Dec. 20, 1949 W. M. HALL ET AL 2,491,971

SWITCH TUBE DEVICE FOR WAVEGUIDES

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FIG. 1.

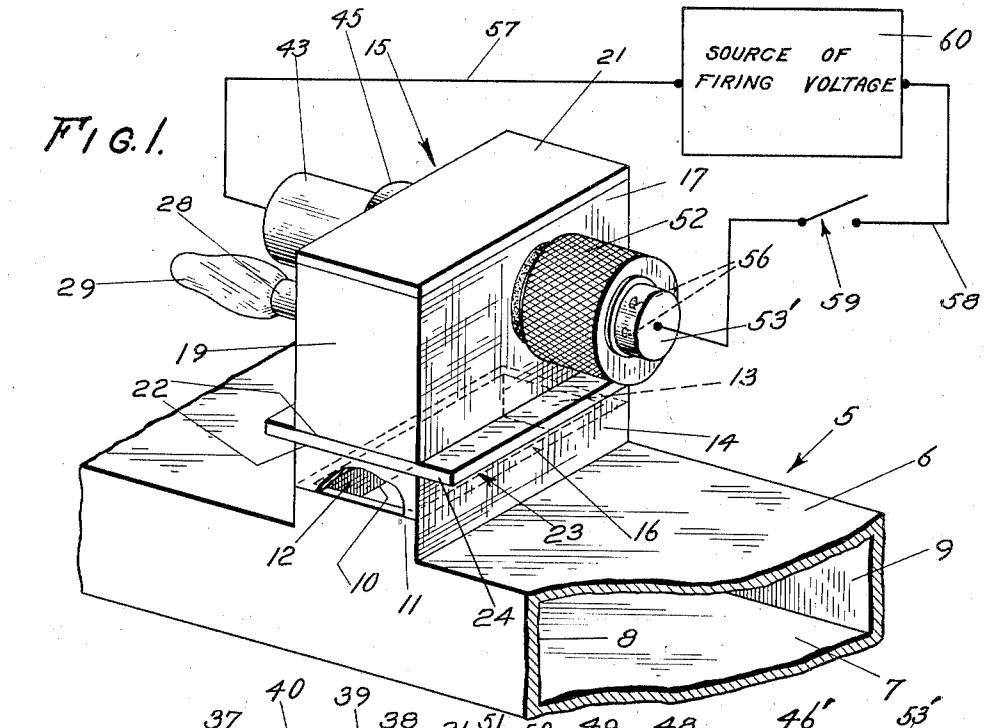
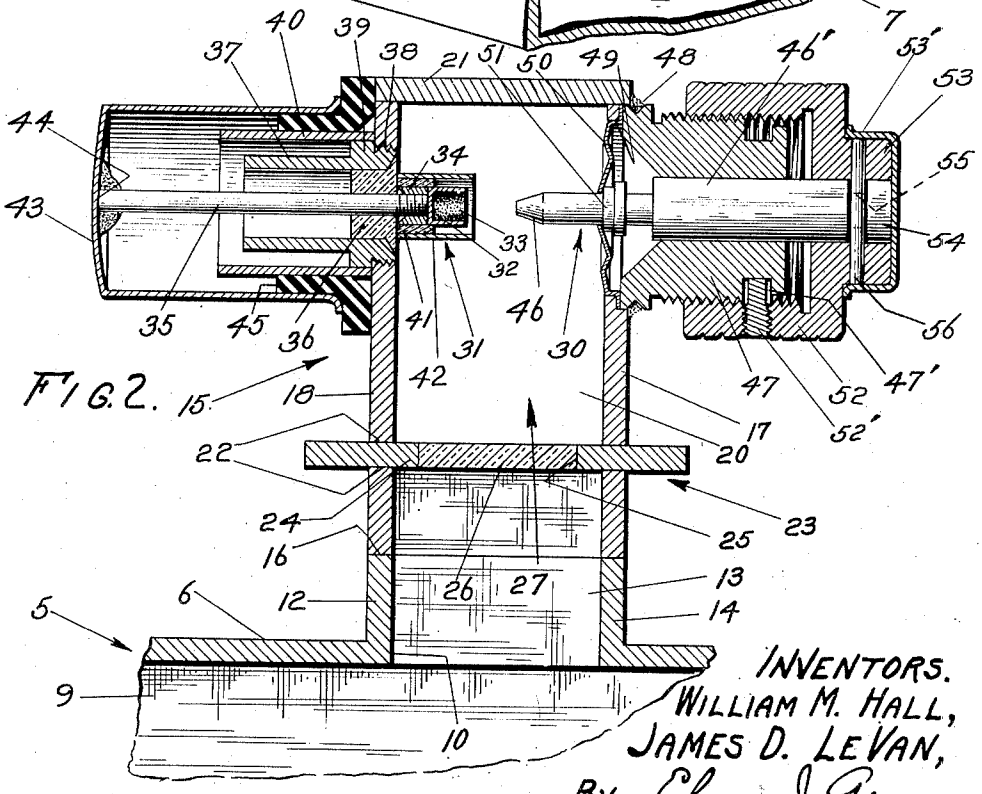


FIG. 2.



