controlling functions only and always under conditions which depart a predetermined amount from normal. Thus abnormal conditions may arise which might give considerable deflection of the instrument toward the contact; but unless the voltage dropped a certain amount (or the current increased a certain amount, if the movement of the contact is effected by an ammeter device) it would not be desirable to break the circuit S. In that case the drop in voltage (or increase in current) would not cause the contact to be moved far enough for the arm or pointer to meet it, and the circuit S would therefore not be disturbed.

The local circuit of the switch B is shown in all the figures as normally open; but the switch may of course be constructed so as to be opened by breaking a normally closed circuit, the two methods being substantial equivalents.

It will be noted that in indicating or circuit-controlling devices such as are herein described the torque is due to two elements, one of them dependent upon the current in the circuit which includes the device and the other dependent upon the voltage in this circuit. The magnitude of the torque depends upon the respective values of the two elements and upon the value of the phase angle between them. The magnitude of the torque may therefore be varied by varying one or more of these values, which may be effected in a variety of ways, as before explained. In the apparatus shown in the three figures the two elements mentioned are in each case currents or the fields due to them, dependent in value upon the voltage and current of the circuit in which the indicating or circuit-controlling device is connected. In the case of the instruments shown in Figs. 2 and 3 the torque may be varied by varying the values of the currents and of the phase angle between them.

Throughout the claims I have referred only to a "circuit-controlling device," as circuit control is in some respects the chief object of the invention; but a mere indication of the conditions in the circuit may be all that is desired, in which case the device need not actually cause the circuit to be broken or controlled in any way. I therefore am not limited to a circuit-controlling device properly so called, but may use as well merely a device which gives an indication of the conditions present.

What I claim is—

1. The combination with a source of current connected with one or more other sources of current, of a circuit-controlling device actuated by force proportional to the vectorial product of components dependent upon current and electromotive force respectively, and adapted with reference to the phase relation of the said components to produce higher torque under conditions accompanied by low power factor than when accompanied by high power factor, as set forth.

2. The combination with a source of current connected with one or more other sources of current, of a circuit-controlling device actuated by force proportional to the vectorial product of components dependent upon current and electromotive force respectively, and means for adjusting the magnitude and phase relation of the said components, as set forth.

3. The combination with a source of current connected with one or more other sources of current, of a circuit-controlling device actuated by force proportional to the vectorial product of components dependent upon current and electromotive force respectively, and means for adjusting the magnitude of one or more of the said components, as set forth.

4. The combination with a source of current connected with one or more other sources of current, of a circuit-controlling device actuated by force proportional to the vectorial product of components dependent upon current and electromotive force respectively, and automatic means for adjusting the magnitude and phase relation of the said components, as set forth.

5. The combination with a source of current connected with one or more other sources of current, of a circuit-controlling device actuated by force proportional to the vectorial product of components dependent upon current and electromotive force respectively, and automatic means for adjusting the magnitude of one or more of the said components, as set forth.

6. The combination with a source of current connected with one or more other sources of current, of a circuit-controlling device actuated by force proportional to the vectorial product of components dependent on current and electromotive force respectively, and automatic means for adjusting the magnitude and phase relation of the said components, dependent for operation upon decrease of voltage, as set forth.

7. The combination with a source of cur-

rent connected with one or more other sources of current, of a circuit-controlling device actuated by force proportional to the vectorial product of components dependent upon current and electromotive force respectively, and automatic means for adjusting the magnitude of one or more of the said components, dependent for operation on decrease of voltage, as set forth.

8. The combination with a source of current connected with one or more other sources of current, of a circuit-controlling device connected with the first-mentioned source, a local circuit, a movable contact therein, a circuit-closing device actuated by the circuit-controlling device, and means for moving the contact toward the circuit-closing device, the operation of said means being dependent upon, and proportional in extent to, abnormal electrical conditions in the external circuit of the circuit-controlling device, as set forth.

9. The combination with a source of current connected with one or more other sources of current, of a circuit-controlling device connected with the first-mentioned source, a local circuit, a movable contact therein, a circuit-closing device actuated by the circuit-controlling device, and means for carrying the movable contact toward the circuit-closing device, the operation of the said means being dependent upon, and proportional in extent to, decrease of voltage in the external circuit of the circuit-controlling device, as set forth.

10. The combination with a source of current connected with one or more other sources of current, of a circuit-controlling device connected with the first-mentioned source and actuated by force proportional to the vectorial product of components dependent upon current and electromotive force, a local circuit, a movable contact therein, a circuit-closing device, actuated by the circuit-controlling device, means for moving the contact toward the circuit-closing device, means for adjusting the magnitude and phase relation of the said components, and mechanism for actuating both said means, dependent for operation upon abnormal conditions in the external circuit of the circuit-controlling device, as set forth.

11. The combination with a source of current connected with one or more other sources of current, of a circuit-controlling device connected with the first-mentioned source and actuated by force proportional to the vectorial product of components dependent upon current and electromotive force, a local circuit, a movable contact therein, a circuit-closing device actuated by the circuit-controlling device, means for moving the contact toward the circuit-closing device, means for adjusting the magnitude of one or more of the said components, and mechanism for actuating both said means, dependent for operation upon abnormal electrical conditions in the external circuit of the circuit-controlling device, as set forth.

12. The combination with a source of current connected with one or more other sources of current, of a circuit-controlling device connected with the first-mentioned source and actuated by force proportional to the vectorial product of components dependent upon current and electromotive force, a local circuit, a movable contact therein, a circuit-closing device, actuated by the circuit-controlling device, means for moving the contact toward the circuit-closing device, means for adjusting the magnitude and phase relation of the said components, and mechanism for actuating both said means, the operation of said mechanism being dependent upon, and proportional in extent to, decrease of voltage in the external circuit of the circuit-controlling device, as set forth.

13. The combination with a source of current connected with one or more other sources of current, of a circuit-controlling device connected with the first-mentioned source and actuated by force proportional to the vectorial product of components dependent upon current and electromotive force, a local circuit, a movable contact therein, a circuit-closing device, actuated by the circuit-controlling device, means for moving the contact toward the circuit-closing device, means for adjusting the magnitude of one or more of the said components, and mechanism for actuating both said means, the operation of said mechanism being dependent upon, and proportional in extent to, decrease of voltage in the external circuit of the circuit-controlling device, as set forth.

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