

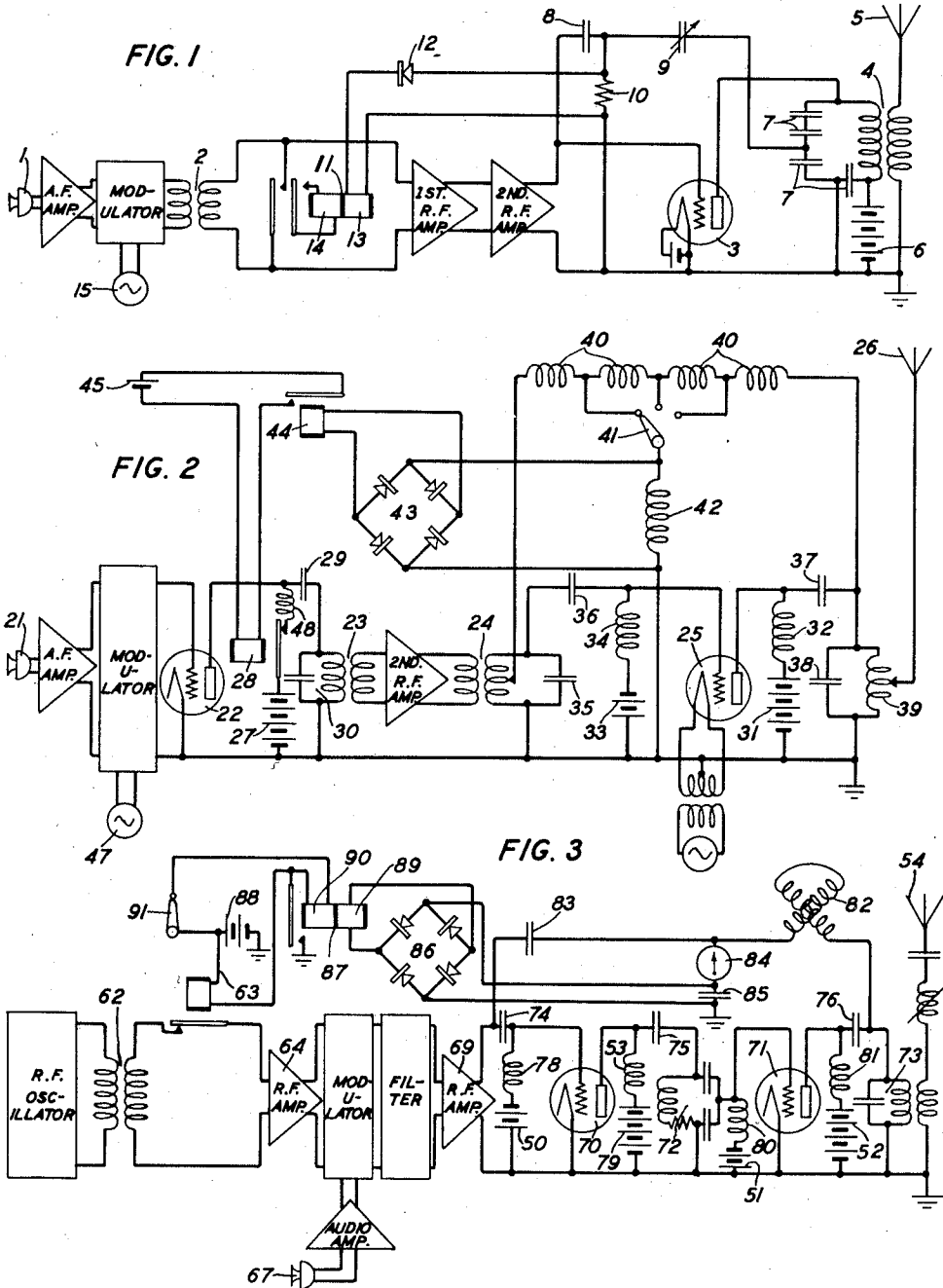
Jan. 5, 1937.

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2,066,522

PROTECTIVE SYSTEM AND METHOD

Filed Dec. 19, 1934



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2,066,522

PROTECTIVE SYSTEM AND METHOD

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Application December 19, 1934, Serial No. 758,171

10 Claims. (Cl. 250—36)

This invention relates to protective systems and methods and more particularly to a system and method for protecting apparatus employed in radio communication systems.

5 An object of this invention is to protect an electrical circuit from the consequences of variations in the constants of the circuit.

A more particular object of this invention is to prevent damage to apparatus of a radio system resulting from circuit changes occurring during the operation of the system.

