April 17, 1951 — R. E. KESTER ET AL — 2,548,889

HIGH-SPEED COAXIAL RELAY

Filed Nov. 9, 1949 — 2 Sheets-Sheet 1

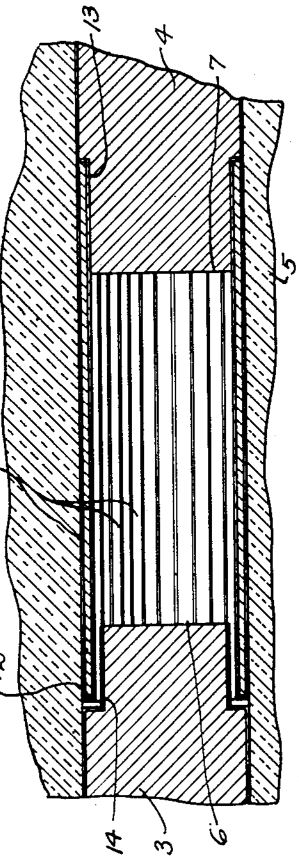

FIG. 1a.

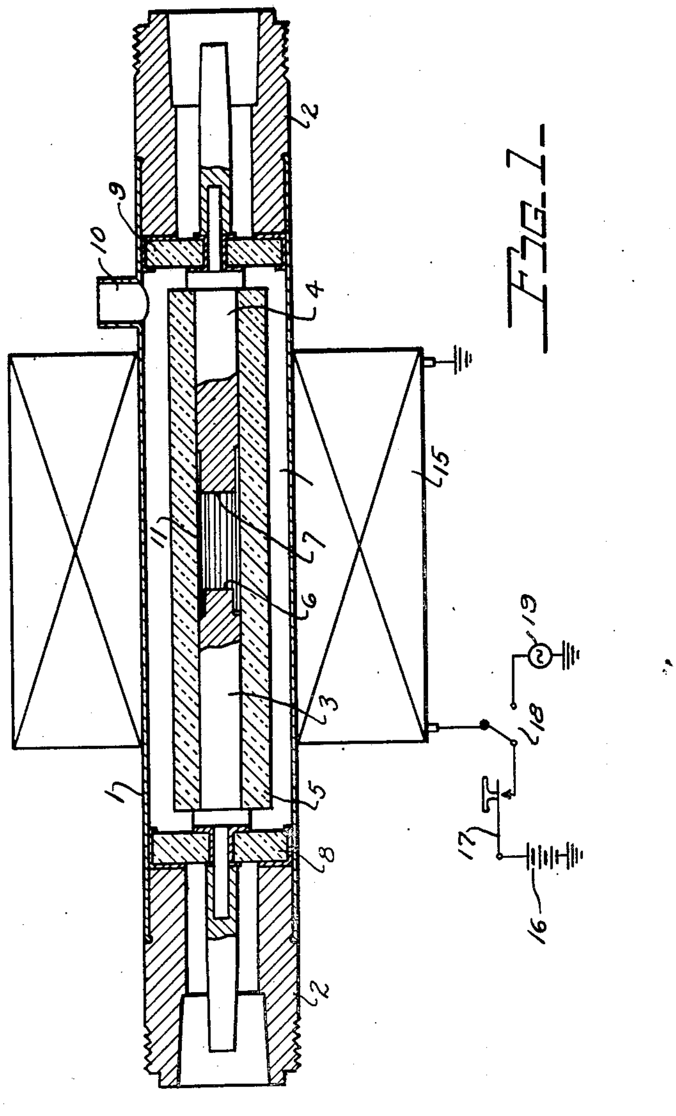

FIG. 1.

