June 29, 1954 J. T. WILNER 2,682,592

RADIO FREQUENCY SWITCH FOR SYSTEMS USING COAXIAL CABLES

Filed May 16, 1952 2 Sheets-Sheet 1

FIG. 1.

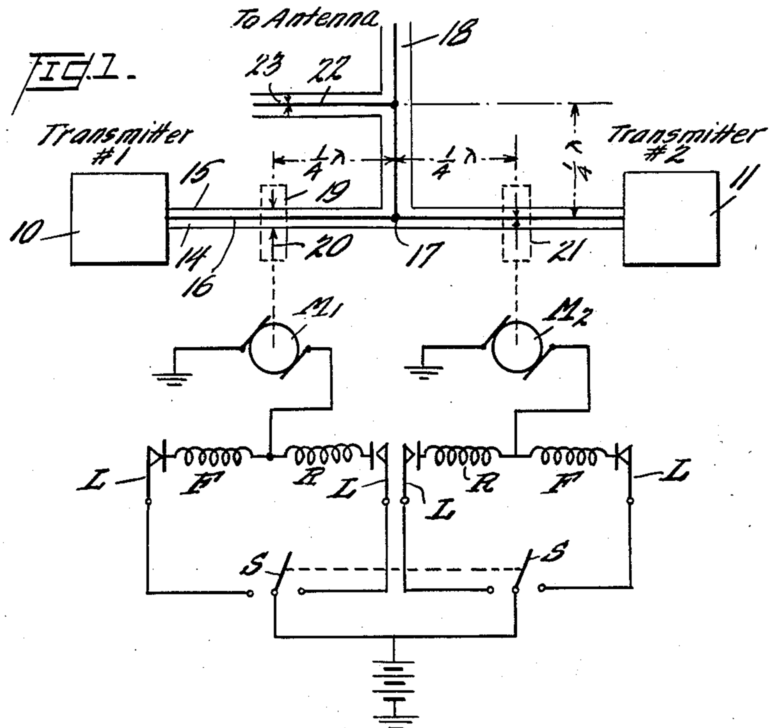

FIG. 5.

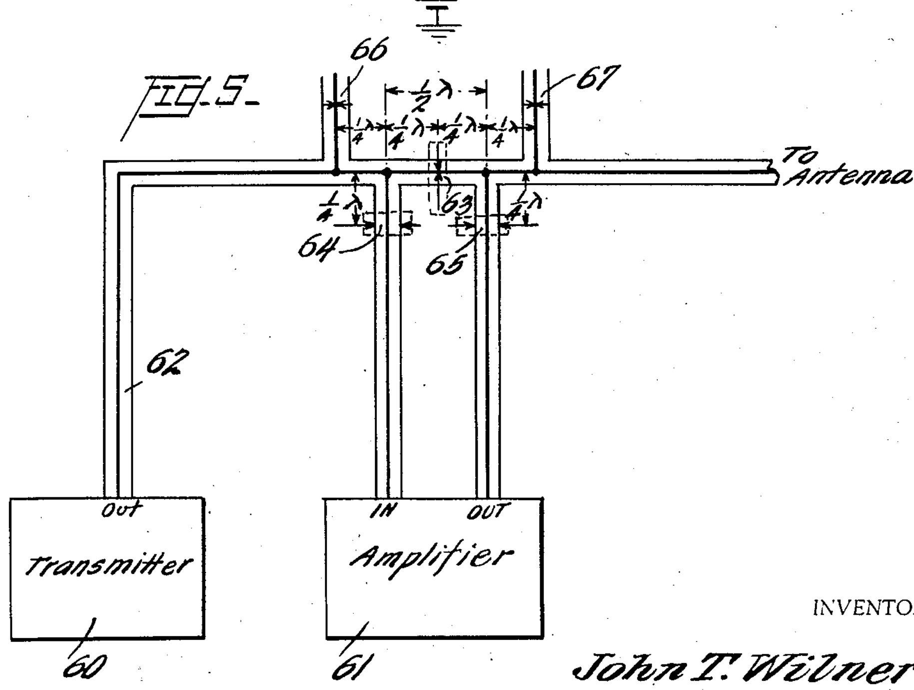

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FIG. 2.

