Jan. 28, 1964 E. M. CHERRY, JR 3,119,911

ELECTRICAL RELAY FOR COAXIAL CABLES

Filed March 14, 1961

Fig. 1

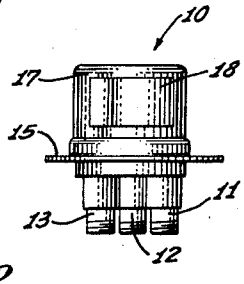


Fig. 3

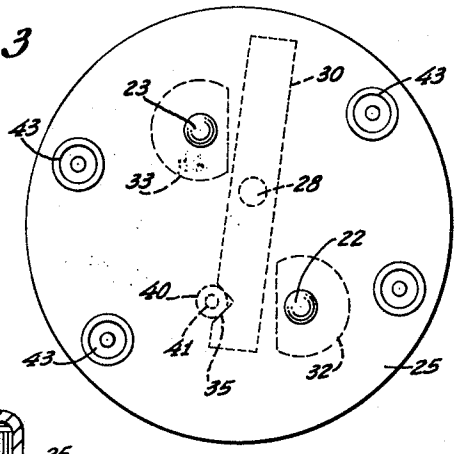


Fig. 2

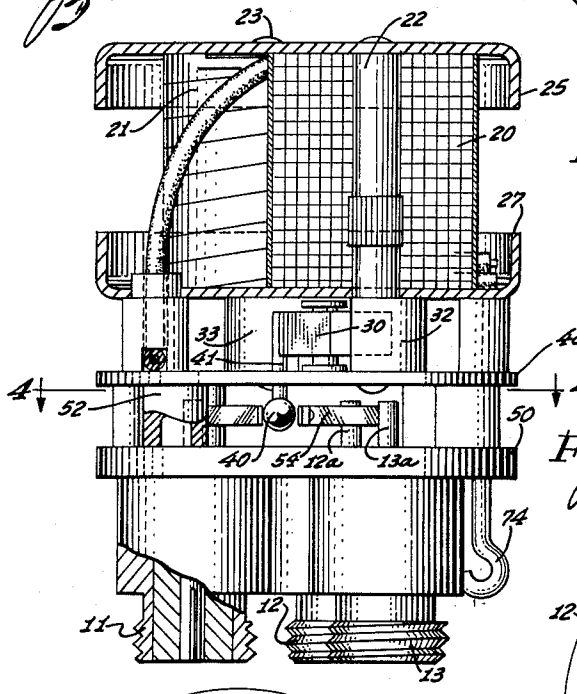


Fig. 5

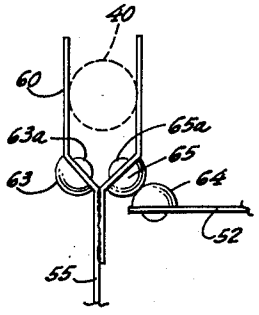


Fig. 4

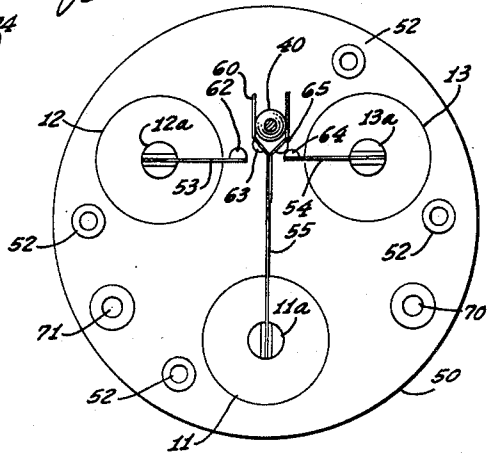
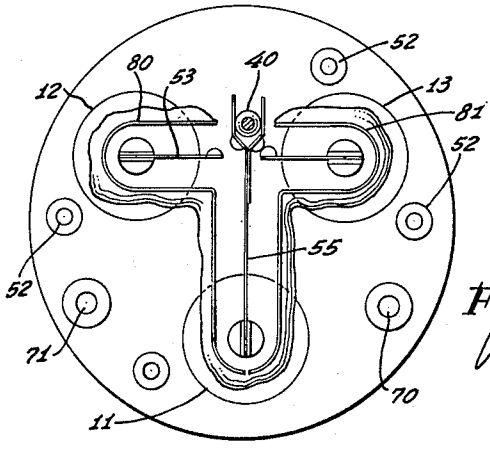


