FIG. 1

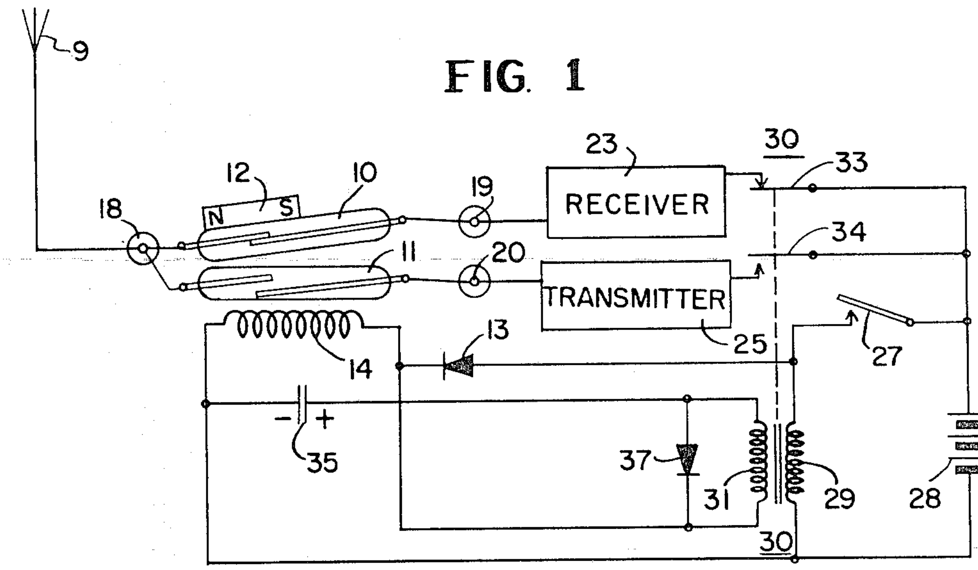


FIG. 2

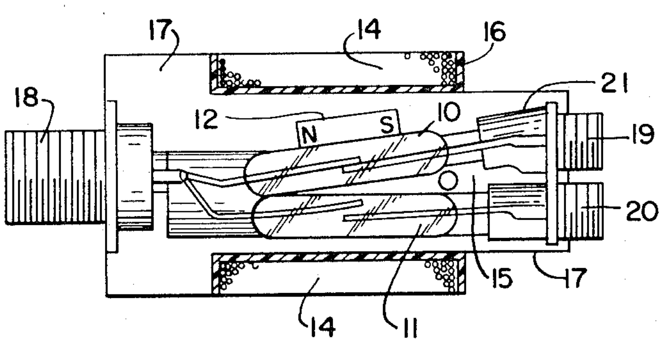


FIG. 3

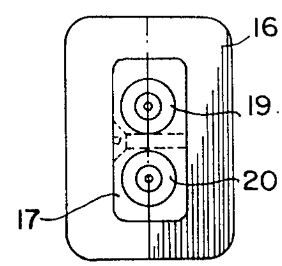
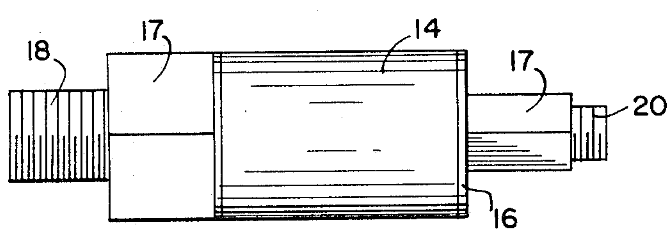


FIG. 4



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United States Patent

[11] 3,562,597

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[45] Patented Feb. 9, 1971
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Continuation-in-part of application Ser. No. 772,319, Oct. 31, 1968, now abandoned.

[54] **RF COAXIAL RELAY**
9 Claims, 4 Drawing Figs.

