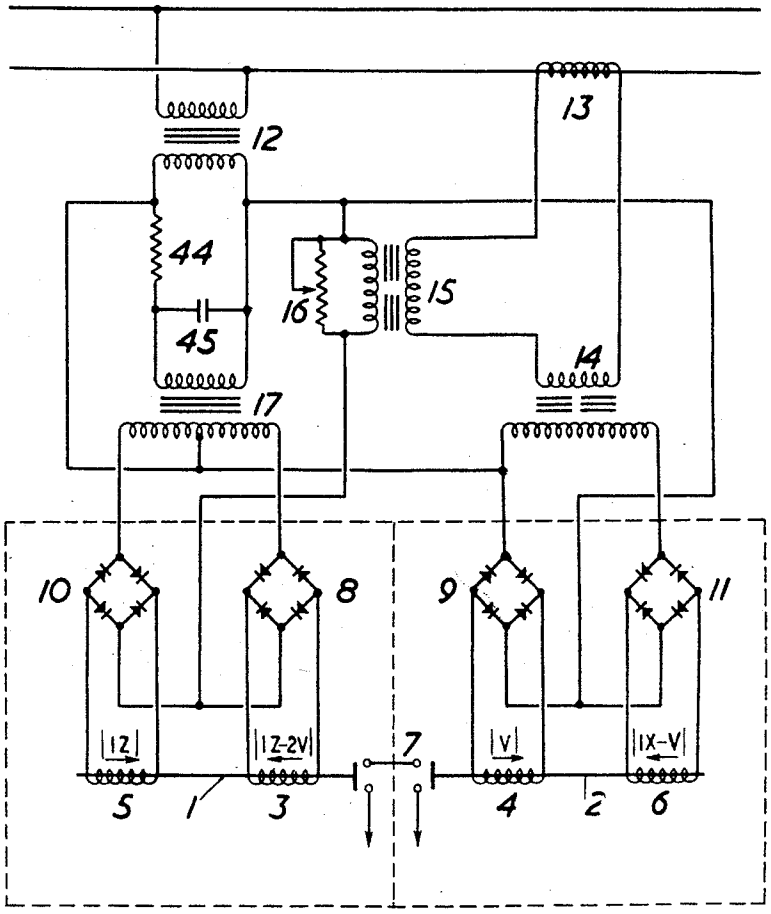
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ELECTRICAL RELAYS

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FIG. 1.