In radio transmitting systems, particularly those employed in transoceanic communications, variations in the circuit constants of the systems occur from time to time. Then, too, occasionally a part of these systems becomes open or short-circuited. A knowledge of the occurrence of these conditions or the disability of a radio transmitting system as long as the conditions exist is vital for the proper functioning of the system. The short-circuiting of a part of the system is especially important since, if it is not removed quickly, considerable damage to associated apparatus invariably results.

25 The phase relation and the relative magnitudes of the electromotive forces across various parts of a radio transmitting system are determined by the constants of the circuit. When the constants of a part of the circuit are changed or when an open or short circuit exists in that part of the circuit, the electromotive force across that part of the circuit is altered in phase, or magnitude, or both with respect to the electromotive force across another part of the system. This variation in the phase or amplitude relation of the electromotive forces across different parts of the circuit is caused by a change in the impedance of one or several parts of the circuit. For example, the output electromotive force of a space discharge device employed in a radio transmitting system is opposite in phase and proportional in amplitude to the input electromotive force. When the output circuit becomes short-circuited or open or is detuned, the impedance of that circuit is altered. As a result, the relation of the phase or amplitude of the input and output electromotive forces is changed.

In accordance with this invention, variations in the impedance of a circuit with the resulting changes in phase or amplitude relation of the electromotive forces when a material change in the constants of the circuit occurs disables the circuit. The relative phase or amplitude changes of the potential differences across two impedances respectively associated with two parts

of the circuit actuate means to disable the circuit whenever variations in the impedance of one part of the circuit occur.

In a specific embodiment two high impedances are associated respectively with the input and output circuits of a space discharge device employed in a radio frequency power amplifier. Normally, the space discharge device of a radio frequency power amplifier is associated with a system which is tuned so that the output circuit has no reactance. Under these conditions the output electromotive force of the device is proportional to the input electromotive force and 180 degrees out of phase with it. Accordingly, when two impedances of the same nature having the proper relative magnitudes are respectively associated with the input and output circuits of the device and the system is tuned, no radio frequency current flows between the junction point of these impedances and ground. Any short circuit or other abnormality which changes the impedance of the output circuit changes the phase, or magnitude, or both of the output electromotive force thereby causing a current to flow between the junction point and ground. Means responsive to the passage of current between the junction point and ground removes the input of an earlier stage of the system or otherwise disables the system. This means is adjusted to prevent its actuation for slight changes in the impedance of the output circuit.

A more comprehensive understanding of this invention is obtained by reference to the accompanying drawing in which:

Fig. 1 is a schematic diagram of an embodiment of this invention in which two high impedances comprising chiefly capacitance are employed to disable the input circuit of a radio communication system when variations in the constants of the circuits of the system occur;

Fig. 2 is a schematic diagram illustrating an embodiment in which the impedance elements are inductance and the supply of current is removed when abnormalities are produced in a radio communication system; and

Fig. 3 is a schematic diagram of an embodiment of this invention in which two impedances of different types are used to remove the oscillator from a radio system when variations in the constants of the circuits of the system exist.

In Fig. 1, a radio communication system is shown. A microphone 1 is connected to an audio frequency amplifier. The audio frequency amplifier is connected to a modulator supplied with radio frequency energy by the oscillator 15.

The modulated radio frequency current from the modulator passes through a transformer 2 to a first radio frequency amplifier and then through a second radio frequency amplifier to the input of a power amplifier comprising a space discharge device 3. From the output of the power amplifier 3 the radio frequency currents pass through a coupling transformer 4 to an antenna 5. Space current for the device 3 is supplied by a unidirectional source 6 through one of the windings of the coupling transformer 4. A plurality of condensers 7 are connected in parallel with one of the windings of the coupling transformer to form a tuned circuit.

A condenser 8 is connected at one terminal to the input circuit of the device 3, while the other terminal is connected through a resistance 10 to ground. The resistance 10 may be any type of impedance element—resistance, capacitance or inductance. One terminal of a variable condenser 9 is connected to the output circuit of the device 3 between two of the plurality of condensers 7, while the other terminal of variable condenser 9 is connected through the resistance 10 to ground. The condensers 8 and 9 may be any other type of impedance elements such as resistance or inductance. Bridged across the resistance 10 is the operating winding 13 of a relay 11. A copper-oxide rectifier 12 is inserted in series with winding 13 of relay 11. One make contact and armature of the relay 11 are shunted across the input circuit of the first radio frequency amplifier. Another make contact and armature of the relay 11 serve to short-circuit an additional winding 14 of relay 11 to provide a delay reopening.

