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TRANSMIT RECEIVE DEVICE

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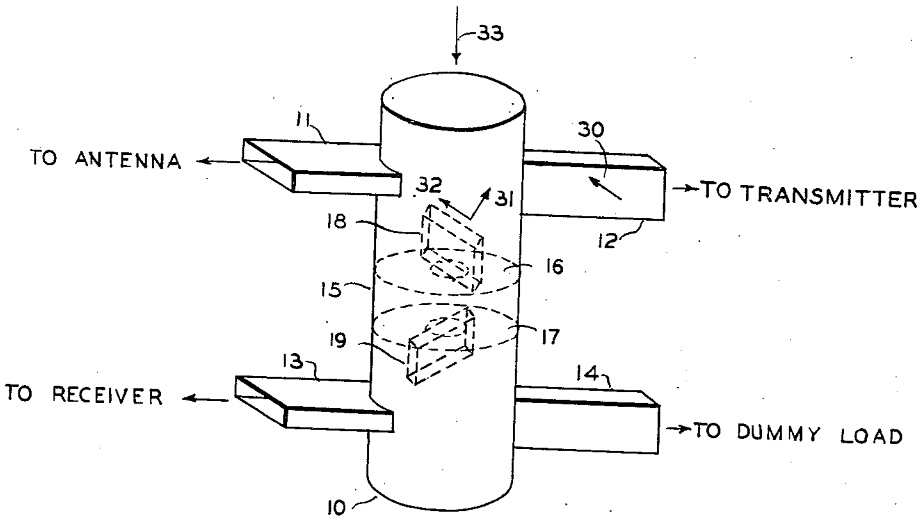

FIGURE 1

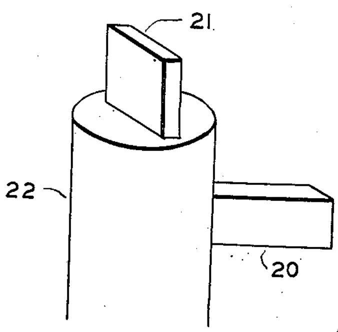

FIGURE 3

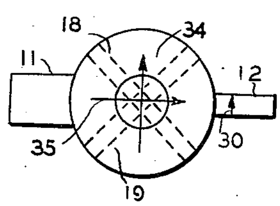

FIGURE 2

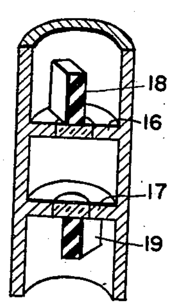

FIGURE 1A

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TRANSMIT RECEIVE DEVICE

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6 Claims. (Cl. 178—44)

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This invention relates in general to electrical switches, and more particularly to electrical switches which operate by virtue of the energy reflected from a conducting spark gap, said spark gap being broken down by the large amount of energy fed to the device.

According to conventional electronic circuit practice for some purposes, a radio receiver and a radio pulse transmitter use the same antenna, both being physically connected to it. The power output of the transmitter may be 10^6 to 10^{12} times as great as the rated power input to the receiver. Thus, if no arrangement is made to effectively disconnect the receiver from the antenna during the period in which the transmitter is transmitting, several input stages of the receiver may be put out of commission, with the result that the thermionic tubes or crystals that may be in these stages will be burned out.

Also, if both the transmitter and receiver are connected to the antenna line when received signals come up the line, these signals will divide according to the relative input impedances of the transmitter and the receiver. Thus, if no arrangement is made to effectively disconnect the transmitter from the antenna during the time when signals are being received, a portion of the power of these signals will be lost in going up the transmitter line. If the power of the received signals is very small, this would be undesirable.

Under some conditions, the transmitter sends out pulses periodically at an audio rate, and it is desirable that the receiver be effectively disconnected from the antenna line as soon as a pulse leaves the transmitter, and that it be effectively reconnected to the antenna line at the end of the transmitted pulse. Due to the comparatively high pulse repetition frequency that may be used, and the steepness of the leading and trailing edges of the pulse, a sensitive device which is operated automatically by the transmitted pulse itself is used, in order to obtain a high degree of accuracy. The aforementioned devices usually takes the form of a spark gap type of apparatus, which is made conductive by the transmitted energy, and so acts as a reflector of electromagnetic waves. Since a spark gap takes a finite time to break down, energy will pass through the device for a short time immediately after the transmitted pulse starts. This energy is called "spike" energy and is tolerable under some conditions only because it lasts a very short time. Because of the fact that it has such a large amplitude, however, the "spike" energy is undesirable, for it weakens the ele-

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ments in the input stages of the receiver. Also, due to the fact that the impedance of a conducting spark gap is not zero, there is not complete reflection of the transmitted pulse from the spark gap when it is broken down and some energy will pass through the device to the receiver. This energy, called "plateau" energy, also shortens the life of the elements in the input stages of the receiver, and so is undesirable.