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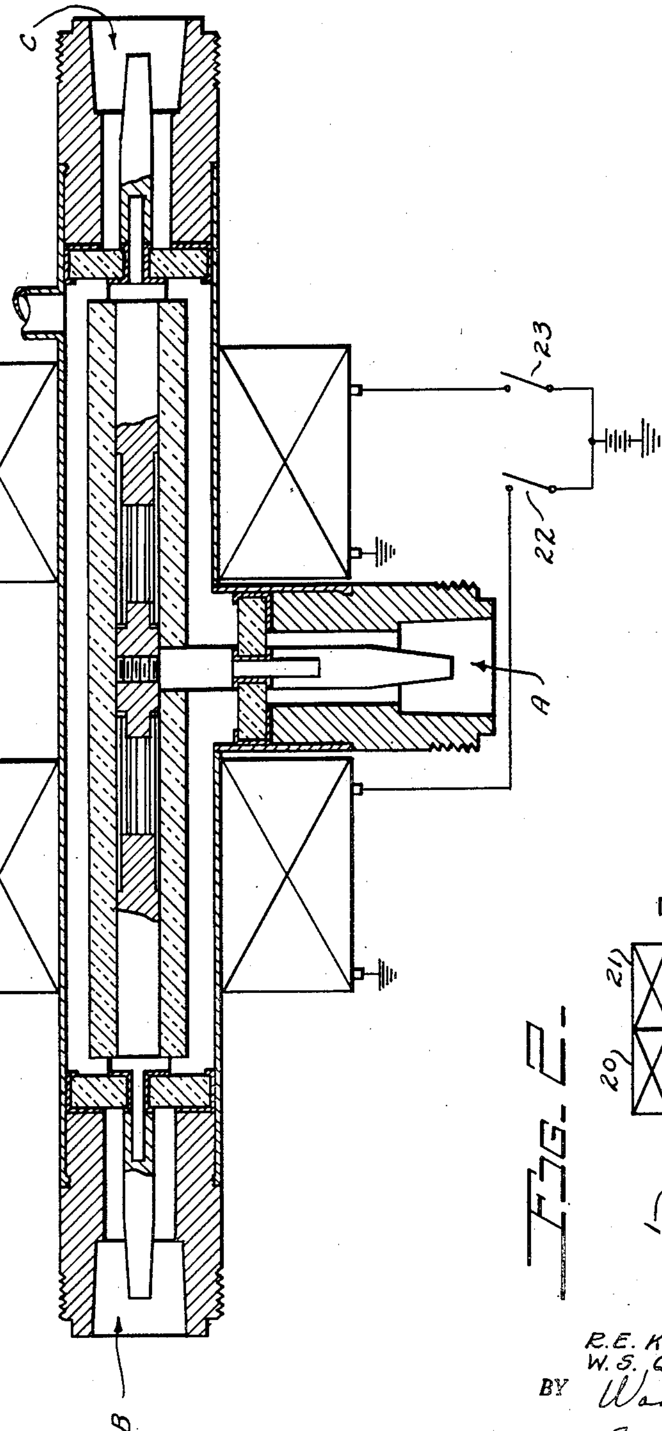

Fig. 3.

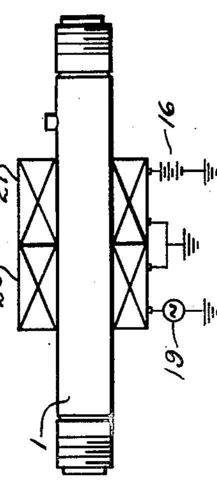

Fig. 2.

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HIGH-SPEED COAXIAL RELAY

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6 Claims. (Cl. 200—103)

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The invention described herein may be manufactured and used by or for the Government for governmental purposes without payment to us of any royalty thereon.

This invention relates to relays and in particular to a relay which may be inserted in a coaxial transmission line.

It is the object of the invention to provide a relay for insertion in a coaxial transmission line which does not destroy the continuity of the line when closed, which is adapted for high speed operation so as to permit modulation of the energy in the line at moderately high frequencies in the audible range, and which is reliable in operation.

The relay consists of an evacuated section of coaxial transmission line having a cylindrical outer conductor of a non-magnetic metal and a cylindrical inner conductor of a magnetic metal with a gap intermediate the ends of the inner conductor. The gap is bridged by a plurality of spring steel fingers of high magnetic permeability positioned side by side around the periphery of and attached to the inner conductor on one side of the gap. The fingers extend across the gap and overlap a recessed portion of the center conductor on the opposite side of the gap. The fingers are preloaded to a non-contacting position and to close the circuit are brought into contact with the center conductor by passing magnetic flux through the center conductor and the fingers. The latter is accomplished by means of a flux producing winding positioned about the outside of the relay. The winding may be energized by direct or alternating current, the latter causing the contacts to close twice during each cycle of the current. If only one closure per cycle is desired two windings, one energized with alternating current and the other with direct current, may be used. In this case the flux produced by the direct current winding should equal or approximately equal the maximum flux produced by the alternating current winding.

