235-400 SR
E113A XR 2,134,901

[redacted] [redacted]

Tx 235 — 400

Nov. 1, 1938. R. J. WEY 2,134,901

ELECTRIC SIGNALING OR CONTROLLING SYSTEM

Filed July 2, 1936 3 Sheets-Sheet 1

Fig. 1.

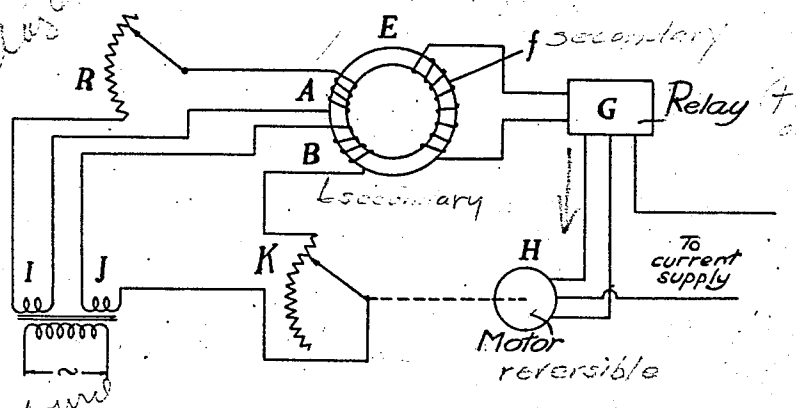
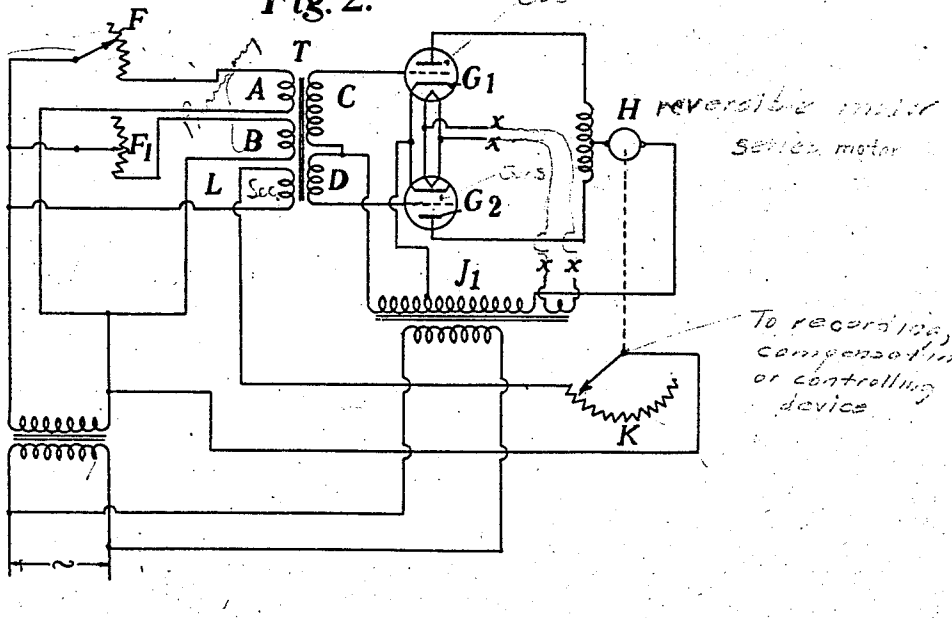


Fig. 2.



sums up A, B & L which is F, F1, and K

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Filed July 2, 1936 3 Sheets-Sheet 2

Fig. 3.

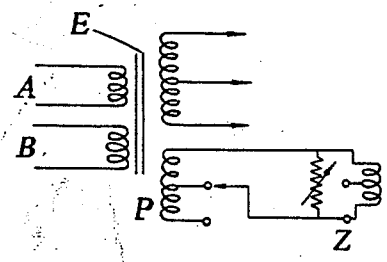


Fig. 4.

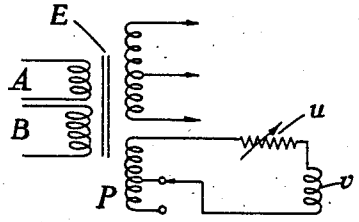


Fig. 6.