Fig. 6



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ELECTRICAL RELAY FOR COAXIAL CABLES

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This invention relates to electrical relays and, more particularly, to miniature coaxial relays for radio frequencies up to 3,000 or 4,000 megacycles.

It is well known that conduction at very high frequencies does not follow the conventional pattern associated with direct or comparatively low frequency currents. In the region of microwaves, this effect becomes so pronounced that connections no longer resemble wiring systems but are more like plumbing systems with provisions made to "pipe" currents from point to point. The present invention is for use in the range where electrical conductors are still utilized but where the problems encountered in handling of such high frequencies in the order of hundreds of megacycles have to be carefully considered.

Conductors which are utilized for the transmission of high frequency waves such as at radio frequencies are generally utilized in pairs spaced relatively close to minimize radiation therefrom. Spacing between such pairs of conductors, the sizes of the individual conductors, and the dielectric between them determine certain transmission characteristics of the transmission line, one of which is known as the surge impedance, or characteristic impedance. Abrupt changes in such impedance along a transmission line generally produce deleterious effects, as is well known in the art. The conductors may be arranged in a coaxial manner with one enveloping the other to further minimize radiation effects. At frequencies that require coaxial conduction, conventional relays and switching means cannot readily be utilized because the current cannot be confined to the usual conducting elements of such devices and the impedance irregularities offered by such elements may be excessively high. Moreover, when high frequency currents such as at radio frequencies are utilized, the impedance mis-match and capacitive coupling in such devices cause standing waves and undesirable crosstalk.

In a specific illustrative embodiment of this invention, a coaxial relay is provided which maintains the impedance characteristics of the coaxial lines into which it is inserted. The impedance characteristics of the coaxial lines are maintained even though the relay is a relatively small and compact device. In many applications, the size and weight of the relay is of considerable importance. In the specific illustrative embodiment, the over all length of the relay, including the coaxial connectors at one end to which the coaxial cables are connected, may be less than 1½ inches.

The characteristic impedance is maintained and the reflected energy from the switch is quite small due to a number of features including the provision of a uniform electric field in the relay. The uniform electric field is provided between two parallel discs, one of which supports the coaxial connectors to which the cables are connected, and the other of which supports a balanced armature and winding means for actuating the armature. The disc supporting the balanced armature and the winding means functions to magnetically isolate the magnetic circuits from the coaxial electrical circuits. The balanced armature maintains its normal or operated position in the presence of shocks and vibrations and supports an actuating finger extending through the magnetic isolating disc into the space between the two discs.

The spacing between the two discs is such as to provide

for substantially the same characteristic impedance as is provided by the coaxial cables terminating at the relay. A flexible arm is supported in the space between the two discs in substantial alignment with the balanced armature. The finger supported on the balanced armature actuates the flexible arm to establish the operative transfer connection through the switching means including the flexible arm.

Features of this invention relate to the provision of a bead of insulating material at the end of the actuating finger which fits into a bifurcated end of the flexible arm. The flexible arm functions as a resilient member for restoring both itself and, by means of the actuating finger, the balanced armature to their respective normal positions when the winding means are deenergized.

Other features of this invention relate to the provision of magnetic members on each side of the winding means which function both as part of the magnetic circuits for actuating the balanced armature and as supports for a shell or casing including the winding means and the balanced armature. The shell fits against the magnetic members and is in good thermal contact therewith to provide for the dissipation of the thermal energy generated by the energization of the winding means.

Further features of this invention relate to the provision of strip conductors in the space between the two parallel discs, which conductors form together with portions of the disc, outer coaxial conductors for the flexible arm and associated contacts. The strip conductors reduce the small discontinuity through the coaxial relay to minimum value.