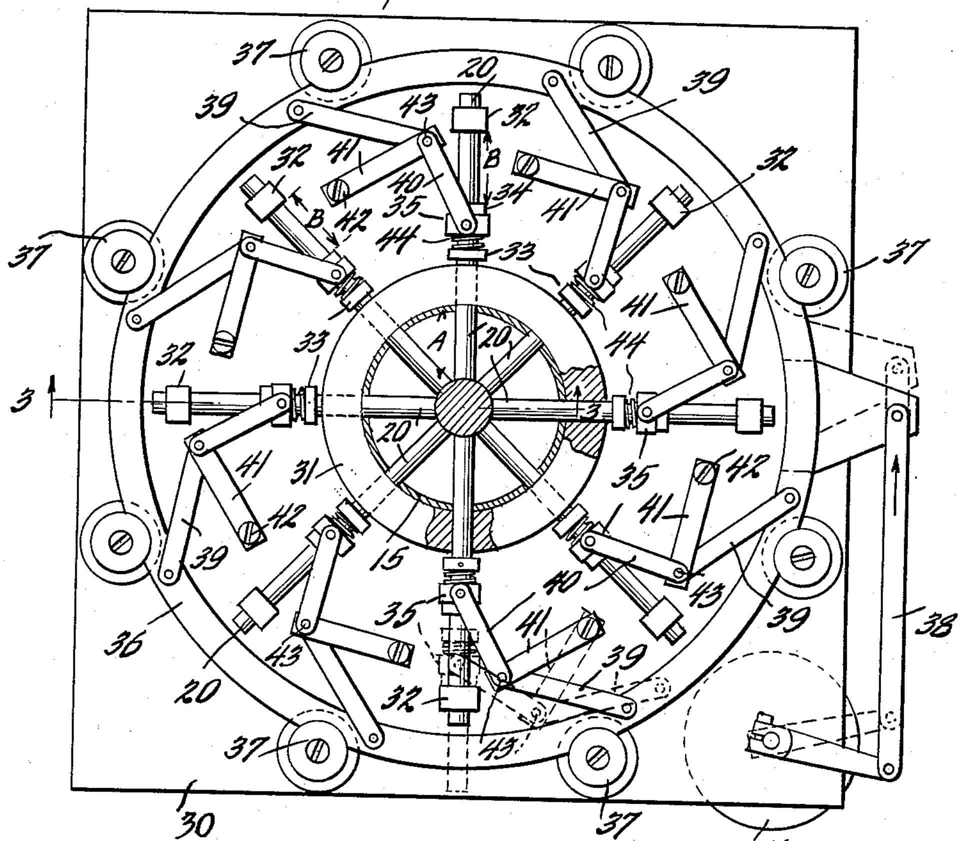

FIG. 3.

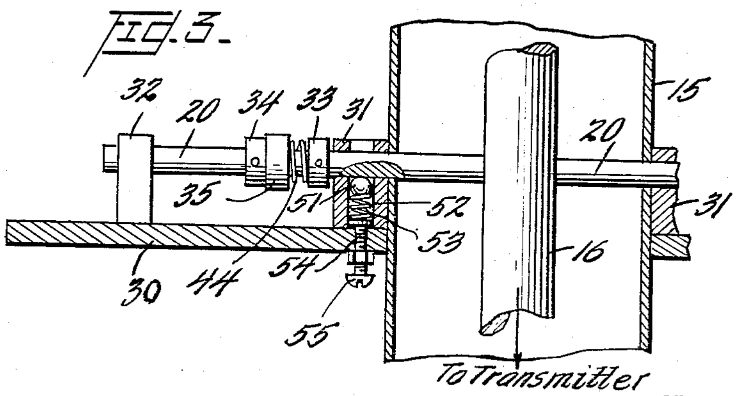

FIG. 4.

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RADIO FREQUENCY SWITCH FOR SYSTEMS USING COAXIAL CABLES

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11 Claims. (Cl. 200—163)

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This invention relates to radiofrequency switches for systems using coaxial cables.

Switches for shifting the power in a coaxial cable from one line to another are well known in the prior art but they are in general unsatisfactory because they distort the signals, when very high frequency video signals are used, and they are inefficient as well as slow in operation. It is a primary object of this invention to provide a switch that overcomes the disadvantages of the prior art.

Another object of this invention is to provide a switch which may be used with a coaxial cable to short the outer and inner conductors at a selected point along the length of the cable and which once it is installed and adjusted will always short the cable at the desired point without even slight variations in the position of the effective short-circuit.

Still another object of the invention is to provide a switch that may be used to shift the coaxial antenna cable of a television station from the main transmitter to a stand-by one.

Other objects and advantages of this invention will appear as this description proceeds.