Under conditions where the carrier frequency of the pulse transmitter is very high, the system may use wave guides as transmission means, in which case it is desirable to have a type of switch which uses to advantage certain types of polarization of the electromagnetic energy which are peculiar to wave guides.

Among the objects of my invention, therefore, are:

1. To provide an effective electrical switch which effectively disconnects such a receiver from the antenna line during the time in which such a transmitter is transmitting.
2. To provide an effective electrical switch which effectively disconnects the transmitter from the antenna line while the receiver is receiving.
3. To provide such a switch that substantially eliminates the "spike" energy and "plateau" energy which passes through such a type of spark gap switch.
4. To provide such a switch that will operate in a wave guide system.

In accordance with the present invention, there is provided a circular wave guide into which is connected four rectangular wave guides, one connecting to the transmitter, one to the antenna, one to the receiver and one to a dummy load. Inside the cylindrical wave guide there is a spark gap device and two dielectric slabs. The polarization of the rectangular guides and the size and placement of the dielectric slabs are such that substantially all of the transmitted wave will couple into the antenna and substantially all of the received wave will couple into the receiver. It is understood that dielectric slabs are used as an example of means to change the type of polarization within the circular guide. Other means may conceivably be used.

My invention will best be understood by reference to the drawings in which:

Fig. 1 shows a perspective view of the complete electrical switch according to my invention;

Fig. 1A is a longitudinal cross-sectional view of the switch of Fig. 1 taken through the center in a plane parallel to the plane of the paper;

Fig. 2 shows a top view of the device of Fig. 1; and

Fig. 3 shows another method of connecting the wave guides in the device of Fig. 1.

Referring now to the description of the apparatus and to Fig. 1, there is shown a cylindrical wave guide 10 into which four rectangular wave guides are connected, one guide 11 being connected to the antenna as marked, one guide 12 to the transmitter as marked, one guide 13 to the receiver as marked and one guide 14 to a dummy load as marked. Wave guides 12 and 14 have their short axes perpendicular to those of wave guides 11 and 13, with wave guide 11 being diametrically opposite wave guide 12, and wave guide 13 being diametrically opposite wave guide 14. Placed in the cylindrical guide 10 symmetrically with respect to the top group of guides 11 and 12 and bottom group of guides 13 and 14 is a spark gap device 15 comprising two irises 16 and 17 placed perpendicular to the long axis of the guide 10 and spaced a quarter wavelength apart. The apertures in the irises are covered with glass and the device is filled with a gas at low pressure. A dielectric slab 18 is placed on top of one iris 16 at such an angle within the wave guide 10 that its axis which is along a diameter of the wave guide 10 makes an angle of 45° with the long axis of guides 11 and 12. Another dielectric slab 19 is placed on the bottom of the other iris 17 at such an angle within the wave guide 10 that its axis which is along a diameter of the wave guide 10 makes an angle of 45° with the long axes of guides 13 and 14 and is perpendicular to a similar axis of slab 18. The lengths of each of the slabs 18 and 19 along the long axis of the wave guide 10 is such that the component of an electromagnetic wave parallel to the plane of the slab will be retarded by a quarter of a wavelength in passing through the slab.

Fig. 2 shows more clearly the placement of the dielectric slabs with respect to one another and with respect to the wave guides.

Fig. 3 shows an alternative way of connecting the transmitter wave guide 20 and the antenna wave guide 21 into the circular guide 22. In this case, the transmitter guide 20 and antenna guide 21 are mutually perpendicular. The receiver wave guide, not shown, is connected in the same manner as the antenna guide 21, and the dummy load wave guide, not shown, is connected in the same manner as the transmitter guide 20. The remainder of the apparatus is the same as that of the device of Fig. 1.