Further advantages and features of this invention will become apparent upon consideration of the following description when read in conjunction with the drawing wherein:

FIGURE 1 is a side view of the coaxial relay of this invention;

FIGURE 2 is a partially sectionalized side view of the coaxial relay of this invention with the shell or casing removed;

FIGURE 3 is a top view of the coaxial relay of this invention with the shell removed and illustrating the operation of the balanced armature;

FIGURE 4 is a sectional view taken along lines 4—4 of FIGURE 2 illustrating particularly the operation of the flexible arm;

FIGURE 5 is an enlarged fragmentary view of the bifurcated end of the flexible arm utilized in the coaxial relay of this invention; and

FIGURE 6 is a sectional view of another embodiment of the coaxial relay of this invention.

Referring first to FIGURE 1, a high frequency or radio frequency relay **10** is depicted suitable for handling frequencies up to 3,000 or 4,000 megacycles. The over all length of the relay may be 1¼ inches including the length of three connectors **11** through **13** at one side of the relay **10**. The relay **10** is mounted on a panel, not shown, utilizing the bracket **15** which is affixed to the casing **17** of the high frequency relay **10**. A name plate **18** may also be affixed to the casing **17**. The relay **10** functions to selectively connect a coaxial cable, not shown, terminating at the connector **11** to coaxial cables, also not shown, terminating at the connectors **12** and **13**.

The relay **10** operates rapidly, provides for very small crosstalk between the coaxial cables terminating thereat, and has an impedance characteristic substantially similar to that of the terminating coaxial cables. Illustratively, the characteristic impedance may be 50 ohms. The characteristic impedance is maintained through the relay **10** in either its normal or its operated condition so that the reflected energy from the relay is quite small.

The relay **10** includes two windings **20** and **21** shown

particularly in FIGURE 2, which may be serially connected. External wires may be soldered to two hook connectors 74 which extend through a support disc 50 and a spaced support disc 48. The windings 20 and 21 may be energized by a 28 volt direct current potential. When the windings 20 and 21 are energized, they generate magnetic flux through a magnetic circuit including the cores 23 and 22 in the windings 20 and 21, respectively, and a balanced armature 30. The windings 20 and 21 may be wound in opposite directions so that fluxes through the magnetic cores 22 and 23 are in opposite directions. A cup-shaped magnetic member 25 made from a magnetic material such as an iron alloy forms a return path for the magnetic flux at one end of the magnetic cores 22 and 23, and the balanced armature 30 together with two magnetic core extensions 33 and 32 complete the magnetic circuit at the other end of the cores 23 and 22. The extension 33 may be integral with the core 23 and the extension 32 may be integral with the core 22. The cores 22 and 23 may be made of steel and the armature 30 may be made of sintered iron.

As shown particularly in FIGURE 3, the balanced armature 30 is pivoted on a pin 28 extending from the disc 48 which forms a support for the magnetic extensions 33 and 32 and also for the pin 28. A magnetic cup member 27 made of a non-magnetic material such as brass is supported at one end of the windings 20 and 21. The member 27 does not form part of the magnetic circuit as a substantial air gap is provided between the magnetic cores 22 and 23 passing respectively through the windings 20 and 21 and the member 27. The cup-shaped members 25 and 27 support the casing 17 mentioned above in reference to FIGURE 1. The casing 17 fits snugly over the two cup-shaped members and in good thermal contact therewith to dissipate the heat developed in the windings 20 and 21 when the windings are energized. The members 25 and 27, accordingly, function both as supports for the casing 17 and also as thermal sinks therefor. The member 25, however, functions further as part of the magnetic circuit in the coaxial relay 10. The casing 17 may be attached to the cup-shaped member 25 as by soldering or riveting at positions 43 which are shown in FIGURE 3.

In the position shown in phantom in FIGURE 3, the balanced armature 30 is in its normal position. When the windings 20 and 21 are energized, the magnetic armature 30 is rotated in a counter-clockwise direction to abut against the core extensions 33 and 32. As illustrated in FIGURE 3, the core extensions 33 and 32 have a flattened surface against which the armature 30 abuts. In the presence of external shocks or vibrations, the position of the balanced armature 30 is not disturbed because these effects at one end of the armature 30 are cancelled by counter-balancing effects at its other end.