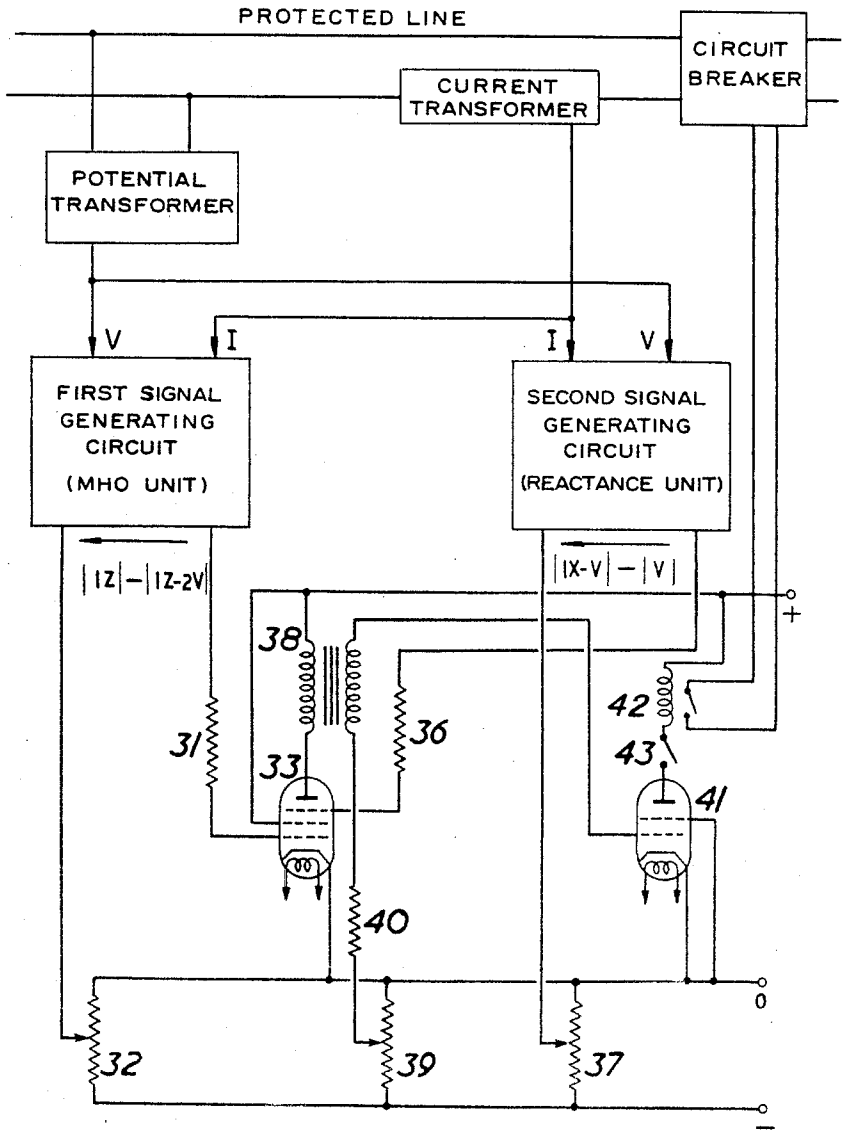


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FIG. 2.