When variations in the impedance of the output circuit of the power amplifier 3 occur, due to the short-circuiting of one of the elements of the output circuit, for example, the relative phase or amplitude of electromotive force of the output circuit with respect to the other part of the system is changed. The impedance elements 8 and 9 are adjusted so that when the system is functioning normally, the currents flowing through these elements are equal. The condenser 9 is variable to facilitate this adjustment. Since normally the system shown in Fig. 1 is tuned, the output circuit has no reactance and the output electromotive force of the device 3 is proportional to the input electromotive force and 180 degrees out of phase with it. As a result, no radio frequency current passes between the junction points of the condensers 8 and 9 and ground. When, however, the impedance of the output circuit changes due to short-circuits or other abnormalities, the phase or magnitude, or both, of the output electromotive force is changed and the normal relationship between the phase and magnitude of the electromotive force of the input and output circuits is destroyed. As a result, radio frequency current passes through the resistance 10. Part of this radio frequency current passing through the copper-oxide rectifier 12 actuates the relay 11 to engage the armatures and make contacts of that relay. The engagement of one armature and make contact of relay 11 results in the disability of the input circuit of the first radio frequency amplifier. The engagement of the other armature and make contact of relay 11 results in the short-circuiting of winding 14.

The delay reopening winding 14 with its associated armature and make contact is provided in order that the disability of the system may

be effected for a short period after the relay 11 has been energized. Other delay reopening devices may be employed for this purpose. If no delay reopening device is provided for the relay 11, only a momentary disability of the system results.

It is observed that one side of the condenser 9 connected to the plurality of condensers 7 is associated with those condensers so that only a portion of the output electromotive force is impressed upon the condenser 9. Since the electromotive force in the output circuit is considerably greater than that of the input circuit, this practice affords a convenient method of rendering equal the electromotive forces impressed on the condensers 8 and 9 associated with the input and output circuits, respectively. If the plurality of condensers 7 are sufficient in number to provide a fine variation, it is not necessary to have condenser 9 variable.

Fig. 2 shows a radio communication system embodying this invention in which inductances are employed instead of capacitances and the disability of the system is effected by removing the supply of plate current from at least one of the space discharge devices of the system. Voice frequency current passes from the microphone 21 through an audio frequency amplifier to a modulator. Radio frequency energy is supplied by an oscillator 47 to the modulator. The modulated radio frequency current passes from the modulator to a first radio frequency amplifier comprising a space discharge device 22. A second radio frequency amplifier is coupled to the output of the first radio frequency amplifier through a coupling transformer 23. From the output of the second radio frequency amplifier the radio frequency currents pass through a coupling transformer 24 to a power amplifier comprising a space discharge device 25. The output of the power amplifier is connected to an antenna 26 and ground.

Space current is supplied to space discharge device 22 by a unidirectional source 27 through a choke coil 48 and the armature and break contact of a relay 28. Two condensers 29 and 30 are connected in series in the output of the space discharge device 22, condenser 30 being parallel with one of the windings of the coupling transformer 23 to form a resonant circuit. Space current for the device 25 is supplied by a unidirectional source 31 through a choke coil 32. A bias for the control electrode of device 25 is furnished by a battery 33 through a choke coil 34. Two condensers 35 and 36 are connected in series in the input circuit of device 25, condenser 35 being shunted across one of the windings of the coupling transformer 24 to form a resonant circuit. Likewise, two condensers 37 and 38 are connected to the output of space discharge device 25, the condenser 38 forming a resonant circuit with inductance 39 to which the antenna 26 is connected. Condensers 36 and 37 are preferably of low reactance so that there is no appreciable radio frequency potential difference across either of them.

A plurality of inductances 40 are connected to the input and output circuits of the power amplifier comprising the device 25. The connection to the input circuit is accomplished by means of a tap on the winding of the coupling transformer 24 in the input circuit of the device 25. A switch 41 is provided by which any proportion of the plurality of inductances 40 may be connected in the input or output circuits and ground

through an impedance element 42. The element 42 may be any type of impedance. Two terminals of a full-wave copper-oxide rectifier 43 are connected in parallel to the element 42. The two other terminals of the rectifier 43 are connected to a relay 44. The engagement of the armature and make contact of relay 44 causes energy to be supplied to relay 28 from a battery 45.