[52] U.S. Cl. 317/137, 317/141, 317/157; 335/5, 335/153
[51] Int. Cl. H01h 51/27, H01h 1/66, H01h 47/00
[50] Field of Search .... 335/4, 5; 325/15; 317/141, 137, 157; 307/154, (Inquired)

[56] **References Cited**

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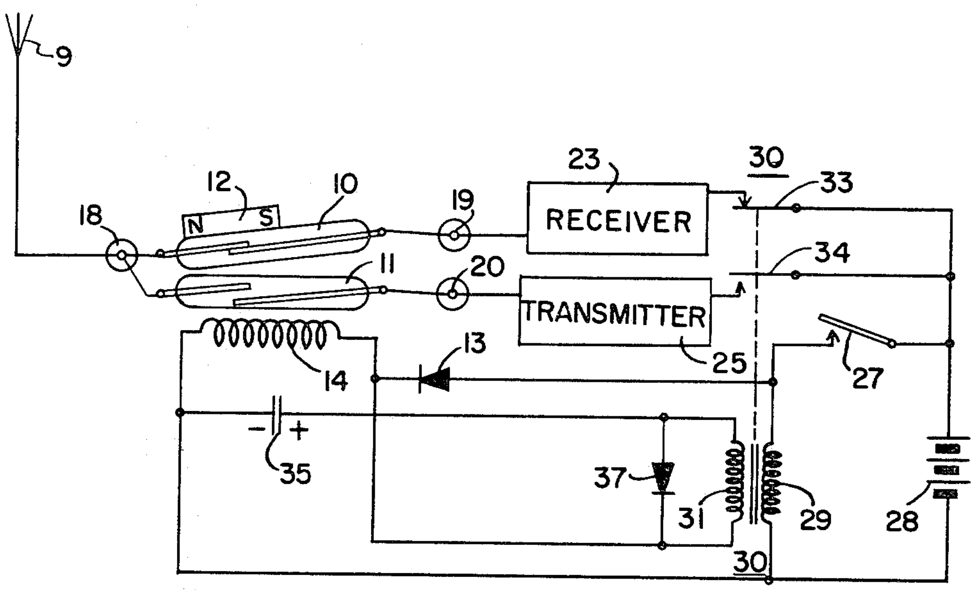
ABSTRACT: A radio frequency (RF) coaxial relay for connecting either of two coaxial terminals coupled, respectively, to a radio receiver and a radio transmitter, to a third coaxial terminal coupled to an antenna, includes a pair of magnetically actuated reed switches located within a cast nonmagnetic conductive housing. The reed contacts are capable of carrying high currents but are incapable of switching high currents, so that a sequencing circuit is provided so that the contacts of the reed switch coupled to the transmitter do not switch the transmitter when power is applied therefrom. In addition, the switch leaves of the reeds are copper-plated in order to cause the RF resistance of the reed switches to be low.



RF COAXIAL RELAY

This application is a continuation-in-part of application, Ser. No. 722,319, now abandoned filed Oct. 31, 1968.

BACKGROUND OF THE INVENTION

A number of applications exist requiring a relay capable of switching connections between three conductors meeting at a common point to form a "Y" junction, that is, a relay which can connect either of two input terminals to a single output terminal. Among useful applications for such a relay or connector to connect coaxial lines to one another are IF switching in microwave networks, transmit-receive antenna switching in two-way radio equipment, switching pulse-code modulated data in telemetering systems, or in switching branch cables in submarine cable systems. Coaxial relays for effecting such switching in response to external control signals exist in the art, but some existing coaxial relays can be operated in only one position. Other relays of this type utilize relatively complex switching devices having three or more terminals or requiring more than a single operating coil. In addition, for RF applications, it is necessary for the relay to switch and carry large currents and voltages. This results in a relatively expensive relay.

Thus, it is desirable to provide an RF coaxial relay for interconnecting either of two coaxial lines to a third, where the relay may be operated in any position, is uneffected by a hostile operating environment including dirt, dust, moisture and the like, and where the relay is inexpensive; so that it can be used in a wider range of applications than is possible with existing relays.