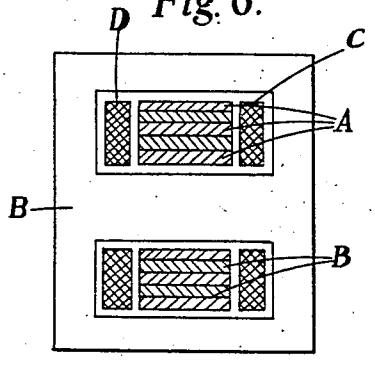
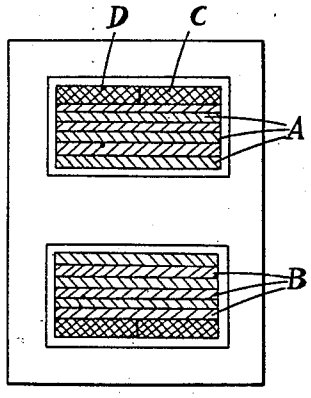


Fig. 7.



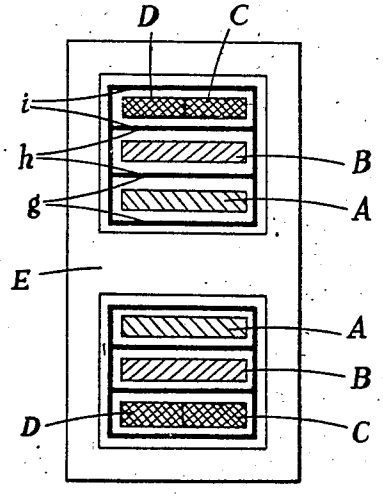


Fig. 5.

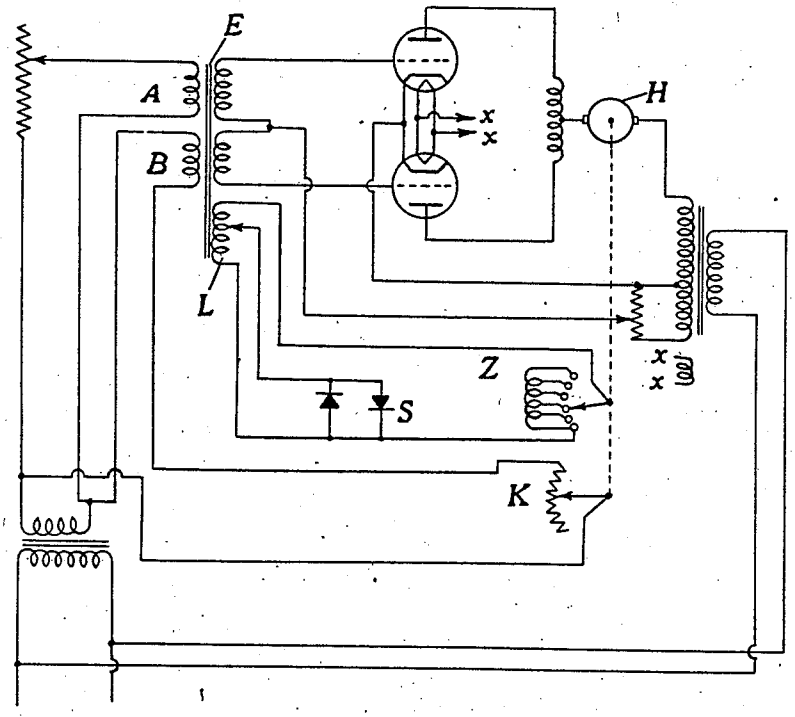
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Filed July 2, 1936 3 Sheets-Sheet 3

Fig. 8.