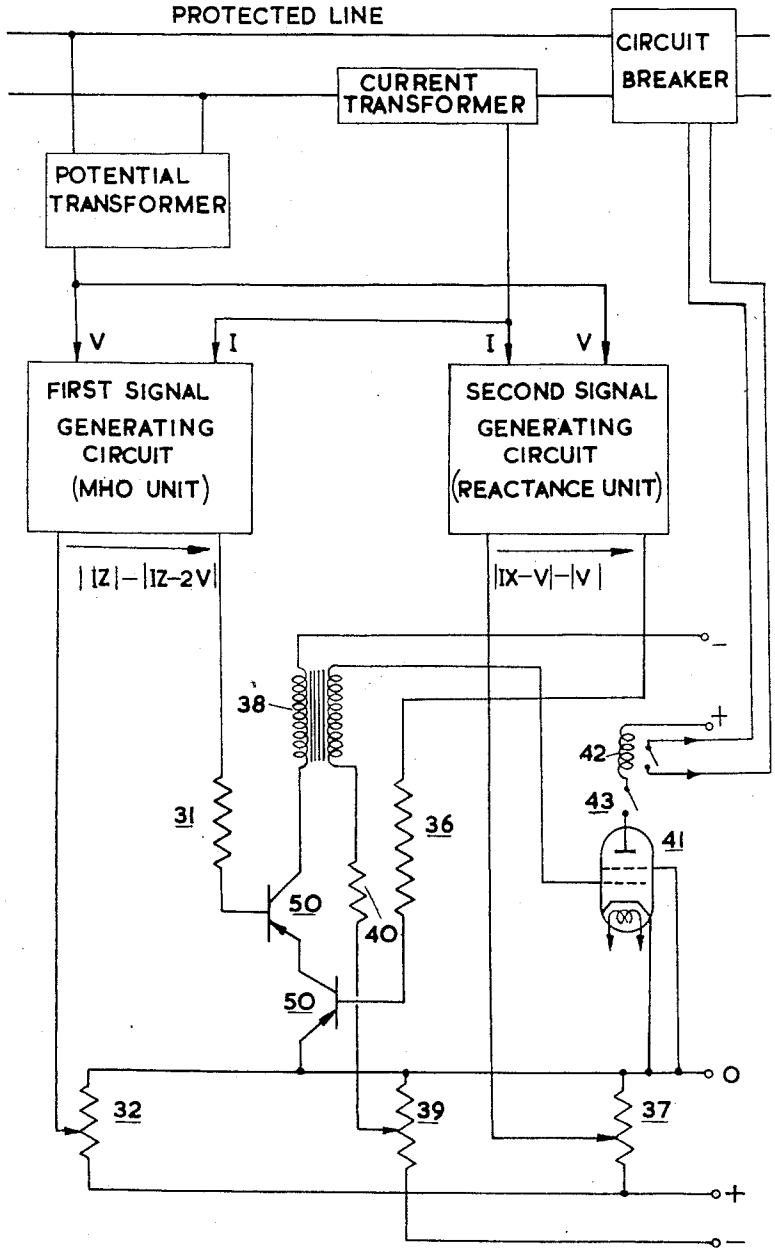


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FIG.3



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ELECTRICAL RELAYS

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Application July 12, 1954, Serial No. 442,825

Claims priority, application Great Britain August 25, 1953

3 Claims. (Cl. 317—51)

This invention relates to power network protection relay systems. It is particularly concerned with relay systems which respond to the combined action of signals provided by two distinct electrical circuits which have different response characteristics to electrical signals drawn from different parts of the network. One way previously proposed of combining the action of such signals is to cause each to operate a relay and connecting the contacts of the relays in some suitable way so that the protection system will only operate when both relays hold their contacts closed. As is known in the art, one such relay may respond to the impedance of a protected line and the other may respond to the direction of power flow in the line. A protection system of this kind has therefore a directional impedance characteristic.

It is an object of this invention to provide an improved relay system in which the use of two mechanical contactor type relay devices is eliminated by substituting an electronic valve device rendered conductive to operate the relay in response to the simultaneous action of two control signals derived from different electrical circuits that respond to signals drawn from different parts of the protected network.

Relay systems utilizing such valve devices are known (see for example U.S. Patent 2,404,643), but previous proposals have required the use of a gas discharge tube having two control grids and relay operation in dependence upon two grid control signals is then governed by the instantaneous relationship between the strengths of the control signals. Usually, however, such systems operate in dependence upon the phase relationship between the signals applied to the control grids. However, where it is required to compare the amplitudes of two alternating signals regardless of their phase relationship it becomes necessary to rectify and smooth at least one of them before effecting a comparison. Such a smoothing action can introduce difficulties leading to false relay operation. The trouble may be remedied by separating the two functions of the two-grid gas discharge valve and having the detection function promote the initiation of a trigger action.

Thus, it is in accordance with this invention for an electric power network protection relay system to comprise, in combination, two signal generating circuits each of which is adapted to respond to changes in both the current and voltage of a circuit protected by the system and generates a steady D.C. output signal that is a function of said current and said voltage, signal bias means for biasing said D.C. output signals by predetermined amounts to cause the polarities of the biased signals to depend upon the amplitudes of the output signals from said generating circuits, an electronic valve device having two control electrodes each of which responds to a different one of said biased signals to restrain the valve from conducting when either of said output signals has the appropriate polarity, an electronic trigger circuit responsive to a conductive condition of said valve device,

and an electro-responsive device adapted to perform a circuit protection function in dependence upon a triggered control exercised by said trigger circuit.

As the detection and trigger functions are in this way isolated the electronic valve device having two control electrodes can not be a gas discharge valve and may, in fact, comprise any suitable form or combination of electronic switch or switches.

Thus, according to a feature of the invention, said electronic valve device comprising a pentode vacuum tube having a short-based suppressor grid and said biased signals are applied to this grid and the control grid respectively.

According to an alternative feature of the invention, said electronic valve device comprises two transistor elements whose collector-emitter circuits are connected in series and whose bases form the two control electrodes respectively.

In order that the invention may be better understood a particular embodiment of it will be described with reference to the accompanying drawings in which:

Fig. 1 depicts two relay units having different characteristics combined in a known way to operate a protection device.

Fig. 2 depicts a schematic version of the system shown in Fig. 1 applied to a relay system according to this invention, the two-electrode electronic valve device being in this case a pentode vacuum tube.

Fig. 3 depicts an alternative form of the system shown in Fig. 2, the two-electrode electronic valve device being in this case a series combination of two transistor elements.