After the system shown in Fig. 2 has been tuned, the plurality of inductances 40 are balanced so that no appreciable current passes through the element 42. This balancing is accomplished by means of the switch 41, or by means of the tap connecting the inductances to the winding of the coupling transformer 24. If abnormalities occur in the output circuit of the power amplifier comprising the space discharge device 25, such, for example, as a short circuit in the output circuit of device 25, the change in impedance of the output circuit changes the phase or magnitude or both of the output electromotive force resulting in a current flow through the element 42. As a result of radio frequency current passing through the full wave rectifier 43, the relay 44 is energized to engage its armature and make contact. As a result, relay 28 is also energized to disengage its armature from the break contact thereby removing the source of anode current 27 from the anode of device 22. This latter action results in the disability of the first radio frequency amplifier.

Fig. 3 shows an embodiment of this invention in which more than one stage of amplification is included between input and output circuits, the voltages of which are to be balanced, and in which the input and output voltages instead of having opposite phases have the same phase.

A radio frequency oscillator is coupled by means of a transformer 62 through the break contact and armature of a relay 63 to a radio frequency amplifier 64. The output of the amplifier is connected to a modulator. Audio frequency currents are supplied to the modulator through an audio frequency amplifier from a microphone 67. Modulated radio frequency energy passes from the modulator through a band filter. The filter eliminates the carrier and one sideband for single sideband transmission. The remaining sideband passes through a low power radio frequency amplifier 69, two stages of power amplification comprising space discharge devices 70 and 71, and an antenna coupling circuit 73 to an antenna 54. Interstage coupling between the space discharge devices 70 and 71 is provided by a coupling circuit 72. Three blocking condensers 74, 75 and 76 are connected in the input circuit of device 70, the output circuit of device 70 and the output circuit of device 71, respectively. Biasing potentials for devices 70 and 71 are furnished by batteries 50 and 51 through choke coils 78 and 80, respectively. The anode current for devices 70 and 71 is supplied by unidirectional sources 79 and 52 through coils 53 and 81, respectively.

Interstage coupling circuit 72 is of a nature such that no phase shift is introduced between the anode potential of space discharge device 70 and the control electrode potential of space discharge device 71. Since the anode potentials of 70 and 71 are opposite in phase to their respective control electrode potentials, the anode potential of device 71 has the same phase as the control electrode potential of device 70. The

two equal currents of opposite phase necessary for balancing the protective device may be obtained by employing, as the high impedances of the protective circuit, two reactances of opposite sign, such as an inductance 82 and a condenser 83 connected respectively (or, if desired, in reverse order) to the anode circuit of 71 and the control electrode circuit of 70. An impedance element such as a condenser 85 and a radio frequency ammeter 84 in series are connected between ground and the common connecting point of impedance elements 83 and 82. Inductance element 82 is variable to permit balancing to be obtained, balancing being indicated by a zero reading on the radio frequency ammeter 84.

Two terminals of a full wave copper-oxide rectifier 86 are connected across the impedance element 85. Two other terminals are connected to the operating winding 89 of a relay 87. A relay 63 is energized by the engagement of the armature and make contact of relay 87, current being supplied by a source 88. The disengagement of the armature and break contact of relay 63 disconnects the oscillator from the system. An auxiliary or holding winding 90 of relay 87, the energization of which is accomplished by the engagement of the armature and make contact of relay 87 through a normally closed switch 91, insures the disability of the system until the switch 91 is opened.

When the system is tuned and no abnormality exists, the impedance elements 83 and 82 are balanced by adjusting the variable inductance 82. Balance is indicated by a zero reading on the radio frequency ammeter 84. If the system becomes unbalanced as a result of trouble conditions, current flows through impedance element 85 causing a radio frequency voltage to be impressed upon rectifier 86. The direct current output of rectifier 86 operates relay 87 closing the circuit from the control voltage supply 88 through the winding of relay 63 and also through the holding winding 90 of relay 87. Relay 63 operates, removing the supply of radio frequency potential from the amplifier 64. The transmitting system is thereby disabled until the operator restores it to its operative condition by opening momentarily the normally closed switch 91.

The utility of this invention is not limited to the application where a zero degree or one hundred and eighty degree phase relation exists between the two radio frequency electromotive forces which are to be balanced. For example, if the interstage coupling circuit 72 of Fig. 3 is replaced by a coupling circuit having a ninety degree phase shift, the system can be balanced by employing for one of the two high impedances of the protecting system a resistance and for the other a reactance of appropriate sign. Again, if an interstage coupling circuit having some other phase angle is to be used, combinations of resistance and reactance could be employed in the protective circuit to produce the required two currents of equal magnitude in opposite phase. The zero degree and one hundred eighty degree relations which have been illustrated are however far more common in practice.