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SWITCH TUBE DEVICE FOR WAVE GUIDES

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Our present invention relates to switching devices, and more particularly, to a switch tube for controlling the propagation of electromagnetic energy through a hollow wave guide, or through a coaxial transmission line, or through any other similar mechanism capable of conveying energy of the general character indicated.

It is the main object of our present invention to obtain such control by altering the impedance of a discontinuity in an energy-transmission system, such as one of those above referred to, whereby, at the will of the operator, said discontinuity may be made to appear to the energy being conveyed as an infinite impedance, or as a short circuit.

It is a further object of our present invention to provide a switch tube which enables, as nearly as is possible, the attainment of the ideal impedance conditions above described.

It is a still further object of our present invention to accomplish the foregoing in a simple and inexpensive manner.

These and other objects of my present invention, which will become more apparent as the detailed description thereof progresses, are attained, briefly, in the following manner:

For purposes of illustration, it will be assumed throughout this specification that the energy-transmission system to which our present invention is applied comprises a hollow, rectangular wave guide, and that the discontinuity in said wave guide consists of a transverse, rectangular opening in one of the side walls upon which terminate the e-lines of the propagated electromagnetic energy. There will obviously be a high impedance between the longer side edges of such an opening, and it is with the alteration of this impedance that our present invention is concerned.

Secured to the wave guide, over the above-mentioned opening, is a wave-guide section, which is closed at one end, and open at the other so as to communicate with the interior of said wave guide.

Said wave-guide section is provided with a partition, which is pervious to the propagated energy, and which cooperates with the side walls and closed end of said wave-guide section to form a chamber containing an ionizable atmosphere, for example, a mixture of helium and hydrogen at reduced pressures.

Disposed within said chamber is a pair of electrodes, one, an anode, and the other, a cold cathode, said electrodes extending inwardly from opposite side walls of the wave-guide section, and

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being connected across a source of firing voltage.

Said electrodes are so located in said wave-guide section with respect to the discontinuity to be controlled, and with respect to the closed end of said wave-guide section, that the electrical distance between said electrodes and said discontinuity always remains equal to the length of an integral number of half-waves at the frequency of the propagated energy, whether or not the device is being fired. Therefore, when the device is firing, the resulting short-circuit condition between said electrodes is reflected at said discontinuity, and the propagated energy can continue along the wave guide; but, when the device is not firing, the open-circuit condition between said electrodes is reflected at said discontinuity, and the propagated energy cannot pass the infinite impedance presented thereto.

In the accompanying specification we shall describe, and in the annexed drawing show, an illustrative embodiment of the switch tube of our present invention.

It is, however, to be clearly understood that we do not wish to be limited to the details herein shown and described for purposes of illustration only, inasmuch as changes therein may be made without the exercise of invention and within the true spirit and scope of the claims hereto appended.

In said drawing,

Fig. 1 is a perspective view of a wave guide provided with a switch tube made in accordance with the principles of our present invention; and

Fig. 2 is a longitudinal sectional view taken substantially through the center of such a switch tube.

Referring now more in detail to the aforesaid illustrative embodiment of our present invention, and with particular reference to the drawing illustrating the same, the numeral 5 generally designates an energy-transmission system, here shown in the form of a hollow, rectangular wave guide comprising spaced side walls 6 and 7 connected by end walls 8 and 9.

The side wall 6 is provided with a transverse, rectangular opening 10 which constitutes the above referred to discontinuity whose impedance to the energy travelling through the wave guide it is desired to control, said opening being surrounded by walls 11 to 14, inclusive, integrally formed with and rising from said side wall 6 for a purpose later to be described.

The switch tube of our present invention, generally designated by the reference character 15, is secured to the wave guide 5 by being mounted

upon and hermetically sealed, as at 16, to the upper edges of the walls 11 to 14, inclusive, said switch tube itself constituting a wave-guide section comprised of side walls 17 and 18 connected by end walls 19 and 20. Said wave-guide section is open at one end, where it meets the rising walls 11 to 14, inclusive, so as to communicate with the interior of the wave guide 5, and it is closed at its other end by a top wall 21.