In the case of a relay antenna connector, for connecting either the receiving unit or the transmitting unit to the antenna, it also is desirable for the relay to serve as an equipment interface connector as well as the antenna connector.

SUMMARY OF THE INVENTION

It is an object of this invention to provide an improved RF coaxial relay system.

It is another object of this invention to provide a coaxial antenna switch system for a two-way radio where operation of the antenna switch is sequenced with the application of power to the transmitter and receiver so that the antenna switch does not switch high currents and voltages.

In a preferred embodiment of the invention, first and second two-terminal magnetic switching devices operate to close a circuit therethrough to an antenna under the influence of a magnetic field. One terminal of each switching device is connected to a common point, and one of the switching devices is provided with a magnetic bias to cause it to be closed in the unenergized condition, while the other switching device remains open. The normally closed device is connected to a radio receiver and the other switching device is connected to a radio transmitter. To effect switching of the relay from the normally closed switching device to the other switching device, a means is provided for applying a magnetic field simultaneously to both devices, wherein the applied field opposes the biasing field for the normally closed switching device. This causes the closed switching device to open and the normally open switching device to close to effect switching of the relay. To prevent the device connected to the transmitter from switching high currents and voltages, operation of the relay is sequenced with the application and removal of operating power to the transmitter, so that power is applied to the transmitter after the device is closed and is removed from the transmitter before the device is opened.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a schematic wiring diagram of a preferred embodiment of the invention;

FIG. 2 is a partially cut away plan view illustrating the construction of the relay in accordance with a preferred embodiment of the invention; and

FIGS. 3 and 4 are end and top views, respectively, of the relay shown in FIG. 2.

DETAILED DESCRIPTION

Referring now to the drawing, wherein the same reference numerals are used to designate the same elements in all of the FIGS., there is shown a coaxial reed relay consisting of two magnetically operated, glass-enclosed reed switches **10** and **11**. The switches **10** and **11** each include a pair of reed contacts terminating in an electrode extending through opposite ends of the glass envelopes of the switches **10** and **11**. The electrodes may be formed separately from the contacts or the contacts and electrodes may be of unit or single-piece construction. The reed contacts within the switches **10** and **11** are normally open, and close upon being subjected to a magnetic field extending parallel to the longitudinal direction of the reed contacts as viewed in FIGS. **1** and **2**. The electrodes extending from the left-hand end of the reed switches **10** and **11** as seen in FIGS. **1** and **2** are connected together in common to the center terminal of a coaxial connector **18** which may be connected externally to an antenna **9**. The other electrodes of the reed switch **10** is connected to the center terminal of a coaxial connector **19** connected to a radio receiver **23**, while the other terminal of the reed switch **11** is connected to the center terminal of a coaxial connector **20** connected to a radio transmitter **25**.

In order to cause the relay including the reed switches **10** and **11** to operate as a single-pole double-throw switch between the antenna terminal and the receiver and transmitter terminals, a permanent magnet **12** is located adjacent the reed switch **10**, causing a permanent magnetic field to bias the contact of the reed switch **10** into their closed position. Thus, the antenna is normally connected to the receiver **23** through the switch **10**; and the contacts in the reed switch **11** are normally open in the absence of any other external magnetic field applied to the relay, since the field of the magnet **12** in the region occupied by the switch **11** is not strong enough to close the contacts in the switch **11**.

When it is desired to switch the relay to disconnect the receiver from the antenna and to connect the transmitter to the antenna, and to switch the power from the receiver **23** to the transmitter **25**, a push-to-talk or transmit switch **27** is closed to apply DC current from a DC source **28** through an operating coil in the form of a primary winding **29** of a receive/transmit relay **30**, also having a secondary winding **31**. At the same time, DC current is applied through a diode **13** and an operating coil **14**, which is located adjacent the switches **10** and **11**. The magnetic field created by current passing through the coil **14** opposes the field of the biasing magnet **12** in the region of the switch **10** and is of sufficient magnitude to overcome the effects of the magnetic bias provided by the permanent magnet **12**, thereby causing the contacts in the reed switch **10** to open. At the same time, the contacts located within the reed switch **11** close under the influence of the magnetic field generated by the coil **14** when DC current flows therethrough. Thus, so long as current is present flowing through the coil **14** in the direction indicated by the diode **13**, the contacts of the reed switch **11** are closed and the contacts of the reed switch **10** are open.