With reference to Fig. 1 two relay units are distinguished by the dotted lines. The relays are depicted diagrammatically by armatures **1** and **2**, operating coils **5** and **6**, restraining coils **3** and **4**, and the contact system **7**. Each of coils **3**, **4**, **5** and **6** is energized via a full wave rectifier system denoted respectively by the Graetz arrangements **8**, **9**, **10** and **11**. The signals applied to these rectifiers are some function of the current and voltage of the line to be protected. In this example a particular combination is adopted so that the invention may be better described. A signal proportional to the voltage of the protected line is derived from potential transformer **12** and a signal proportional to the current in the protected line is derived from current transformer **13**. These signals are denoted by V and I respectively. The current I flows through the primary windings of two transactors **14** and **15** connected in series. It is noted that a transactor is a reactor with a secondary winding. It affords a strong output signal in an isolated circuit proportional to the potential drop across its low primary impedance. The E.M.F. induced across the secondary winding of transactor **14** will, due to the highly inductive nature of the transactor, be capable of representation by a term IX, where X is a constant value of reactance. The E.M.F. induced across the secondary winding of transactor **15** will be capable of representation by a term IZ, where Z is a constant value of impedance. This is not purely reactive due to the adjustable resistor **16** connected across the secondary winding of transactor **15**. The signal V is applied to a two-to-one ratio step up transformer **17** having a centre-tapped secondary winding. Thus a signal V is also generated across each half of this secondary winding. Considering now the signals applied to each rectifier system in turn it is noted that rectifier arrangement **8** is energized by three signal components in series viz. a signal V from the secondary of transformer **17**, a signal V from the secondary of the transformer **12**, and a signal IZ from the transactor **15**. The

directional senses are such that the V signals add and oppose the signal IZ. Consequently, the restraining current in relay operating coil 3 will be proportional to $|IZ-2V|$, the modulus effect being due to the rectification. In the case of coil 5 the V signals are in opposition and so the operating current in coil 5 is simply proportional to $|IZ|$. Restraining coil 4 responds simply to a V signal and so carries a current proportional to $|V|$ whereas operating coil 6 responds to a signal derived from the difference between IX and V and so carries a current proportional to $|IX-V|$. Thus, the system shown in Fig. 1 is designed to close both sets of contacts in the contact system 7 and so complete a protection circuit when both of the following mathematical conditions apply.

$$|IZ-2V|<|IZ|$$
$$|IX-V|>|V|$$

The arrows indicate the directional action of coils 3, 4, 5 and 6 and the signals associated with these coils are also shown in Fig. 1.

In the above example this combination of two conditions is achieved mechanically. An alternative form for these mathematical expressions is:

$$|IZ|-|IZ-2V|>0$$
$$|IX-V|-|V|>0$$

If electrical signals can be produced which are proportional to $|IZ|-|IZ-2V|$ and $|IX-V|-|V|$ and a device responsive to the condition that these signals are simultaneously positive is utilized then the protection operation can be performed via a single relay instead of two. Such comprises one feature of the present invention.

The operating characteristic of the relay system shown in Fig. 1 is that of a combined reactance unit and a mho unit. The whole relay system is, therefore, a directional distance relay.

In Fig. 2 a diagrammatic circuit arrangement is shown whereby this feature of the invention may be carried into effect.

In Fig. 2, the relays of Fig. 1 are replaced by a static relay unit having a pentode valve and a gas discharge tube. In this case the two signal generating circuits, which function in Fig. 1 to provide the operating signals for the relays, are shown schematically and denoted respectively by "mho unit" and "reactance unit."

Referring now to Fig. 2, a signal proportional to the voltage of the protected line is derived from a potential transformer and a signal proportional to the current in the protected line is derived from a current transformer. These signals are denoted V and I respectively, as before. These circuits function respectively to generate steady D.C. output signals which are equal to $|IZ|-|IZ-2V|$ and $|IX-V|-|V|$, where Z and X represent constant values of impedance and reactance respectively and are characteristic of the corresponding signal generating circuits.