The walls 17 to 20, inclusive, of the tube 15 are split, as at 22, to receive a partition 23 consisting of a conducting frame 24 provided with a central, rectangular aperture 25 in which is sealed a window 26 made of material which is pervious to electromagnetic energy, said window being of such size that it will pass a frequency band of appreciable width. The partition 23, together with the upper portions of the split walls 17 to 20, inclusive, and the wall 21, defines a hermetically sealed chamber 27 which is provided with an ionizable atmosphere, for example, a mixture of helium at a pressure of 22 mm., and hydrogen at a pressure of 2 mm., the presence of the hydrogen being desirable because of its relatively short deionization time.

In order to enable filling of the chamber 27 with the aforementioned atmosphere, the wall 18 is provided with a tube 28 communicating with said chamber, the outer end of said tube being provided with a glass seal 29 upon completion of the filling operation.

Mounted in the opposite side walls 17 and 18 of the tube 15, so as to extend into the chamber 27, are an anode member 30 and a cathode member 31, said electrodes being coaxially disposed in opposition to each other, and presenting a gap between their opposed ends.

The cathode member 31, preferably, comprises a cathode cup 32 provided with a highly electron-emitting coating 33 on its inner surface, said cup being secured to a suporting collar 34 which is internally threaded to receive a rod 35, in turn, imbedded in a glass bead 36. The latter is sealed to a conducting sleeve 37, threadedly engaged, as at 38, in the wall 18 and extending outwardly therefrom, said sleeve being provided with a flanged portion 39 over which fits another conducting sleeve 40, abutting the wall 18 at its inner end, and, like the sleeve 36, extending outwardly from said wall. The sleeves 37 and 40, together, constitute an R.-F. choke to prevent radiation of electromagnetic energy from the rod 35.

The cathode support 34 is surrounded by an insulating collar 41 and this, in turn, is surrounded by a cathode shield 42.

The outer end of the rod 35 contacts a cap 43, as at 44, said cap seating over an insulating collar 45 surrounding the choke sleeve 40 at the base thereof.

The anode member 30, preferably, comprises a conducting rod 46 which is provided with an enlarged portion 46' slidably mounted in an externally threaded bushing 47, said bushing being hermetically sealed, as at 48, in a shouldered opening 49 formed in the wall 17. In order to maintain the chamber 27 air-tight, the opening 49 is covered by a centrally-apertured, flexible diaphragm 50 secured, at its outer periphery, in the shouldered portion of said opening 49 and, at its central aperture, to a collar 51 formed on the anode rod 46.

Engageable over the bushing 47 is an internally threaded cap 52 having a head 53 at its outer

end which is receptive of the outer end 54 of the anode rod 46, said outer end 54 being provided with an annular channel 55 receptive of a pair of pins 56 transversely disposed in the head 53. After the pins 56 are in place, the head 53 is provided with a cap 53' to keep said pins from falling out. It will be noted that rotation of the cap 52 reciprocates the anode rod 46, whereby the gap between the opposed ends of the rod 46 and the cathode cup 32 may be adjusted for a purpose which will later become apparent. After this adjustment is made, the cap 52 is locked against rotation by means of a screw 52' threadedly engaged in said cap and bearing against the bottom wall of an annular recess 47' formed in the bushing 47.

Caps 44 and 52 are connected, through conductors 57 and 58, and a switch 59, to a source of voltage 60, so that when the switch 59 is closed, a discharge takes place between the electrodes 30 and 31.

Now, such a discharge has the effect, together with the electrodes 30 and 31, of introducing a low inductance between the walls 17 and 18 of the tube. The section of the tube between the electrodes and the end wall 21 can also be considered as presenting an inductance across the tube at the location of the electrodes. The impedance, therefore, appearing at the location of the electrodes is that of these two inductances in parallel, and the resulting inductance must be taken into account in arriving at the location of the electrodes with respect to the discontinuity to be controlled. Taking this inductance into account the distance between the electrodes and the discontinuity is made slightly less than the length of an integral number of half-waves at the operating frequency of the wave guide. Preferably this distance should be slightly less than a single half wave so that the low impedance condition bewteen the electrodes, which is reflected at the discontinuity, will be a minimum. When such a low impedance condition obtains, the energy being propagated through the wave guide can continue past the discontinuity.

On the other hand when the tube is not discharging, the electrodes 30 and 31 present a certain capacitance between the walls 17 and 18. The electrodes are, therefore, designed and proportioned so that the capacitance reactance is such that considering the distance between the electrodes and the end wall 21 of the tube, which has already been fixed, the impedance reflected at the discontinuity in the wave guide is a maximum, and the propagated energy is prevented from passing said discontinuity.