The current passed by the diode **13** also passes through the secondary winding **31** of the two winding relay **30**, opposing the flux buildup in the relay **30** which is generated by the current flowing through the primary winding **29**, so that the contacts **33** and **34** of the relay **30** remain in the position shown in FIG. **1**. The current flowing through the secondary winding **31** also charges a capacitor **35** to the polarity indicated in FIG. **1**. When the capacitor **35** is charged (after the contacts of the reed switch **11** are closed and the contacts of the switch **10** are open), the current flow through the secondary winding **31** of the relay **30** decreases; and the relay **30** is operated by the flux buildup caused by the current flowing through the winding **29**. When this happens, the switch contacts **33** open and the switch contacts **34** close to apply power to the transmitter **25**, the output of which then is applied through the already closed contacts of the reed switch **11** to the antenna **9**. As a result, the reed switch contacts **11** are closed before the application of power from the transmitter **25** to the reed **11**.

When it is desired to switch back to the receiver mode of operation, the push-to-talk switch 27 is opened to the position shown in FIG. 1. This then breaks the DC current paths to the windings 29 and 14 from the battery 28, and the flux in the windings 29 and 31 of the relay 30 immediately collapses. The contacts 33 and 34 then immediately switch to the position shown in FIG. 1, breaking the application of power to the transmitter 25 and reapplying power to the receiver 23 from the battery 28. The current flow through the winding 14, however, is continued by the discharge of the capacitor 35 through the diode 37 to maintain the current flowing through the winding 14 thereby causing the contacts of the reed switch 11 to remain closed and the contacts of the switch 10 to remain open until after the contacts 34 are opened and the contacts 33 are closed by the deenergization or release of the relay 30.

After the capacitor 35 has discharged, current ceases flowing through the winding 14; and the reed switches 10 and 11, revert to the state of operation shown in FIG. 1, with the contacts of the switch 10 being closed and the contacts of the switch 11 being opened. Once, again, it should be noted that the switch 11 opens after power ceases to be applied to the transmitter 25, so that no high voltage or high current is ever switched by the contacts of the reed switch 11.

By sequencing the operation of the reed switches 10 and 11 with the application and removal of operating power to the transmitter 25, it is possible to use relatively inexpensive reed switches since no high voltage or high current is switched by the reed switches 10 and 11. In order to permit the reed switches to carry high RF currents after switching, the reed switch leaves, including the contacts and conductors, are copper plated, causing them to have a low RF resistance, keeping the insertion losses of the relays less than 0.1 Db up to 450 MHz.

Referring now to FIGS. 2, 3 and 4, there are shown side, end and top views of the physical structure of the reed relay illustrated schematically in FIG. 1, with a portion removed in FIG. 2 to show the arrangement of the elements.

The coaxial relay shown in FIGS. 2, 3 and 4 consists of a cast housing 17 made of two joined sections (one of which is shown in FIG. 2) of an electrically conductive but nonmagnetic material, such as aluminum. Located within the housing 17 is an opening 21 of sufficient size to house the two reed switches 10 and 11 and the permanent magnet 12. The switches 10 and 11 are separated from one another by a portion of the housing in the form of a tongue 15 to form two independent coaxial lines from the connectors 19 to 18 and connectors 20 to 18, respectively; and the magnet 12 is located on the upper side of the switch 10 somewhat remote from the reed switch 11. Thus, the magnetic field surrounding the magnet 12 has negligible effect on the contacts within the reed switch 11, but does cause the contacts within the reed switch 10 to be in their closed position in the absence of any other external field. The coil 14 is wound concentrically around a removable bobbin 16 which then is applied to the housing 17, so that the coil 14 induces a magnetic field within the housing 17 in the area occupied by both of the reed switches 10 and 11 whenever current is passed through the coil 14.