Referring now to the operation of the system and to Fig. 1, let us suppose for example that transmitter wave guide 12 is operating in the $TE_{1,0}$ mode. In this mode the electric flux lines are along the short dimension of the guide, as shown at 30 and are of such a polarization with respect to the cylindrical guide 10 that the $TE_{1,1}$ mode is set up in guide 10. This mode is set up because it is the dominant mode and it can be made to have a substantial amount of its electric lines as represented by 34, Fig. 2, parallel to the electric lines 30 in guide 12. This transverse-electric mode, one in which the electric field is linearly polarized, is propagated down the guide 10 until the dielectric slab 18 is reached. At this point, the vector representing the electric field can be broken down into two components, one 31 perpendicular to the slab and one 32 parallel to the slab. The slab is of such a length along the guide 10 that an electric field parallel to it is delayed by a quarter of a cycle in passing through it with respect to a wave perpendicular to its face. At the bottom of the slab, due to the delaying action, the electric field from the transmitter becomes circularly polarized, with rotation in a counterclockwise direction looking in the direction 33. When the circularly polarized field passes through the second dielectric slab 19, it again becomes linearly polarized in the $TE_{1,1}$ mode with the electric vector parallel to its original direction 30.

Referring now to the automatic switching action of the device, it can be seen that a pulse emitted from the transmitter branch 12 can not pass into the receiver branch 13. Let wave guide 12, as before, be operating in the $TE_{1,0}$ mode, and let this field, as before, excite the $TE_{1,1}$ mode in circular guide 10. The dielectric slab 18 circularly polarizes the wave, and it is in this condition when it reaches the iris 16. Under some conditions this wave comes from a high-power transmitter and it contains a large amount of energy, which causes the gap in iris 16 to eventually break down. This gap cannot fire, however, until the iris is charged, and so the transmitted pulse passes through the spark gap device 15 for the amount of time it takes for the gap to break down. This circularly polarized "spike" of energy then passes through dielectric slab 19 which causes it to again become linearly polarized. Due to the relative placement of the two slabs with respect to the external guides and with respect to each other, the wave becomes linearly polarized in such a direction 34, Fig. 2, that it couples easily into wave guide 14 and so the "spike" energy is dissipated in the dummy load. The receiver guide 13 cannot absorb this wave, because the length along the axis of guide 13 perpendicular to and in the same plane as the electric vector 34 is less than the cut-off dimension for the $TE_{1,0}$ mode.

As soon as the gap in the iris 16 fires, it places a very low impedance across the wave guide 10 at this point. The energy reaching the iris, therefore, splits into two components, one, a very large percentage of the total, being reflected by the low impedance gap, the other, called the "plateau" energy, passing through the device. Thhis "plateau" energy will experience modifications similar to those the "spike" energy received, and so will be coupled into guide 14 to the exclusion of guide 13, and be dissipated in the load. The energy reflected from the fired gap passes again through dielectric slab 18 and again becomes linearly polarized, this time in the direction represented by vector 35, Fig. 2. The distance from guide 11 to the top of the circular guide 10 is so chosen that the reflected wave combines with the incident wave at the entrance to guide 11 so as to create a bending of the electric lines in this area so that the field represented by vector 35 couples into guide 11 setting up the $TE_{0,1}$ mode in this guide. As is true for the other wave guides in the system, antenna guide 11 can pass only the dominant mode, in this case the $TE_{0,1}$ mode.

Iris 17 is placed a quarter wavelength away from iris 16 so that when the gap in iris 16 fires, creating a low impedance and a minimum electric field across it, there will be a maximum electric field across the gap in iris 17, causing it to break down. The effect of the two gaps is to create a lower effective impedance across the gap of iris 16 when it is firing.

It can furthermore be seen that received energy entering guide 10 from the antenna guide 11 can couple only into receiver guide 13. A received pulse sets up a polarization in guide 10 as represented by vector 35 in Fig. 2. This orientation cannot couple into guide 12 so all of it is propagated down guide 10. The energy of the received pulse is too small to break down the spark gaps. The dielectric slab 18 circularly polarizes the wave, which is linearly polarized again by slab 19 in a direction parallel to the original direction 35 and so couples into guide 13 and sets up the $TE_{0,1}$ mode. The orientation of guide 14 is such that a wave of polarization 35 cannot couple into it.

Referring now to Fig. 3, there is shown another way of connecting the antenna guide and the receiver guide. The device operates in the same manner as the above-mentioned device, with the $TE_{0,1}$ mode being set up in guide 21 by the energy reflected from the iris gap.