Several preferred embodiments of the invention will be described in connection with the accompanying drawings in which

Fig. 1 shows a sectional view of a coaxial relay in accordance with the invention,

Fig. 1*a* is an enlarged view of the contact section of Fig. 1,

Fig. 2 shows an alternative method of actuating the contacts with alternating current, and

Fig. 3 shows a multiple circuit switching arrangement using coaxial relays.

Referring to Fig. 1 the coaxial relay consists of an outer cylindrical shell **1** of a non-magnetic metal such as brass. Each end of the shell or outer conductor **1** is equipped with coaxial fittings **2** for joining the assembly to a coaxial transmission line. Inner conductors **3** and **4** are made of

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a metal having high magnetic permeability such as iron, are cylindrical in shape and are closely fitted into a tube **5** made of glass or other suitable insulating material. The lengths of center conductors **3** and **4** are such as to provide a gap between the ends **6** and **7** thereof. An air-tight chamber is formed by fusion seals **8** and **9** through which connections to the center conductors **3** and **4** pass. The chamber may be evacuated and sealed by means of nipple **10**. The inner surface of outer conductor **1** and the outer surfaces of center conductors **3** and **4** may be plated with a thin coat of silver or other highly conductive metal to reduce the resistance of the conductors to high frequency currents.

The gap between the ends **6** and **7** of the center conductors is bridged by a plurality of fingers **11** which may be better seen in Fig. 1*a*. The fingers **11** are made of a spring steel having high magnetic permeability such as carbon steel and may be in the form of wires or narrow flat strips. The fingers are coated with a thin layer of silver throughout their lengths except at the ends **12** where they are coated with an electrically conductive material having high resistance to wear and corrosion such as chromium. The fingers **11** are placed in slightly spaced relationship around the periphery of conductor **4** with their longitudinal axes parallel to the axis of conductor **4** the end **7** of which is recessed as at **13** so that the outer perimeter of the fingers conforms to that of the center conductor. The fingers are attached to center conductor **4** rigidly and with high electrical conductivity by any suitable means such as silver solder. Before assembly in tube **5** the fingers are preloaded outward so that they normally lie against the inner wall of the tube after assembly. The end **6** of center conductor **3** is recessed and the ends **12** of fingers **11** overlap the recessed portion. The recess is sufficiently deep to form a small gap between the recessed surface **14** and the ends **12** of the fingers when the latter are lying against the inner surface of tube **5**. The recessed surface **14**, like the ends **12** of the fingers, is faced with a thin layer of a wear and corrosion resistant metal such as chromium.

A connection between conductors **3** and **4** is effected by bringing the ends **12** of the fingers into contact with recessed surface **14**. This is accomplished by establishing a magnetomotive force between the two conductors which causes the fingers to move toward the recessed surface **14** of conductor **3** in order to reduce the gap between the ends of the fingers and the recessed surface to zero and consequently the reluctance of the magnetic circuit between the two conductors to a minimum value. The fingers should have sufficient initial circumferential spacing to prevent binding when forced into contact with the recessed surface 14 which has a slightly smaller circumference than recessed surface 13.