While preferred embodiments of this invention have been illustrated and described, various modifications therein may be made without departing from the scope of the appended claims.

What is claimed is:

1. A radio system comprising an oscillator for supplying said system with sustained oscillations, a power amplifier, input and output cir-

cuits connected thereto, an impedance element connected to each of said circuits and means responsive to an unbalance of the potentials across said element for removing said oscillator from said system.

2. In combination, a unilateral repeating device for repeating electrical oscillations, input and output circuits connected thereto, a source of oscillations included in said input circuit, means for deriving a first voltage from said input circuit, means for deriving a second voltage from the oscillations repeated in said output circuit which is substantially equal in magnitude and opposite in phase to said first voltage under normal operating conditions of said device, and means responsive to changes in the vector sum of said voltages for disabling said device.

3. In combination, a unilateral repeating device for repeating electrical oscillations, input and output circuits connected thereto, a source of oscillations included in said input circuit, oscillation responsive means for disabling said device, means for deriving a first voltage from said input circuit, means for deriving a second voltage from the oscillations repeated in said output circuit which is substantially equal in magnitude and opposite in phase to said first voltage under normal operating conditions of said device, and means for impressing said voltages differentially upon said oscillation responsive means.

4. In an alternating current system, a unilateral amplifying device, input and output circuits connected thereto, a source of oscillations included in said input circuit, an impedance element, means for deriving from the oscillations in said input circuit and from the oscillations repeated in said output circuit respectively two voltages which are substantially equal in magnitude and opposite in phase under normal operating conditions of said device, means for impressing said voltages differentially upon said impedance element, and means responsive to a fall of potential in said element for disabling said device.

5. In an alternating current system, a space discharge amplifier, input and output circuits connected thereto, a source of oscillations included in said input circuit, an impedance element, a first circuit including said impedance element and at least a portion of said input circuit, a second circuit including said impedance element and at least a portion of said output circuit, means included in said first and second circuits for normally balancing the voltages across said element due to the oscillations in said input circuit and to the amplified oscillations in said output circuit, and means responsive to a voltage drop across said element for disabling said amplifier.

6. In a high frequency system, a space discharge amplifier having an anode, a cathode, and a control electrode, an oscillation source connected to said grid and said cathode, an oscillatory circuit tuned to the frequency of said source connected to said anode and said cathode, a path including a plurality of similar impedances

in series extending between said grid and a point in said oscillatory circuit, an impedance element connected between said cathode and a point in said path normally at the same high frequency potential as the cathode, and means responsive to a flow of current in said impedance element for disabling said amplifier.

7. In a high frequency system, a power amplifier comprising a plurality of space discharge devices connected in cascade, input and output circuits connected thereto, an oscillation source included in said input circuit, oscillation responsive means for disabling said input circuit, a first circuit including said oscillation responsive means, an impedance element, and at least a portion of said input circuit, a second circuit including said oscillation responsive means, a second impedance element, and at least a portion of said output circuit, said impedance elements being of unlike character and being so proportioned that the voltages across the said oscillation responsive device due respectively to the oscillations in said input circuit and the amplified oscillations in said output circuit are substantially balanced under normal operating conditions of the system.

8. In a high frequency system, a power amplifier comprising a plurality of space discharge devices connected in cascade and having their cathodes at a common high frequency potential, input and output circuit connected to said amplifier, an oscillation source included in said input circuit, a plurality of unlike impedances forming a path extending between a point in said input circuit and a point in said output circuit, said impedances being proportioned to make the potential at an intermediate point in said path substantially equal to the common potential of the cathodes of said devices under normal operating conditions, an impedance element connected between said intermediate point and said cathodes, and means responsive to an oscillating potential drop across said impedance element for disabling said input circuit.

9. In a high frequency system, a space discharge amplifier, input and output circuits therefor, an oscillation source included in said input circuit, an impedance element, circuit connections for impressing a voltage from said source on said element, circuit connection for impressing a substantially equal oppositely phased voltage from said output circuit on said element, and means responsive to an unbalance of said voltages for disabling said oscillation source.

10. In an alternating current system comprising a space discharge amplifier, input and output circuits therefor, and an oscillation source connected to said input circuit, a protective system comprising means for balancing under normal operating conditions of said amplifier a portion of the amplified oscillatory voltage against a portion of the input voltage of said amplifier, and means responsive to an unbalance of said normally balanced voltages for disabling said amplifier.

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