While there has been described what is at present considered the preferred embodiment of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is, therefore, aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

I claim:

1. An electrical switch system for coupling a transmitter and a receiver to a common antenna comprising a circular waveguide, a first rectangular waveguide coupling the transmitter to said circular waveguide, the longitudinal axis of said first waveguide being radial to the longitudinal axis of said cylindrical waveguide and the longer sides of said first waveguide being parallel to said cylindrical waveguide longitudinal axis, a second rectangular waveguide coupling the antenna to said circular waveguide, said second waveguide being axially aligned with said first waveguide and having its longer sides perpendicular to said cylindrical waveguide longitudinal axis, a dissipating load and a third rectangular waveguide coupling said dissipating load to said circular waveguide, said third waveguide being longitudinally displaced along said circular waveguide from said first waveguide and having its longer sides coplanar with the longer sides of said first waveguide, a fourth rectangular waveguide coupling the receiver to said circular waveguide, said fourth waveguide being longitudinally aligned with said third waveguide and having its longer sides parallel to the longer sides of said second waveguide, a spark gap device in said circular waveguide, said spark gap device being symmetrically disposed between said rectangular waveguides, a first quarter wave phase shifting slab positioned between said spark gap device and said first and second waveguides, an axis of said slab being along a diameter of said circular waveguide making an angle of 45 degrees with the longitudinal axis of said first and second waveguides, and a second quarter wave phase shifting slab positioned between said spark gap device and said third and fourth waveguides, an axis of said slab being along a diameter of said circular waveguide making an angle of 90 degrees with said first slab axis whereby energy pulses from said transmitter are radiated from said antenna without injuring said receiver and energy pulses received by said antenna are impressed upon said receiver without being dissipated within said transmitter.

2. The electrical switch system recited in claim 1, wherein said spark gap device comprises two irises spaced one-quarter wavelength apart at the frequency of operation and positioned perpendicularly to said circular waveguide longitudinal axis, the apertures of said irises being covered with glass, the space between said irises being filled with a gas at a low pressure, and the said first and second quarter wave phase shifting slabs respectively being in contact at one end with the iris nearest to it.

3. The electrical switch system recited in claim 1, wherein said first, second, third and fourth rectangular waveguides are dimensioned to transmit plane polarized energy in the fundamental mode in a first plane of polarization and not at a plane at right angles to said first plane.

4. The electrical switch system recited in claim 1, wherein said second and fourth waveguides are each respectively coupled to said circular waveguide through the circular waveguide end nearest to said first and third waveguides, the said second and fourth waveguides being axially aligned with said circular waveguide and forming a plane at right angles to the plane formed by said first and third waveguides.

5. An electrical switch system comprising first, second, third and fourth energy coupling means, said means being designed to transmit linearly polarized energy in a fundamental mode in a single plane of polarization, said means all coupling to a common circular waveguide, said first and second coupling means being oriented to have their transmission polarization planes at different angles to each other, said third and fourth coupling means being displaced from said first and second coupling means and respectively similarly oriented, spark gap means to reflect intense energy from said first to said second coupling means within said wave guide and to permit passage therethrough of weak energy, a first quarter wave phase shifting slab positioned between said spark gap means and said first and second coupling means, an axis of said slab being along a diameter of said circular waveguide and making an angle of 45 degrees with the longitudinal axis of said first and second coupling means, and a second quarter wave phase shifting slab positioned between said spark gap means and said third and fourth coupling means, an axis of said second slab being along a diameter of said circular wave guide making an angle of 90 degrees with said first slab axis.

6. An electrical switch system comprising first, second, third and fourth energy coupling means, said means being designed to transmit linearly polarized energy in a fundamental mode in a single plane of polarization, said means all coupling to a common coupling means, said first and second coupling means being oriented to have their transmission polarization planes at different angles to each other, said third and fourth coupling means being displaced from said first and second coupling means and respectively similarly oriented, spark gap means to reflect intense energy from said first to said second coupling means within said common coupling means and to permit passage therethrough of weak energy, first transformer means within said common coupling means and disposed at said spark gap means between said first and second coupling means for transforming linearly polarized energy from said first and second coupling means into circularly polarized energy and for retransforming the energy reflected by said spark gap means into linearly polarized energy in a polarization plane ac-

ceptable by said second coupling means, and second transformer means within said common coupling means and disposed at said spark gap means between said their and fourth coupling means for transforming circularly polarized energy into linearly polarized energy in a polarization plane to be acceptable only by one and not the other of said third and fourth coupling means.

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