As shown in FIGURE 3, the balanced armature 30 has a V-shaped groove 35 toward one end into which is fitted and soldered a finger 41. The finger 41 extends through a small opening in the support disc 48 into the space between the two shielding plates or discs 48 and 50. The base or disc 50, which was briefly mentioned above, supports the three connectors 11 through 13 which may be soldered thereto. The connectors 74 to the windings 20 and 21 pass through both of the discs 48 and 50. The shield or disc 48 may be made from a suitable material such as brass so as to serve as a shield for isolating the magnetic circuits of the relay 10 from the high frequency electrical circuits of the relay 10. For example, the disc 48 is preferably a non-magnetic but electrically conductive material such as brass but may also be made from a magnetic material. The finger 41, which extends into the space between the two discs 48 and 50, supports a bead 40 made of an insulating material such as glass.

As shown particularly in FIGURES 4 and 5, the bead 40 fits into the bifurcated end 60 of a flexible arm 55. The flexible arm 55 is aligned along a direction substantially similar to that of the main axis of the balanced armature 30 and is attached at the pin 11*a* to the connector 11. The pin 11*a* is in electrical contact with the center conductor of the coaxial cable, not shown, terminating at the connector 11. The travel of the flexible arm 55 at its bifurcated end 60 is relatively small, illustratively 0.035 inch. The central conductors of the connectors 12 and 13 are electrically connected, respectively, to the pins 12*a* and 13*a*. The pins 12*a* and 13*a* in turn support strip members 53 and 54 which are selectively contacted by the bifurcated end 60 of the arm 55. The pins 11*a* through 13*a* are slotted at their distal ends and the members 55, 53 and 54 are respectively fitted therein and soldered thereto.

The bifurcated end 60 supports two beads of electrical contact materials 63 and 65 for abutting respectively beads 62 and 64 supported on the strip members 53 and 54. As shown in FIGURE 5, the bifurcation angle is approximately 45 degrees so that, at contact, the bead 65 makes a sliding contact against the bead 64. This configuration avoids contact bounce or chatter which introduces noise into the high frequency electrical circuits. Beads 63*a* and 65*a*, shown in FIGURE 5, are integral with the beads 63 and 65, respectively, on the bifurcated end of the flexible arm 55. The flexible arm 55 exerts approximately 10 grams of force against the contact 64 when the arm 55 is in its normal position. When the arm 55 is actuated by the bead 40 responsive to the energization of the windings 20 and 21, it similarly exerts a force of approximately 10 grams against the bead 65 on the strip member 53. Actually, the bead 40 travels .035 inch but the spacing between the two beads 62 and 63, as shown in FIGURE 4, is only .020 inch. These dimensions take up any spacing between the bead 40 and the arms of the bifurcated end 60 and insure a good electrical contact.

The two discs 48 and 50 provide for a uniform electric field in the space therebetween. This results from the fact that the spacing between the discs is such that the discs may be effectively considered to be separated by an infinite distance. A number of spacers 52, shown in FIGURES 2 and 4, separate the two discs 48 and 50. The spacing between the two discs 48 and 50 is such as to provide a characteristic impedance through the relay 10 which is substantially the same as the characteristic impedance of the coaxial cables terminating at the relay 10. The discontinuities introduced by the conductive components in the space between the two discs 48 and 50 are minor and the space is isolated from the magnetic circuits by the non-magnetic disc 48. The production of a uniform electric field is further facilitated by the dimensions of the flexible arm 55 since these dimensions are instrumental in controlling the characteristic impedance of the relay.