The respective output signals from the mho unit and the reactance unit, that is the first signal generating circuit and the second signal generating circuit respectively, are applied to different grids of pentode tube 33. The combined signal $|IZ|-|IZ-2V|$ is applied via the grid resistor 31, after being biased by the potentiometer 32, to the control grid of a pentode tube 33. The signal $|IX-V|-|V|$ is applied via grid resistor 36 and bias potentiometer 37 to the suppressor grid of pentode tube 33. The valve is preferably a short suppressor based valve which affords sensitive control by the two grids used above. If both of the signals $|IZ|-|IZ-2V|$ and $|IX-V|-|V|$ suddenly become positive the valve 33 will allow current to flow from a high tension source via the primary of a coupling transformer 38 connected in its anode circuit. The secondary of transformer 38 connects a source of bias 39 via a high resistance of resistor 40 to the control grid of a gas filled tube 41. Thus, when the signals applied to the control and suppressor grids of the tube 33 are both simultaneously strong enough to render the tube conductive the primary winding of transformer 38 becomes in effect connected across the H.T. supply and is energized suddenly with the result that an E.M.F. is induced in the secondary of the transformer. This initiates a discharge in tube 41. The load element 42 in the anode circuit may be a tripping circuit or a relay operating a coil, the relay being arranged to perform a tripping function. It may have extra contacts to open switch 43 and permit the protecting system to reset. Alternatively, 42 may be a tripping circuit of a circuit breaker or other protection device and the switch 43 may be a contact switch on the breaker or this device. The tube 41 may be of the type which permits many amperes of current to flow for a small period.

Such tubes are available commercially and their capacity is being increased. A typical tube has the commercial symbol 2D21 and this tube allows a current of 10 amps. to flow provided it is interrupted within 0.1 of a second after the discharge is initiated. This is strong enough to trip some circuit breakers directly without the use of auxiliary relay devices. There is also the thyratron tube having the symbol 3D22 which will pass 30 amps. for long enough to trip a circuit breaker. Thus the relay can be made wholly independent of mechanical movement in its operation.

It is noted that the resistor 44 and capacitor 45 of Fig. 1 are used to endow the protection system with a form of "memory action" which assists in the response on faults which cause a reduction in strength of the signal V. This form of "memory action" has been described in our co-pending British patent application Serial No. 24,143/53 (Patent No. 750,696). It is further noted that the heater circuits of the tubes may be energized from a voltage signal drawn from the line.

The electronic tube which responds to two control signals can be replaced by a series combination of transistor elements.

Such a modification is shown in Fig. 3. Here, the tube 33 is replaced by two transistors denoted 50. The transistors are connected in series and form an electronic valve having two control electrodes. These electrodes are respectively the bases of the transistors. In operation, the circuit shown in Fig. 3 functions in a similar manner to that shown in Fig. 2 but it is to be noted that the polarities of the control signals and power supplies have been reversed in order to adapt the transistorized version of the circuit for analogous operation.

What I claim as my invention and desire to secure by Letters Patent is:

1. An electric power network protection relay system comprising, in combination, two signal generating circuits each of which is adapted to respond to changes in both the current and voltage of a circuit protected by the system and generates a steady D.C. output signal that is a function of said current and said voltage, signal bias means for biasing said D.C. output signals by predetermined amounts to cause the polarities of the biased signals to depend upon the amplitudes of the output signals from said generating circuits, an electronic valve device having two control electrodes each of which responds to a different one of said biased signals to restrain the valve from conducting when either of said output signals has the appropriate polarity, an electronic trigger circuit responsive to a conductive condition of said valve device, and an electro-responsive device adapted to perform a circuit protection function in dependence upon a triggered control exercised by said trigger circuit.

2. An electrical power network protection relay sys-

tem according to claim 1, wherein said electronic valve device comprises a pentode vacuum tube having a short-based suppressor grid and said biased signals are applied to this grid and the control grid respectively.

3. An electrical power network protection relay system according to claim 1, wherein said electronic valve device comprises two transistor elements whose collector-emitter circuits are connected in series and whose bases form the two control electrodes respectively.

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