Aug. 9, 1949. C. G. REINSCHMIDT 2,478,781

CIRCUIT MAKER AND BREAKER

Filed June 2, 1944

FIG. 1

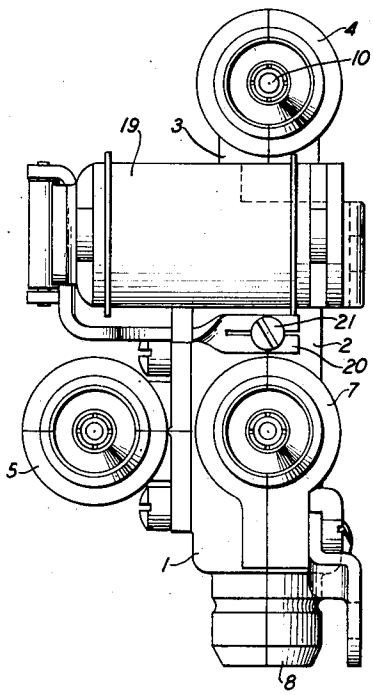


FIG. 2

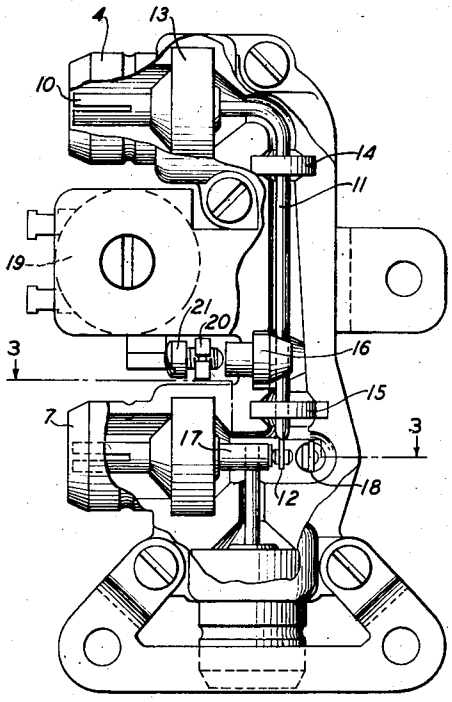


FIG. 4

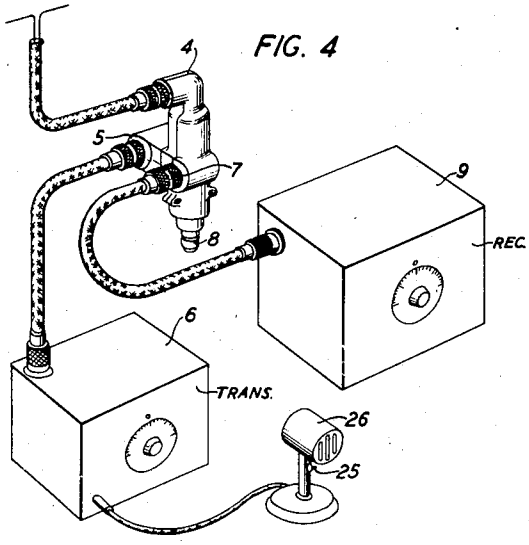
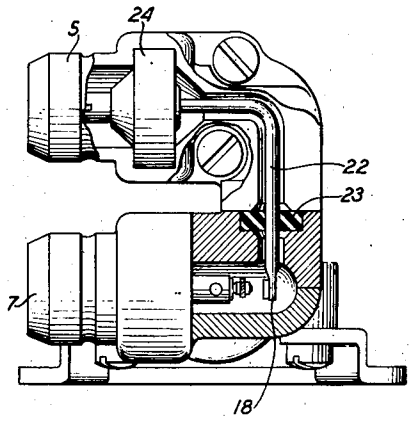


FIG. 3



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Patented Aug. 9, 1949

2,478,781

UNITED STATES PATENT OFFICE

2,478,781

CIRCUIT MAKER AND BREAKER

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Application June 2, 1944, Serial No. 538,426

2 Claims. (Cl. 178—44)

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This invention relates to circuit makers and breakers and particularly to switching means employed in systems handling currents of frequencies in the megacycle ranges.