In the embodiment shown in FIGURE 6, strip conductors 80 and 81 surround the flexible arm 55 and the strips 54 and 53. The various components shown in FIGURE 6, which are similar to the components shown in FIGURES 1 through 5, have been given similar reference designations. The pair of strips 80 and 81 are provided which have a height equal to the distance between the two discs 48 and 50 so as to substantially enclose the arm 55 and the strip members 53 and 54. The strips 80 and 81 together with small portions of the discs 48 and 50 form rectangular enclosures for the arm 55 and members 53 and 54. The dimensions of this enclosure are substantially similar to the dimensions of the outer conductor of the coaxial cables terminating at the relay 10 so as to provide for a similar characteristic impedance. The strips 80 and 81, accordingly, complete the enclosure between the discs 48 and 50 for the electrical inner conductors through the switching portion of the relay 10. The entire relay 10, including the outer

conductors, the strips 80 and 81 and the discs 48 and 50, may be grounded.

Although this invention has been disclosed and illustrated with reference to particular applications, the principles involved are susceptible of numerous other applications which will be apparent to persons skilled in the art. The invention is, therefore, to be limited only as indicated by the scope of the appended claims.

What is claimed is:

1. A coaxial relay for use with coaxial cables, including, a balanced armature made of magnetic material and having a normal and an operative position and pivotable in a first particular plane, winding means operatively coupled to the armature for pivoting said balanced armature in the first particular plane from said normal position to said operative position, a flexible arm made of resilient and electrically conductive material for selectively interconnecting the coaxial cables, said flexible arm having a normal unflexed position and an operative flexed position and being pivotable between the normal unflexed position and the operative flexed position in a second particular plane substantially parallel to the first particular plane, a shield disposed in a third particular plane substantially parallel to the first and second particular planes and made of a material to magnetically isolate said balanced armature and said winding means from said flexible arm, the balanced armature and the winding means being disposed on one side of the shield and the flexible arm being disposed on the opposite side of the shield, and a finger mounted on said balanced armature and extending through said shield in a direction transverse to the first, second and third particular planes and coupled to the flexible arm for pivoting said flexible arm to its operative position upon the energizing of said winding means and for providing a return of said balanced armature by said flexible arm to the normal position when said winding means is de-energized.

2. A coaxial relay for use in selectively establishing connections between coaxial cables including, a pair of spaced plates made of electrically conductive material and disposed in a spaced and substantially parallel relationship to each other, a flexible arm made of resilient and electrically conductive material and positioned between said pair of spaced plates in substantially parallel relationship to the pair of spaced plates for movement in a plane substantially parallel to said pair of spaced plates, actuating means positioned external to the space between said pair of plates and against one of said pair of plates for moving said flexible arm in a direction substantially parallel to said pair of plates, said actuating means having a finger extending through a first one of said pair of plates for engaging said flexible arm, connectors supported on the other one of said pair of plates at a position external to the plates and receiving the coaxial cables and providing an electrical continuity with the coaxial cables, and shielding means disposed in the space between said two plates in a transverse relationship to the pair of plates and disposed in co-operative relationship with said connectors and with said pair of plates substantially to envelope said flexible arm and form an outer coaxial conductor for said arm.

3. A coaxial relay for use in selectively establishing connections between coaxial cables including,

a pair of spaced plates made of electrically conductive material,

a flexible arm made of resilient and electrically conductive material and positioned between said pair of spaced plates for movement in a plane substantially parallel to said pair of spaced plates,

actuating means positioned external to the space between said pair of plates and against one of said pair of plates for moving said flexible arm, said actuating means having a finger extending through a first one of said pair of plates for engaging said flexible arm,

connectors supported on the other one of said pair of plates at a position external to the plates and receiving the coaxial cables and providing an electrical continuity with the coaxial cables, and

shielding means disposed in the space between said two plates and disposed in cooperative relationship to envelope said flexible arm and form an outer coaxial conductor therefor, said shielding means including strips of conductive material extending from one of the pair of plates to the other, and wherein the strips of conductive material envelope the connectors and the flexible arm.