An RF coaxial connector 18, to be connected to the antenna, is shown mounted on the left end of the housing 17 in electrical connection therewith; so that the outer conductor of the connector 18 is connected to the housing 17, which forms the outer conductor of the coaxial cable connection between the connector 18 and the housing 17. The inner conductor of the connector 18 is connected in common to the first electrodes extending from the left-hand end of each of the reed switches 10 and 11. It should be noted that the connector 18 also could be mounted on the housing 17 at right angles to the switches 10 and 11 if so desired.

At the other end of the housing 17, a pair of coaxial connectors 19 and 20, adapted to be connected to the receiver and transmitter, respectively, are connected to the housing 17, so that the outer conductors of the coaxial cables terminating in the connectors 19 and 20 are electrically connected to the housing 17 and the tongue 15 which provide the outer conductor for the coaxial switch. The inner conductor of the connector 19 is connected to the right-hand electrode of the reed switch 10, and the inner conductor of the connector 20 is connected to the right-hand electrode of the reed switch 11.

In the absence of any external flux being induced in the reed switch 10 and 11 by the application of current through the coil 14, the magnet 12 causes the contacts within the reed switch 10 to be closed; so that the connector 18 is coaxially connected to the connector 19 to interconnect the receiver and antenna with one another. Whenever DC current of the proper polarity passes through the coil 14, the magnetic field established within the coil 14 opposes the magnetic field of the magnet 12 to cause a cancellation of the field, thereby releasing the contacts of the reed switch 10; and at the same time, the magnetic field induced in the interior of the housing 17 by the application of current through the coil 14 causes the contacts within the reed switch 11 to close to connect the transmitter to the antenna.

Thus, it can be seen that the coaxial relay shown in FIGS. 1 and 2 is a direct-current operated unit of the single-pole double-throw type. Since the reed switch 11 connected in the transmitter leg of the switch is capable of operation upon the passage of DC current in either direction through the coil 14, and since the receiver leg including the switch 10 operates only upon the application of DC current through the coil 14 in such a direction as to oppose the magnetic field induced in the switch 10 by the permanent magnet 12, it is necessary to provide the diode 13 in series with the coil in order to make the relay completely polarity sensitive and in order to avoid having both of the sets of contacts in both of the reed switches 10 and 11 closed simultaneously, which would result in a failure of operation of the relay. In addition, the diode 12 provides isolation between the discharge path of the capacitor 35 through the winding 14 and the winding 29 of the relay 30, so that all of the discharge current flows through the winding 14.

The glass-enclosed reed switches used in the assembly shown in the preferred embodiment are not capable of switching large currents and voltages. They are capable, however, of passing relatively large currents and voltages once the contact openings and closing have been effected. By proper sequencing of the relay in the operation of the circuit of which it is a part to cause the contacts within the switches 10 and 11 to only carry current and not switch it, these limitations of this coaxial relay are overcome. The relay also should be constructed to match the impedance of the coaxial lines connected to it as closely as possible to obtain optimum circuit performance.

Since the transmitter 25 only has operating power applied to it after the contacts of the switch 11 are closed and has operating power removed before the contacts of the switch 11 are opened, the transmitter never operates into an open circuit but always operates into a load. The use of two separate reed switches 10 and 11, provides superior operation compared with a conventional C-type reed switch having two fixed contacts and one moveable contact, by providing a lower distributed capacitance between the electrodes connected to the center conductors of the coaxial connectors 19 and 20. This results from separating the ends of the switches 10 and 11 by the tongue 15. In addition to acting as the outer conductor of the coaxial lines the nonmagnetic housing 17 provides isolation between the coil 14 and the RF signals carried and switched by the relay. By mounting the coil 14 on a removable bobbin, coils 14 having a different number of turns and therefore providing different DC operating voltages may be interchanged without disturbing the RF section os the switch.