The object of the invention is to provide an electromagnetic switching device having a controlled impedance characteristic for use in the range above the ultra-high frequencies spoken of as the very high frequency range. It is known that the conduction of currents of very high frequencies does not follow the conventional pattern associated with direct currents or comparatively low frequency currents so that conductors become what are usually termed wave guides. In the region of microwaves this effect becomes so pronounced that connections no longer resemble wiring systems but are more like plumbing systems with provision made to "pipe" the currents from point to point. Reference is made to a popular discussion of this subject in an article entitled "Electrical concepts at extremely high frequencies" by Simon Ramo in the September 1942 issue of Electronics.

The present invention is a device for use in the field where electrical conductors are still used but where the problems encountered in the handling of such extremely high frequencies have to be carefully considered. In the present case the shape and size of the conductors play an important part in the impedance which such a device presents to the currents which have to be handled. The conductors must be of the coaxial type and the relative sizes of the centrally located conductor and the sheath are of great importance. Likewise the conducting and switching parts of a relay have to be constructed on the coaxial principle. Conventional relays and switching means cannot be employed since the currents cannot be confined to the usual conducting elements of such devices and the impedance offered by such elements would be excessively high.

In accordance with the present invention the relay consists of a body element having pipe-like cavities therein, each said cavity being provided with a centrally located conductor. The leading of currents through these cavities and along the said centrally located conductors approaches the problems encountered in the region of the microwaves, as aforesaid. In order to switch connections from one outlet to another as by way of example to alternately connect an antenna to a transmitter or to a receiver, a relay or switching device must match the impedance of the transmission lines running therefrom to the antenna, the transmitter and the receiver. If the coaxial

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conductor forming the path from the switching device to the antenna presents the impedance of a fifty-ohm transmission line, and like connecting means extend between the switching device and the receiver and the transmitter, then it is necessary that the switching device present a like impedance in order to prevent an undue loss. The switching device therefore is in the form of a series of cylindrical tubes each having a centrally located conductor, and whose dimensions have been carefully calculated. The actual switching is done by the movement as by flexure of one of the centrally located conductors. This movement may be made by a button of insulation extending from the outside of the body of the device and being in contact with the centrally located conductor so that pressure on this button as by electromagnetic force will take the said conductor away from contact with a second such centrally located conductor leading to a receiver and into contact with a third such centrally located conductor leading to a transmitter. Where insulating washers are employed to hold the centrally located conductor in place, they must be set in recesses which have a greater inside diameter than the inside diameter of the cavities in accordance with the difference in the dielectric constant of the insulating material employed, in comparison with the dielectric constant of the air which at other points fills the space between the centrally located conductor and the inside surface of the cavity.

A feature of the invention is a switch in which the electrodes thereof are centrally located conductors each enclosed in a cylindrical cavity.

Another feature of the invention is a relay having an extremely low ohmic resistance through the contacts thereof but constructed and arranged to present an impedance of a definite value to currents of a given very high frequency.

The drawings consist of a single sheet having four figures as follows:

Fig. 1 is a front view of the device;

Fig. 2 is a side view of the device partly in section;

Fig. 3 is a top view in section as indicated by the line 3—3 in Fig. 2;

Fig. 4 is a perspective view of the device as it would be employed.

The relay of the present invention consists essentially of three metallic body portions 1, 2 and 3 which, fitted together, will form a body having precisely dimensioned hollow spaces therein for the accommodation of centrally located conductors forming the electrical path changing

elements of the device. There are four terminals, an upper terminal 4 forming an outlet for connection to an appropriate piece of apparatus, such as a short wave antenna. A second terminal 5 forms an outlet which may lead to a transmitter 6 as indicated in Fig. 4. Third and fourth terminals 7 and 8, respectively, are connected in multiple and will lead to one or two receiving devices, such as the receiver 9. Each of these terminals on the relay is in the form of a connector of the conventional design.

The connector 4, by way of example, consists of an outer shell formed of part of the body of the relay and an inner connector 10. This inner connector is coaxially arranged and forms one part of a metallic piece which, as shown in Fig. 2, is bent downwardly in a body portion 11 and terminates in a movable contact 12. The conducting piece 11 is held in position by being threaded through insulating discs 13, 14 and 15 by means of a plug of insulation 16. As shown in Fig. 2, the centrally located conducting piece 11 may be forced toward the right out of contact with a conducting piece 17 and into contact with the element 18 shown more clearly in Fig. 3.

The plug 16 may be moved by the action of an electromagnet 19 mounted on the body of the device and controlling an armature 20 adjustable by means of the screw 21.