The required magnetomotive force for actuating the contacting fingers 11 may be supplied by a coil 15 wound about the outside of outer conductor 1, as shown in Fig. 1. If switch 18 is in the left hand position the coil is arranged for energization by direct current from source 16 through switch 17. Closing switch 17 causes a connection to be made between inner conductors 3 and 4 through fingers 11 for as long as the switch is closed. The contacting fingers may also be actuated by alternating current as illustrated by placing switch 18 in the right hand position which connects the coil 15 across source of alternating current 19. With this arrangement the flux produced by coil 15 passes through a maximum twice and the contacting fingers are actuated twice for each cycle of the alternating current. Another arrangement for actuating the coaxial relay by alternating current is shown in Fig. 2. In this arrangement coil 21 is energized by direct current and coil 20 by alternating current. If the currents are adjusted so that the flux produced by the direct current coil is equal to the maximum flux produced by the alternating current coil, the contacting fingers of the coaxial relay are actuated only once for each cycle of alternating current. This equality of fluxes is not necessary, however, the only requirement being that the resultant of the two magnetomotive forces be at some time during the cycle insufficient to actuate the relay. By controlling the relative values of the two magnetomotive forces the time during the cycle for which the contacts are closed or open may be controlled.

Fig. 3 shows an arrangement by which coaxial circuit A may be selectively connected to coaxial circuit B or C, or to both circuits B and C simultaneously, by operation of switches 22 and 23. The two coaxial relays employed are identical in construction and operation to the relay shown in Figs. 1 and 1*a*.

The relay described is well suited to high frequency switching applications, switching frequencies as high as 4000 per second being possible. Consequently the device may be used to modulate a high frequency carrier over a considerable range of audio frequencies. The presence of the relay in a coaxial transmission line does not destroy the continuity of the line when the relay is closed since the fingers bridging the gap form substantially a continuation of the outer surface of the inner conductor. Therefore the characteristic impedance of the line does not change at the relay and undesirable reflections that would result from such a change are avoided. The relay is also very reliable in operation due to the fact that the multiplicity of contact fingers employed permits the failure of a number of them without seriously affecting the performance of the relay.

We claim:

1. A high speed coaxial relay comprising a cylindrical outer conductor of non-magnetic material, a cylindrical inner conductor coaxial with said outer conductor and made of a material having high magnetic permeability, a cylindrical tube of dielectric material closely fitted over said inner conductor, a gap in said inner conductor inside said tube, a plurality of fingers of conductive springy material having high magnetic permeability, said inner conductor at one end of

said gap being reduced in radius by an amount approximately equal to the thickness of said fingers, said inner conductor at the other end of said gap being reduced in radius by an amount greater than the thickness of said fingers, said fingers being positioned in parallel and slightly spaced relationship about the surface of the recessed portion of the inner conductor at said one end of said gap and being mechanically and electrically attached thereto, said fingers being of sufficient length to extend across said gap and to overlap the reduced portion of the inner conductor at the said other end of the gap, said fingers being preloaded before assembly inside said tube so as to normally lie against the inner wall of said tube and in spaced relation to the inner conductor at the said other end of said gap, and means for establishing a magnetomotive force across said gap for bringing the free ends of said fingers into contact with the reduced portion of the inner conductor at the said other end of the gap.

2. Apparatus as claimed in claim 1 in which said means for establishing a magnetomotive force is a coil wound about said outer conductor and energized by direct current.

3. Apparatus as claimed in claim 1 in which said means for establishing a magnetomotive force is a coil wound about said outer conductor and energized by alternating current.

4. Apparatus as claimed in claim 1 in which said means for establishing a magnetomotive force comprises a coil wound about said outer conductor and energized by alternating current and a second coil wound about said outer conductor and energized by direct current.

5. Apparatus as claimed in claim 1 in which said outer conductor is sealed at places on each side of said gap and finger assembly and in which the space between said seals is evacuated.

6. A high speed relay comprising a cylindrical outer conductor of nonmagnetic material, a cylindrical inner conductor of magnetic material coaxial with the outer conductor and having a gap intermediate its ends, a plurality of thin spring fingers of conductive magnetic material attached to said inner conductor at one end of said gap with their free ends overlapping said inner conductor and normally spaced therefrom at the other end of said gap, said fingers being substantially parallel to each other and to the axis of said inner conductor and being closely spaced so as to form a substantially continuous cylindrical surface approximately equal in diameter to said cylindrical inner conductor, and means for establishing a magnetomotive force across said gap for bringing the free ends of said fingers into contact with the inner conductor at said other end of the gap, whereby said gap is bridged by a cylindrical surface that is substantially continuous with said inner conductor.

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