4. A coaxial relay for establishing a connection between two coaxial cables, including, a balanced armature made of magnetic material and having normal and operative positions and pivotable in a particular plane between the normal and operative positions, winding means operatively coupled to the balanced armature for pivoting said balanced armature from said normal position to said operative position, a flexible arm made of reresilient and electrically conductive material and disposed relative to the conductive cables to establish a connection between the two coaxial cables, said flexible arm having a normal unflexed position and an operative flexed position and being pivotable between the normal unflexed position and the operative flexed position in a plane substantially parallel to the particular plane, a shield made of a material for magnetically isolating said balanced armature and said winding means from said flexible arm, the shield being disposed in a plane substantially parallel to the particular plane, means operatively coupled to the balanced armature and to the winding means for supporting the balanced armature and the winding means on one side of the shield, the flexible arm being disposed on the opposite side of the shield from the balanced armature and the winding means, a base made of electrically conductive material and having a surface substantially parallel to the shield and disposed on the opposite side of the flexible arm from the shield for providing a uniform electric field between the base and the shield and in the vicinity of said flexible arm, connectors mounted on said base on the opposite side of the base from the flexible arm in transverse relationship to the particular plane and disposed for attachment to the coaxial cables and for electrical continuity with the coaxial cables, and a finger mounted on said balanced armature and extending through said shield and coupled to said flexible arm for moving said flexible arm to its operative position upon the energizing of said winding means and for providing a return of said balanced armature by the flexible arm to the normal position when said winding means is de-energized.

5. A coaxial relay for establishing a connection between two coaxial cables, including,

a balanced armature made of magnetic material and having normal and operative positions,

winding means operatively coupled to the balanced armature for moving said balanced armature from said normal position to said operative position,

a flexible arm made of resilient and electrically conductive materials and disposed to establish a connection between the two coaxial cables, said flexible arm having a normal unflexed position and an operative flexed position,

a shield made of a material for magnetically isolating said balanced armature and said winding means from said flexible arm,

means operatively coupled to the balanced armature and to the winding means for supporting the balanced armature and the winding means on one side of the shield,

the flexible arm being disposed on the opposite side of the shield from the balanced armature and the winding means,

a base made of electrically conductive material and

having a surface parallel to the shield and disposed in the opposite side of the flexible arm from the shield for providing a uniform electric field between the base and the shield and in the vicinity of said flexible arm,

connectors mounted on said base on the opposite side of the base from the flexible arm and disposed for attachment to the coaxial cables and for electrical continuity with the coaxial cables, and

a finger mounted on said balanced armature and extending through said shield and coupled to said flexible arm for moving said flexible arm to its operative position upon the energizing of said winding means and for providing a return of said balanced armature by the flexible arm to the normal position when said winding means is de-energized, said flexible arm and said balanced armature having elongated shapes, said flexible arm being substantially parallel to said balanced armature and said finger having an actuating tip made of insulating material for contact with said flexible arm.

6. A coaxial relay for establishing a connection between two coaxial cables, including,

a balanced armature made of magnetic material and having normal and operative positions,

winding means operatively coupled to the balanced armature for moving said balanced armature from said normal position to said operative position,

a flexible arm made of resilient and electrically conductive materials and disposed to establish a connection between the two coaxial cables, said flexible arm having a normal unflexed position and an operative flexed position,

a shield made of a material for magnetically isolating said balanced armature and said winding means from said flexible arm,

means operatively coupled to the balanced armature and to the winding means for supporting the balanced armature and the winding means on one side of the shield, the flexible arm being disposed on the opposite side of the shield from the balanced armature and the winding means,

a base made of electrically conductive material and having a surface parallel to the shield and disposed in the opposite side of the flexible arm from the shield for providing a uniform electric field between the base and the shield and in the vicinity of said flexible arm,

connectors mounted on said base on the opposite side of the base from the flexible arm and disposed for attachment to the coaxial cables and for electrical continuity with the coaxial cables, and

a finger mounted on said balanced armature and extending through said shield and coupled to said flexible arm for moving said flexible arm to its operative position upon the energizing of said winding means and for providing a return of said balanced armature by the flexible arm to the normal position when said winding means is de-energized, said flexible arm and said balanced armature having elongate shapes, said flexible arm being substantially parallel to said balanced armature, said finger having an actuating tip made of insulating material for contact with said flexible arm, and said flexible arm having a bifurcated portion for engaging opposite sides of the actuating tip.