The contact 18 as shown in Fig. 3 terminates a conducting piece 22 leading to and forming part of the coaxial connector 5 and held in place by the insulating pieces 23 and 24.

This relay has been designed to be equivalent to a 50-ohm coaxial transmission line in that the relationship of the outside diameter of the inner conductor, such as 11 and 22, and the inside diameters of the outer conductor formed of the body of the device have been maintained as closely as possible to agree with the transmission line formula

$$Z=\frac{138}{\sqrt{K}}\log_{10}\frac{D}{d}$$

wherein K is the dielectric constant, D is the inside diameter of the cavity and d is the outside diameter of the centrally located conductor. It should be noted that where the inner conductor passes through an insulator the diameter of the insulator is greater than the diameter of the air space on either side. This is done because of the difference in dielectric constants (K) between air and the material of the insulator. Even the insulators have been carefully calculated to adhere to the above formula.

The four outlets have been designed to accommodate a coaxial line fitting which attaches to a 50-ohm transmission line. When the proper lines are attached the relay will switch the antenna circuit from the receiver to the transmitter in a conventional manner such as by pressing a button 25 associated with the microphone 26 without the inherent loss that is always present in other switching mechanisms for high radio frequencies.

This relay is primarily intended for aircraft radio equipment at very high radio frequencies (156 megacycles by way of example). It will be apparent, however, that it is useful for other purposes.

What is claimed is:

1. A relay for switching connections in a system handling currents in the very high frequency range comprising body portions having cavities of circular cross-section therein, cylindrical conductors coaxially disposed within said cavities, the inside diameters D of said cavities bearing a fixed relation to the outside diameters d of said cylindrical conductors expressed by the formula

$$Z=\frac{138}{\sqrt{K}}\log_{10}\frac{D}{d}$$

wherein K is the dielectric constant, an insulating button having a stem extending through the said body portion for operation from an external position for moving one of said cylindrical conductors out of contact with a second of said cylindrical conductors and into contact with a third of said cylindrical conductors, the said cavity for said movable conductor being substantially conical in shape, wider at the movable end of said conductor than at the fixed end thereof and proportioned so that both in its normal and its operated position the said conductor will approach the inside wall of its cavity by no less than one-half of (D—d), each said conductor terminating in a coaxial connector of slotted construction and of greater diameter than the conductor, the body portions of said connectors being integral with the body portions of said relay and having a correspondingly greater inside diameter to maintain said fixed relation expressed by said formula, and insulators fitted into cylindrical recesses at the junction of said cylindrical conductors and said coaxial connector for centering said coaxial connector and for preventing derangement of said coaxial conductors through longitudinal thrust against said coaxial conductors.

2. A relay for switching connections in a system handling currents in the very high frequency range comprising body portions having cavities of circular cross-section therein and terminating in a plurality of coaxial connectors, cylindrical conductors coaxially disposed within said cavities, the inside diameters D of said cavities bearing a fixed relation to the outside diameters d of said cylindrical conductors expressed by the formula

$$Z=\frac{138}{\sqrt{K}}\log_{10}\frac{D}{d}$$

wherein K is the dielectric constant, annulus-shaped insulators for holding said conductors in said coaxial positions, recesses of greater inside diameter than said cavities formed in said body portion for holding said insulators, an insulating button having a stem extending through said body portion for operation from an external position, an electromagnet mounted on the external body of said relay and having an armature bearing against said button for the operation thereof, said button bearing against one of said cylindrical conductors for moving it out of contact with a second of said cylindrical conductors and into contact with a third of said cylindrical conductors, an auxiliary coaxial connector having a cylindrical conductor permanently fixed to said second of said cylindrical conductors, the said cavity for said movable conductor being substantially conical in shape, wider at the movable end of said conductor than at the fixed end thereof and proportioned so that both in its normal and its operated position the said conductor will approach the inside wall of its cavity by no less than one-half of (D—d), each said conductor terminating in a coaxial connector of slotted construction and of greater diameter than the said conductor, the body portions of said connectors being integral with the body portions of

said relay and having correspondingly greater inside diameters in accordance with said formula, and positioning insulators at the junction of said cylindrical conductors and said coaxial connectors for preventing longitudinal thrust against said coaxial connectors from deranging the coaxial disposition of said cylindrical conductors, the proportions of said insulators and the cavities in which they fit conforming to the said fixed relation.

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