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Patented Nov. 1, 1938

2,134,901

UNITED STATES PATENT OFFICE

2,134,901

ELECTRIC SIGNALING OR CONTROLLING SYSTEM

Raymond John Wey, Park Royal, London, England, assignor to Republic Flow Meters Company, Chicago, Ill., a corporation of Illinois

Application July 2, 1936, Serial No. 88,543
In Great Britain July 8, 1935

10 Claims. (Cl. 172—239)

This invention relates to regulating, remote-control, repeating, recording, compensating, indicating or controlling systems and has particular reference to systems employing follow-up or other devices in which the position or condition of one element in one circuit is varied whenever the position or condition of another element included in an associated circuit is varied, for follow-up, balance-restoring or like purposes. Such devices are frequently used in various forms of indicating, recording, integrating, regulating, repeating, compensating or control units and the chief object of the present invention is to provide an improved form of signaling or controlling system possessing a high degree of sensitivity.

According to one feature of the invention the system is equipped with a follow-up, balance-restoring or like device comprising a magnetic core or transformer carrying one or more windings through which the current in a primary or controlling circuit and that in a secondary or follow-up circuit are passed and mutually combined by addition or subtraction to produce a resultant voltage drop across such windings and to induce in one or more other windings a voltage proportional to the said voltage drop, the arrangement being such that when the voltage drop departs from a predetermined value or the circuits become mutually unbalanced a relay device associated with the secondary or follow-up circuit is actuated to restore the circuits to their balanced condition.

According to another feature of the invention the voltage induced in said windings is applied to grid element or elements of one or more thermionic valves or gas filled relays and the resultant variation in the anode current is utilized to cause through the intermediary of an electric motor or other convenient source of motive power, a variation in an electrical characteristic of the secondary or follow-up circuit of such a nature that the voltage drop tends to return to its normal or predetermined value.

According to a further feature of the invention the magnetic core or transformer is provided with means for controlling the impedance offered by the winding or windings traversed by the primary or secondary currents, thereby enabling the sensitivity of the device to be accurately controlled. Said means may comprise means for enabling the reluctance offered by the core to be varied, e. g. by variations in an air gap in the magnetic circuit, or they may comprise a variable external impedance associated with a special or additional winding on the core or with one of the existing windings thereon. Said external impedance may take the form of a resistance or reactance or a combination of both, e. g. a condenser or inductance used in conjunction with a resistance or separately. If desired, the external impedance may have a fixed value and the number of turns of the transformer winding to which the impedance is connected may be made variable by means of tappings, it being appreciated that the greater the number of turns included in circuit, the greater will be the effect of the external impedance in modifying the impedance of the balancing transformer.

In order to reduce errors due to stray magnetic flux between the various windings, as distinct from the flux passing through the core, the various windings may be interlaced or subdivided so as to reduce the possible path for stray flux to a minimum. Also, if desired, the transformer may be provided with a metallic screen or screens between the windings or sections thereof so as to reduce the effect of stray magnetic fluxes between the windings and to eliminate electrostatic interaction. Also, for the forming of the core of the transformer use may be made of a high permeability alloy in the form of laminations so as to reduce the number of turns and physical dimensions necessary to obtain a given impedance.

It will be appreciated that the effective value of the external impedance may be varied by hand to suit the particular use for which the device is to be employed or, if desired, the impedance varying means may be coupled with a variable or displaceable element of the secondary or follow-up circuit to permit the sensitivity of the device to be varied automatically to suit different operating conditions.

Where the induced voltage is applied to the grid element or elements of one or more thermionic valves or gas filled relays, the grid coil or coils may be wound on the same spool as the primary or secondary coils, or in association with them, and may, if desired, be subdivided, but it is preferred to separate the grid coils into two separate and distinct windings arranged over the other windings, or one at each end, so that the effect of stray fluxes from the primary or secondary windings on the two grid windings may be made equal and negligible.

In order to prevent excessive magnetization resulting in a temporary or a permanent alteration of the magnetic properties of the core, a non-linear impedace, e. g. a rectifier, is preferably connected acoss one of the windings, the characteristic of the impedance being such that its ef-

fective impedance value will fall rapidly with increasing applied voltage. In this manner, the voltage drop across such winding can be kept below a predetermined value and the voltage drops across the other windings can be prevented from exceeding proportionate values. Such non-linear impedance may be connected with any of the aforesaid windings or it may be connected with a special or additional winding. Usually, however, it is preferable to connect the non-linear impedance to the same winding as the external linear impedance, such winding being provided with tappings to enable the relative voltages across the two impedances to be adjusted.