7. A high frequency switch for use with cables having inner and outer conductors, including, a pair of spaced and substantially parallel plates made of electrically conductive material, a balanced armature made of magnetic material and having normal and operative positions and disposed at a position external to the plates and closer to the first plate than to the second plate and movable between the normal and operative positions in a direction substantially parallel to the plates, winding means magnetically coupled to said balanced armature for moving said balanced armature from said normal position to said operative position upon an energizing of the winding means and disposed at a position external to the space between the first and second plates and closer to the first plate than to the second plate, a flexible arm made of resilient and electrically conductive material and disposed relative to the coaxial cables to selectively interconnect the coaxial cables terminating at the relay, said flexible arm having a normal unflexed position and an operative flexed position and disposed in the space between the first and second plates and movable between the normal unflexed position and the operative flexed position in a direction substantially parallel to the pair of spaced plates, means supporting said winding means and said balanced armature on the first plate at the position external to the position between the first and second plates, a finger mounted on said balanced armature and extending through the first plate and coupled to the flexible arm for moving said flexible arm to its operative position upon the energizing of said winding means and for providing a return of said balanced armature by the flexible arm to the normal position when said winding means is de-energized, and means supported on the second plate in the space external to the space between the first and second plates and electrically coupled to the coaxial cables and extending through the second plate into the space between the first and second plates for electrical engagement with the flexible arm in accordance with the movement of the flexible arm between the normal unflexed position and the operative flexed position.

8. A high frequency switch for use with cables having inner and outer conductors, including, a housing, a pair of parallel plates disposed in spaced relationship and supported within the housing, switching means including a flexible arm disposed in the space between said plates in substantially parallel relationship to the plates and movable in a direction substantially parallel to the plates between first and second positions to obtain an operation of the switching means respectively in the first and second states, actuating means supported on a first one of said pair of plates at a position external to the space between the plates for actuating said switching means, and means operatively coupled to the actuating means and the flexible arm in the switching means and extending through the first one of said plates for driving the flexible arm in accordance with the operation of the actuating means.

9. The combination set forth in claim 8 in which the actuating means are magnetic and in which the switching means produce an electric field and in which said first one of said plates is made from a material to isolate the magnetic field produced by the actuating means from the electric field produced by the switching means.

10. A coaxial relay for use with coaxial cables, including, a balanced armature made of magnetic material and having normal and operative positions and movable in a particular plane between the normal and operative positions, winding means magnetically coupled to the balanced armature for moving said balanced armature in the particular plane from said normal position to said operative position, a flexible arm made of resilient and electrically conductive material for selectively inter-connecting the coaxial cables terminating at the relay, said flexible arm having a normal unflexed position and an operative flexed position and movable between the normal unflexed position and the operative unflexed position in a plane substantially parallel to the particular plane, a shield made of a magnetic material and disposed to magnetically isolate said balanced armature and said winding means from said flexible arm, the shield being disposed between the flexible arm and the armature and the winding means in substantially parallel relationship to the particular plane to separate magnetically the flexible arm from the armature and the winding means, a finger mounted on said balanced armature on the same side of the shield as the

balanced armature and extending through said shield and operatively coupled to said flexible arm for moving said flexible arm to the operative flexed position upon the energizing of said winding means and for obtaining a return of said balanced armature by said flexible arm to the normal position when said winding means is de-energized, said winding means having end members made of magnetic material, and a casing in thermal contact with said end members of said winding means for dissipating heat generated when said winding means is energized.

11. The coaxial relay set forth in claim 10, including, a plate disposed in spaced relationship to the shield and on the opposite side of the flexible arm from the shield and made from a material to provide a magnetic shielding, the plate being disposed in substantially parallel relationship to the shield, and connectors supported on the plate at a position external to the space between the plate and the shield and having electrical contacts extending into the space between the plate and the shield for engagement by the flexible arm in accordance with the movements of the flexible arm between the normal unflexed position and the operative flexed position.

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