In carrying out the foregoing objects I employ in addition to the coaxial line a plurality of fingers extending radially inward from the outer conductor. When it is desirable for current to pass the switch undisturbed the fingers are retracted until their inner ends are flush with the inner wall of the outer conductor. When it is desirable to block a flow of current, the fingers are moved inwardly until they firmly contact the inner conductor. As will appear later, the switch is located exactly an odd multiple of quarter wavelengths from a T junction. In order that the switch may be accurately positioned at the desired point along the coaxial cable resilient means press the fingers against that wall of their socket which is closest to the T junction. A special linkage, hereinafter described in detail, is employed for moving the fingers in and out synchronously.

Two or more of these switches may work together in an overall system. Since the switches are operated by reversible motors it is readily possible to move the fingers of one switch inwardly while those of the other switch are moving outwardly.

In the drawings:

Figure 1 is a schematic diagram of one circuit with which my novel switch finds effective use.

Figure 2 is a plan view of a switch incorporating the invention.

Figure 3 is a sectional view taken along line 3—3 of Figure 2.

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Figure 4 is an end view of one of the fingers employed in Figures 2 and 3.

Figure 5 is a schematic diagram of a modified radio circuit in which the new switch finds effective use.

In order to fully understand the reason for certain features involved in the construction of my new switch it is desirable to be familiar with a transmitting system in which the switch finds effective application. Figure 1 is such a system and illustrates a television transmitting station having a main transmitter 10 and a stand-by transmitter 11 both of which preferably operate on the same frequency which may be 200 megacycles for example. The two video units 10 and 11 are interconnected by a coaxial cable 14 having an outer conductor 15 and an inner one 16. The coaxial cable 18 is connected to cable 14 at a T-junction and extends to the antenna.

Located one-quarter wavelength to the left of junction 17 is a switch 19, of a type fully described in connection with Figures 2, 3, and 4. Switch 19, has fingers 20 which may remain in the position shown, in which event current may flow from video unit 10 to the antenna. The fingers may be moved inward by motor M1 until they interconnect the outer conductor 15 with the central conductor 16. Switch 21 is similar to switch 19 except that motor M2 is arranged to move the fingers of switch 21 inward whenever the fingers 20 of switch 19 are moved outward and vice versa. The fingers of switch 21 are "in" and block flow of current from transmitter 10 to transmitter 11, when transmitter 10 is being used. Located along the antenna cable 18 about one-quarter wavelength from junction 17 is a compensating stub 22 which comprises a shorting disc 23 that interconnects the central conductor and the outer cable. Disc 23 is adjustable toward and away from conductor 18 for reasons that will hereinafter appear.

As is well known, when switch 21 shorts the outer to the inner conductor, no power will flow from transmitter 10 into transmitter 11, because switch 21 is located exactly one-quarter wavelength from junction 17. Therefore power from transmitter 10 is faced with infiinite impedance in the branch leading to transmitter 11. In the case of television transmitters where the band of transmitted waves is very broad, this is not strictly true since the distance between junction 17 and switch 21 can at best be one-quarter wavelength at the mean frequency. When wide band waves are to be transmitted it is desirable to add stub 22. It is connected to the line one-half wavelength from switches 19 and 21.

Switch 21 is a good short circuit only at one frequency. Frequencies above and below this media cause reactances to be placed across the line at the junction 17. To neutralize these reactances, the stub 22 is placed so that the shorting disc 23 is one-half wavelength from junction 17. The disc 23 is then adjusted so that the side band reactances are equal but opposite to the ones produced at junction 17 by switch 21. This is by virtue of the fact that equal reactances placed one-quarter wavelength apart on a transmission line cancel out.

The switches are driven in and out by motors M1 and M2. Each motor has two fields, F and R, for opposite directions of rotation, and also has limit switches L for stopping the motor once it has moved the switch to the limit of its travel. The limit switches L are well known limit switches for stopping a motor at the end of predetermined motion. Double pole double throw switch S may be operated to its left hand position in which event motor M1 operates in a forward direction to move fingers 20 of switch 19 inward and motor M2 operates in a reverse direction to move the fingers of switch 21 outward. When switch S is thrown to the right the fingers of switch 19 move outward and those of switch 21 inward.

The switch 19 is shown in greater detail in Figures 2, 3 and 4, where the operating parts are mounted on base 30 which carries a brass ring 31 which guides the fingers 20. The base 30 also carries eight bearings 32 one for each finger 20. Each finger 20 carries collars or flanges 33 and 34 rigidly secured thereto in spaced relation. A sleeve 35 is located around each finger 20 and is arranged for limited in and out motion relative thereto. A large ring 36 is guided by a plurality of rotatable wheels 37. Ring 36 is moved clockwise and counter-clockwise by motor M through a linkage 38. Sleeve 35 and ring 36 are interconnected by links 39, 40 and 41, the latter one of which links is pivoted at 42 to base 30. Link 39 is pivoted at one end to ring 36 and link 40 is pivoted to sleeve 35. Links 39, 40 and 41 are pivoted to each other at point 43. A spring 44 is interposed between sleeve 35 and flange 33.