The aforesaid primary element may form part of a measuring instrument or it may be constituted by an element the condition or position of which is caused to vary with a physical, electrical or other characteristic such as, for example, velocity, fluid flow, temperature, or pressure.

In order that the said invention may be clearly understood and readily carried into effect, the same will now be more fully described with reference to the accompanying drawings, in which:—

Fig. 1 illustrates diagrammatically one convenient mode of carrying the invention into effect;

Fig. 2 illustrates a modification employing relays of the thermionic type;

Figs. 3 to 7 illustrate alternative modes of changing the value of the inductance of the balancing transformer and of protecting the transformer from the effects of stray flux; and

Fig. 8 illustrates diagrammatically another mode of carrying the invention into effect.

In the embodiment of the invention shown in Fig. 1, the primary circuit comprises a winding A on a core E and in series with a controlling resistance R and a supply transformer winding I. The effective value of the resistance R is adapted to be varied in known manner by variations in the condition of the physical, electrical or other characteristic which it is desired to compensate for, control or record. The secondary circuit comprises a secondary winding B also on the core E and arranged in series with a resistance K and a supply transformer winding J. The core E also carries an additional winding *f* connected to a relay G which controls the supply of power to a reversible electric motor H adapted to actuate the contact arm of the resistance K and to operate the compensating, controlling or recording device which, for simplicity, is not shown in the drawings.

The relay G is so adjusted or designed that any departure from a predetermined voltage induced in the winding *f* will cause the motor H to rotate in one direction or the other. That is to say, when the currents in the primary and secondary windings A and B are such as to produce the normal or predetermined voltage on the winding *f*, the arrangement is in equilibrium and no rotation of the motor takes place, but if the resistance R varies causing the current in winding A to vary, the voltage induced in *f* will depart from its normal value and the motor H will displace the contact arm of the variable resistance D, thereby altering the current in B until the balance is once more restored.

The aforesaid relay may be of any known type e. g. electro-mechanical, or it may be of the thermionic type such as is comprised by the two gas-filled relays G_1 and G_2 shown in Fig. 2. In this embodiment, the grids of the relays are connected respectively to the grid windings C and D on a balancing transformer T and the anodes of the relays are each connected through the field windings of the reversible electric motor H to a source of anode current supply derived from a transformer J_1 which also supplies grid bias from a tapping on its secondary winding. The primary or controlling element or elements comprises one or more resistances or impedances F and F_1 the effective values of which are caused to vary in known manner with variations in the physical quantity being controlled, recorded or compensated, and the current in the primary circuit or circuits passes through the windings A and B on the transformer T.

The secondary current passes through a variable resistance K and a third winding L on the transformer T and the resultant magnetization of the core will thus depend upon the sum of the ampere-turns due to A, B and L. The magnetization of the core results in a voltage being induced in the windings C and D, which voltage is applied to the grids of the gas-filled relays G_1 and G_2 so that according to the polarity of this voltage with respect to anode voltage, either one or the other of these relays will be caused to pass anode current. The motor is thus caused to rotate in one direction or the other and by virtue of the motor being coupled to the resistance K the latter is varied so that the current in the secondary circuit passing through the winding L is adjusted until magnetization of the core is brought back to its normal value, which may be zero if desired or found expedient.

It will be appreciated that the variable resistance and the motor H are, as in the previously described embodiment together coupled to the compensating, controlling or recording mechanism. The supply of current for the primary and secondary circuits may be derived from the same source as the anode and grid bias supply for the gas-filled relays and the two circuits may be fed from a common winding or separate windings of suitable transformers as shown.