I claim:

1. A sequencing circuit including in combination:

a first relay having an operating coil;

a second relay having an operating coil;

switch means operated to apply operating current to the operating coils of the first and second relays;

means connected with the switch means for opposing the flux buildup in the first relay for a predetermined length of time following operation of the switch means so that the second relay is operated before the first relay is operated; and

means for maintaining current through the operating coil of the second relay for a second predetermined length of time following termination of operation of the switch means to delay release of the second relay until after release of the first relay.

2. The combination according to claim 1 wherein the means for opposing flux buildup in the first relay includes a secondary winding on the first relay and further includes means for applying current through the secondary winding to oppose the flux buildup in the first relay for said predetermined length of time following operation of the switch means.

3. The combination according to claim 12 wherein the flux buildup opposing means includes unidirectional conductive means coupled across the secondary winding and capacitor means interconnecting the secondary winding of the first relay and the operating coil of the second relay, with the current flowing through the secondary winding being used to charge the capacitor means, whereupon the current ceases to flow in the secondary winding when the capacitor means is charged, and with termination of operation of the switch means, allowing the capacitor means to discharge through the operating coil of the second relay and the unidirectional conductive means in a manner to aid the release of the first relay and to maintain operation of the second relay for said second predetermined length of time.

4. An RF antenna switch for connecting a common antenna terminal to either of two coaxial lines including in combination:

first and second magnetically actuated reed switches, each comprising a normally open magnetic reed contact pair, with a first conductor extending from one of the contacts of the pair and a second conductor extending from the other of the contacts of the pair of each switch;

means for connecting the first conductor of each of the reed switches to a common terminal constituting the inner conductor of a first coaxial line;

means for providing a permanent magnetic bias for the contact pair of the first reed switch to cause the contacts of the first reed switch to be closed;

the second conductors of the first and second reed switches being connected, respectively, to the inner conductors of second and third coaxial lines, with the ends of the reed switches connected to the second and third coaxial lines being spaced apart a greater distance than the ends of the reed switches which are interconnected to the first coaxial line;

a nonmagnetic conductive housing encasing the first and second reed switches and providing the outer portion of the first, second and third coaxial lines, the housing having a tongue extending between the reed switches from the ends connected to the inner conductors of the second and third coaxial lines to complete the outer portion of the second and third coaxial lines and to isolate the contacts of the reed switches from one another, the housing also having a shoulder portion adjacent one end thereof; and

a DC operating coil disposed about the housing substantially surrounding the first and second reed switches and abutting the shoulder, the housing providing isolation between the DC coil and RF signals carried by the reed switches.

5. The combination according to claim 4 wherein the contacts and conductors of the reed switches are copper plated providing a low RF resistance.

6. The combination according to claim 4 wherein the DC coil is wound on a removable bobbin, with location of the coil on the housing being determined by the shoulder portion.

7. The combination according to claim 4 further including a second relay having an operating coil; switch means operated to apply operating current to the operating coil of the second relay and the operating coil disposed about the housing; means connected with the operating coil disposed about the housing for opposing the flux buildup in the second relay for a predetermined length of time following operation of the switch means so that the reed switches are operated before the second relay is operated; and means for maintaining current through the operating coil disposed about the housing for a second predetermined length of time following termination of operation of the switch means to delay termination of operation of the reed switch until after release of the second relay.

8. The combination according to claim 4 wherein the RF antenna switch connects a common antenna terminal to either of two coaxial lines coupled to a transmitter and a receiver, respectively, and further including switching means having first and second states of operation and normally in the first state of operation for selectively applying power to the transmitter and the receiver, power being applied only to the receiver with the switching means in the first state of operation and power being applied to the transmitter with the switching means in the second state of operation; control means for applying operating current to the DC operating coil and also operating the state of operation; and means for delaying operation of the switching means for a predetermined period of time after current is applied to the DC operating coil.

9. The combination according to claim 8 wherein the delaying means maintains application of operating current to the DC operating coil for a predetermined length of time after the control means ceases to apply said operating current, with the switching means switching from the second state to the first state while the operating current is being maintained.