The inner ends of fingers 20 are slightly curved so that they fit the contour of internal conductor 16 as accurately as possible. When the motor M has moved ring 36 clockwise to the position shown in Figure 2, the links 39 and 40 move sleeve 35 inward thus compressing spring 44 somewhat and thereby pressing collar 33 and the finger 20 inward. Due to the springs 44, all of the fingers 20 are pressed against conductor 16 with proper pressure. When the motor M has moved ring 36 counter-clockwise to the limit of its travel in that direction, the links 39 and 40 pull sleeve 35 outward until the inner ends of fingers 20 are substantially flush with the inner wall of the outer cable 15. The lowermost linkage is shown in a dotted line position which represents its position when ring 36 is moved to its extreme counter-clockwise position.

Referring to Figure 1, it is clear that the distance between junction 17 and switch 19 must be accurately fixed at one-quarter wavelength. If the fingers 20 were allowed to operate loosely in ring 31, inaccuracies would result since it would not be possible to predetermine which point around the periphery of finger 20 was contacting with the outer conductor 15. Therefore, each finger 20 has a groove 50 (see Figure 4). A ball 51 positioned in bore 52 is pressed by spring 53 into the groove 50 and presses the finger 20 against the upper side wall of the bore in ring 31. Therefore, the finger 20 always makes best contact with ring 31 along that surface of the finger that is closest to junction 17. Hence, in measuring the distance of one-quarter wavelength, measurement is made from junction 17 to the point on finger 20 which is closest to that junction. The tension of spring 53 may be controlled by rotating the head 55 of screw 54.

It is desirable to have enough fingers 20 around the periphery of inner conductor 16 so that substantially the entire 360 degrees of its periphery are covered by the ends of the fingers when they have moved to the "in" position. This is desirable inasmuch as it is preferable to have the best possible short circuit between outer conductor 15 and inner conductor 16. When the frequency of operation is very high and the best possible results are desired the fingers 20 may be square instead of round in order to increase the contact area between the fingers and the inner conductor. The distance from collar 34 to bearing 32 (distance "B" of Fig. 2) is slightly greater than the distance between the outer surface of the inner conductor 16 and the inner surface of the outer conductor 15 (distance "A" of Fig. 2) so that when the fingers are "out" their inner ends are about flush with the inner wall of the outer conductor thereby presenting a smooth surface. The fact that irregularities in the inner surface of the outer conductor are held to a minimum is an important factor in reducing distortions in the signals.

The ring 31 is connected to outer conductor 15 by silver solder or other means for effecting very good electrical contact.

It is clear that the foregoing switching system is entirely automatic, and that a shift from one transmitter to another may be made by simply throwing switch S (Figure 1). The switch S may be combined with, or located on the same switchboard with, switches controlling the plate power of the two transmitters whereby to expedite the shifting from one to the other.

Television transmitters normally have a sound output feed line separate from the video one. The system of Figure 1 shows only the video output line but it is understood that the application of my switching system to the sound system would be identical in every respect to Figure 1.

In Figure 5, the transmitter 60 normally drives power amplifier 61 through coaxial cable 62. Normally switch 63 shorts the outer and inner conductors of the cable and causes the output of transmitter 60 to drive power amplifier 61. However, if the power amplifier should become defective, the fingers of switch 63 may be retracted and those of switches 64 and 65 moved inward in which event the output from transmitter 60 flows directly to the antenna. Stubs 66 and 67 compensate for any reflections resulting from switch 63. These stubs have the same construction and mode of operation as stub 22 of Figure 1. Each of switches 63, 64, 65 is the same as the switch shown in Figures 2, 3 and 4.

I claim to have invented:

1. In a switch for a coaxial cable, the cable having a tubular outer conductor and an inner conductor, a base plate extending perpendicular to the axis of the cable, a ring extending around and contiguous with the outer wall of the outer conductor, said ring and outer conductor defining radial holes located in a common plane which is perpendicular to the axis of the cable, an elongated finger of conducting material in each of said radial holes, said ring defining

openings, one for each finger, extending parallel to the axis of the cable from one face of the ring to its complementary finger, a ball in each opening, a spring for each ball for pressing its complementary ball toward the finger, each of said fingers including a groove parallel to the axis of the finger and acting as a raceway for said ball, a pair of spaced flanges mounted on the portion of each finger which extends beyond the outer wall of the ring, a sleeve located between said flanges, a coil spring wound around each finger between each sleeve and the innermost flange, a ring of larger diameter than the first named one, means mounting the second ring for rotary motion about the axis of the cable, and a linkage interconnecting each sleeve with the second ring, each linkage comprising a first link pivoted at one end to the sleeve, a second link pivoted at one end to the second ring, a third link pivoted at one end to the base, and a pivot interconnecting the remaining ends of the three links.