As mentioned above, in some instances, it is necessary or advisable to alter the value of inductance of the balancing transformer in order to provide a control over the voltage developed in these windings for a certain out-of-balance of the two currents in the primary and secondary windings. One method of effecting such alterations is to vary the reluctance of the core of the transformer by means of a variable air-gap in known manner, but another method which may be more convenient is inductively to couple with the balancing transformer an external impedance and to vary the value of this external impedance. For example, as is illustrated in Fig. 3, the primary and secondary windings A and B on a core E are inductively coupled by means of a winding P to the impedance Z, which impedance may be a simple resistance, inductance or impedance, or it may be a composite impedance of resistance *u* and inductance *v*, as shown for example in Fig. 4, and in order to vary the value of the impedance, either the resistance or the inductance, or both, may be made variable and/or the winding P may be tapped as shown. In the alternative method of connection shown in Fig. 4, the resistance *u* is in series with the inductance *v*. The accuracy of the transformer of this nature may be affected by stray or leakage fields due to the passage of magnetic flux through the space surrounding the windings as distinct from the flux passing through the core of the transformer. This effect may be

eliminated or minimized by providing metallic shields over one or more of the windings in such a manner that the stray flux is prevented from affecting the adjacent windings and that the only common flux linking the various windings is that passing through the core of the transformer.

For example, as is illustrated in Fig. 5, the windings A and B constituting the primary and secondary windings may be wound on a core E and the windings C and D constituting the grid windings may be wound over the primary and secondary windings in such a manner that metallic shields *g*, *h* and *i* are interposed between the windings and around the outsides in the manner shown, thus screening the stray flux so that no voltages are induced in the windings C and D, except by the flux in the core E.

Another method by which the effect of stray flux can be reduced is to interlace or sub-divide the windings so that they are physically as close as possible to one another and furthermore to arrange them symmetrically so that the effects of stray fields tend to cancel out. Such an arrangement is indicated in Fig. 6 in which the primary winding A and the secondary winding B are subdivided in a number of sections alternately arranged in the manner shown, the grid windings C and D being placed at either end of the primary and secondary windings. The auxiliary winding to which the external impedance is connected for the purpose of modifying the impedance of the transformer itself, may be wound in sections also interleaved with the primary and secondary windings. An alternative method is shown in Fig. 7 in which the two grid windings C and D are arranged outside the interleaved primary and secondary windings A and B.

Since it may be necessary to vary the sensitivity of the device according to varying physical conditions, it is possible to vary mechanically the external impedance according to the movement of the follow-up or balancing resistance.

Referring to Fig. 8, it will be seen that the auxiliary winding L is connected to a variable impedance Z which is coupled mechanically to the driving motor H and the balancing resistance K in the manner shown. Thus the sensitivity of the transformer can be varied according to the value of the balancing resistance K which, in turn, is dependent upon the current flowing in the primary circuit A, since this controls the current in the secondary circuit B. Other means of performing this adjustment automatically according to the movement of the follow-up or balancing member may be used without departing from the scope of the invention, e. g. the air-gap in the core may be varied instead of the external impedance.

In order to prevent excessive magnetization of the core resulting from momentary out-of-balance of the two currents in the primary and secondary windings, due, for instance, to time delay in the operation of the follow-up motor H, the core may become highly magnetized, which would result in the accuracy being affected. This excessive magnetization may be prevented by the connection of a voltage-limiting device across one winding of the transformer, for instance across the auxiliary winding to which the external impedance is connected. This voltage-limiting device may take the form of a rectifier S which has the characteristic of rapidly decreasing resistance with increasing applied voltage. Thus, owing to the limited value of the current which may flow in the auxiliary winding due to maximum out-of-balance of the primary and secondary currents, the voltage across the rectifier will never exceed a predetermined value and hence the flux in the transformer core also cannot exceed a predetermined value.

The auxiliary winding may be tapped to provide a relative adjustment of the voltages applied to the external impedance Z and also to the voltage limiting non-linear impedance shown at S in Fig. 8. Furthermore, in order to reduce the number of ampere turns necessary to produce a given magnetization and hence induced voltage in the grid or relay windings of the balancing transformer, the core of this may be constructed of high permeability alloy.