2. In a switch for a coaxial cable, the cable having an outer hollow conductor and an inner conductor, a plurality of fingers of conducting material located in a common plane which is perpendicular to the axis of the cable, said fingers extending through the wall of the outer conductor, said fingers being movable inwardly and outwardly, resilient means for exerting pressure on all the fingers in a direction parallel to the axis of the cable, and stationary means against which the resilient means presses the fingers to accurately position all of them.

3. In a switch for a coaxial cable, the cable having an outer conductor and an inner conductor, a plurality of fingers of conducting material located in a common plane which is perpendicular to the axis of the cable, means mounting said fingers for movement along radii of said cable with the longitudinal axis of each finger colinear with a radius of the cable, said fingers extending through the wall of the outer conductor, and means for simultaneously moving all of the fingers along their respective axes inwardly and outwardly, between two positions in one of which the fingers all touch the inner conductor and in the other of which the inner ends of the fingers are all flush with the inner wall of the outer conductor.

4. The combination of claim 3 including in addition resilient means for exerting pressure on all of the fingers in a direction parallel to the axis of the cable, and stationary means in a plane perpendicular to the axis of the cable against which the resilient means presses the fingers to accurately position all of them.

5. In a switch for a coaxial cable, the cable having an outer hollow conductor and an inner conductor, a plurality of fingers of conducting material located in a common plane which is perpendicular to the axis of the cable, means mounting said fingers with their longitudinal axes along radii of the cable and enabling the fingers to move along their respective longitudinal axes, said fingers extending through the wall of the outer conductor, a pair of spaced flanges fixed to each finger on a portion thereof that extends outside of the outer conductor, a sleeve movable inwardly and outwardly between said two flanges, resilient material located between the sleeve and the inner flange, and means for simultaneously moving all of the sleeves inwardly and outwardly.

6. In a switch for a coaxial cable, the cable having an outer hollow conductor and an inner conductor, a plurality of fingers of conducting material located in a common plane which is perpendicular to the axis of the cable, means mounting said fingers with their longitudinal axes along radii of the cable and enabling the fingers to move along their respective longitudinal axes, said fingers extending through the wall of the outer conductor, a pair of spaced flanges fixed to each finger on a portion thereof outside of the outer conductor, a sleeve movable inwardly and outwardly between said two flanges, a ring surrounding the outer conductor, means mounting the ring for rotation about the axis of the cable, and a linkage connecting each sleeve to the ring, each linkage including means for moving the sleeve inwardly when the ring is rotated in one direction and for moving the sleeve outwardly when the ring is rotated in the other direction.

7. A switch as defined in claim 6 including resilient material located between each sleeve and its complementary inner flange.

8. A switch as defined in claim 6 having a base and in which each linkage comprises a first link pivoted at one end to the sleeve, a second link pivoted at one end to the ring, a third link pivoted at one end to the base, and a common pivot interconnecting the other ends of the three links.

9. In a switch for a coaxial cable, the cable having a hollow outer conductor and an inner conductor, a plurality of fingers extending through the outer conductor and movable in and out, said fingers all being in a common plane which is perpendicular to the axis of the cable, a groove extending along each finger parallel to the axis thereof, a ball in each groove, and resilient means pressing each ball into its complementary groove.

10. In a switch for coaxial cables, the cable having an outer tubular conductor and an inner conductor, the outer conductor having a metal ring around the periphery thereof, a plurality of radial fingers extending through the ring and the outer conductor and movable inwardly and outwardly, said ring including a plurality of holes, one for each finger, which intersect the fingers and are parallel to the axis of the cable, a ball in each hole, and spring means pressing each ball toward its complementary finger, each finger defining a groove acting as a raceway for its complementary ball.

11. In a switch for a coaxial cable, the cable having an outer hollow conductor and an inner conductor, a plurality of elongated fingers of conducting material located in a common plane which is perpendicular to the axis of the cable, said fingers extending through the wall of the outer conductor in positions with their longitudinal axes respectively colinear with radii of the cable, and means controlling the position of the fingers to move their inner ends against the inner conductor or to retract said inner ends to positions flush with the inner wall of the outer conductor.

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