Having thus described this invention what I claim as new therein and desire to secure by Letters Patent is:—

1. A telemetric system comprising means for producing electric currents varying in accordance with variations in one or more quantities or factors, means for producing an electric current varying in accordance with the condition of a controlled member, a transformer having windings adapted mutually to combine the said currents in such a manner that any departure from the normal value of current in any winding is adapted to cause the operation of a relay connected to a winding of the transformer, said relay controlling the supply of current to a reversible electric motor coupled with the controlled member.

2. A system of the character described comprising means for producing an electric current varying with variations in one factor, means for producing another electric current varying with the condition of a controlled member, a transformer having windings mutually combining said currents, a relay connected with a winding of the transformer and operated upon departure from the normal current in any winding of the transformer, said relay including a thermionic valve, and an electro-mechanical device coupled with the controlled member, the supply of current to the electro-mechanical device being controlled by the relay.

3. A system of the character described comprising means producing an electric current varying with variations in one factor, means producing another electric current varying with the position of a controlled member, a transformer having windings disposed mutually to combine said currents, a relay operated by departure from the normal current value of the current in any winding of the transformer, said relay including a thermionic valve with the control grid thereof connected to a grid winding of the transformer, and a reversible electric motor controlled by the relay and connected in the anode circuit of the thermionic valve and connected to the controlled member to operate it.

4. A system of the character described comprising means producing an electric current varying with variations in one factor, means producing another electric current varying with the position of a controlled member, a transformer having windings disposed mutually to combine said currents, said transformer having an auxiliary winding connected with an external variable impedance, a relay operated by departure from the normal current value of the current in any winding of the transformer, and an electro-mechanical device coupled with the controlled member, the supply of current to the electro-mechanical device being controlled by the relay.

5. A system of the character described comprising means producing a primary electric current varying with variations in one factor, means producing a secondary electric current varying with the position of a controlled member, a transformer having windings disposed mutually to combine said primary and secondary currents and to produce a resultant voltage drop across said windings, means controlling the impedance offered by the winding or windings traversed by the primary and secondary currents, a relay operated by departure from the normal current value of the current in any winding of the transformer and an electro-mechanical device coupled with the controlled member and controlled by the relay.

6. A system of the character described comprising means producing an electric current varying with variations in one factor, means producing another electric current varying with the position of a controlled member, a transformer having windings disposed mutually to combine said currents, said transformer having a core provided with a variable air gap, a relay operated by departure from the normal current value of the current in any winding of the transformer, and an electro-mechanical device coupled with the controlled member, the supply of current to the electro-mechanical device being controlled by the relay.

7. A system of the character described comprising means producing an electric current varying with variations in one factor, means producing another electric current varying with the position of a controlled member, a transformer having windings disposed mutually to combine said currents, said transformer having an auxiliary winding connected with an external impedance, means varying the value of the external impedance in accordance with the position of the controlled member, a relay operated by departure from the normal current value of the current in any winding of the transformer, and an electro-mechanical device coupled with the controlled member, the supply of current to the electro-mechanical device being controlled by the relay.

8. A system of the character described comprising means producing an electric current varying with variations in one factor, means producing another electric current varying with the position of a controlled member, a transformer having windings disposed mutually to combine said currents, said transformer having a core provided with an air gap, means varying said air gap in accordance with the position of the controlled member, a relay operated by departure from the normal current value of the current in any winding of the transformer, and an electro-mechanical device coupled with the controlled member, the supply of current to the electro-mechanical device being controlled by the relay.

9. A system of the character described comprising means producing an electric current varying with variations in one factor, means producing another electric current varying with the position of a controlled member, a transformer having windings disposed mutually to combine said currents, a relay operated by departure from the normal current value of the current in any winding in the transformer, said relay including two thermionic valves having their control grids connected to windings on the transformer, and a reversible electric motor having its windings connected in the anode circuits of said thermionic valves and connected to the controlled member to operate it.

10. A system of the character described comprising means producing an electric current varying with variations in one factor, means producing another electric current varying with the position of a controlled member, a transformer having windings disposed mutually to combine said currents, said transformer having an auxiliary winding connected to a voltage limiting device, a reversible electric motor connected to the controlled member to operate it, and a relay operated by departure from normal of the current in any winding on the transformer and controlling the supply of current to said motor.

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