The location of the partition 23 is also quite critical. The window 26, carried by said partition, behaves as another resonant circuit in parallel with the wave guide at the location of said partition. In order, therefore, to minimize its effect the window is located electrically an odd number of quarter waves from the discontinuity in the wave guide. At such a point the impedance with which the window is in parallel is extremely low when the tube is not discharging. Hence, any reactance introduced by the window will have a minimum effect.

Finally, we have found it best to join the tube 15 to the wave guide at a point approximately an odd number of eighth waves from the discontinuity. At such a point, the effect of poor contact between the tube and the wave guide is a minimum, both when the tube is discharging and

when it is not. For this purpose, the rising walls 11–14, inclusive, are provided.

This completes the description of the aforesaid illustrative embodiment of our present invention. It will be noted from all of the foregoing that we have provided a simple switch tube for controlling the impedance of a discontinuity in a wave guide, whereby the energy being propagated through said wave guide may be presented, at said discontinuity, with either a short-circuit condition, in which case, the energy can continue travelling through the wave guide, or with an infinite impedance, in which case, the energy is prevented from travelling further down the wave guide.

Other objects and advantages of our present invention will readily occur to those skilled in the art to which the same relates.

What is claimed is:

1. A switch tube for changing the impedance of a discontinuity in a hollow wave guide from infinity to a short circuit, comprising: a wave-guide section closed at one end and open at the other; said open end being adapted to communicate with the interior of said hollow wave guide at said discontinuity; a partition disposed within said wave-guide section to form, in cooperation with the walls and closed end thereof, a chamber containing an ionizable atmosphere; and a pair of spaced electrodes disposed within said chamber and adapted to have a voltage applied thereto to cause an electrical discharge therebetween; the electrical distances between said partition and said discontinuity, and said electrodes and said discontinuity, being equal, respectively, to the length of an odd number of quarter-waves and slightly less than the length of an integral number of half-waves at the operating frequency of said wave guide; and the electrical distance between said electrodes and the closed end of said wave-guide section being equal to slightly less than the length of an odd number of quarter-waves at said operating frequency.

2. A switch tube for changing the impedance of a discontinuity in a hollow wave guide from infinity to a short circuit, comprising: a wave-guide section closed at one end and open at the other; said open end being adapted to communicate with the interior of said hollow wave guide at said discontinuity; a partition, including a conducting frame having an iris closed by a glass window, disposed within said wave-guide section to form, in cooperation with the walls and closed end thereof, a chamber containing an ionizable atmosphere; and a pair of spaced electrodes disposed within said chamber and adapted to have a voltage applied thereto to cause an electrical discharge therebetween; the electrical distances between said partition and said discontinuity, and said electrodes and said discontinuity, being equal, respectively, to the length of an odd number of quarter-waves and slightly less than the length of an integral number of half-waves at the operating frequency of said wave guide; and the electrical distance between said electrodes and the closed end of said wave-guide section being equal to slightly less than the length of an odd number of quarter-waves at said operating frequency.

3. A switch tube for changing the impedance of a discontinuity in a hollow wave guide from infinity to a short circuit, comprising: a wave-guide section closed at one end and open at the other; said open end being adapted to communicate with the interior of said hollow wave guide at said discontinuity; a partition disposed within said wave-guide section to form, in cooperation with the walls and closed end thereof, a chamber containing an ionizable atmosphere; a pair of spaced electrodes disposed within said chamber and adapted to have a voltage applied thereto to cause an electrical discharge therebetween; the electrical distances between said partition and said discontinuity, and said electrodes and said discontinuity, being equal, respectively, to the length of an odd number of quarter-waves and slightly less than the length of an integral number of half-waves at the operating frequency of said wave guide; and the electrical distance between said electrodes and the closed end of said wave-guide section being equal to slightly less than the length of an odd number of quarter-waves at said operating frequency; and means to alter the spacing between said electrodes.

4. A switch tube for changing the impedance of a discontinuity in a hollow wave guide from infinity to a short circuit, comprising: a wave-guide section closed at one end and open at the other; said open end being adapted to communicate with the interior of said hollow wave guide at said discontinuity; a partition, including a conducting frame having an iris closed by a glass window, disposed within said wave-guide section to form, in cooperation with the walls and closed end thereof, a chamber containing an ionizable atmosphere; and a pair of spaced electrodes disposed within said chamber and adapted to have a voltage applied thereto to cause an electrical discharge therebetween; the electrical distances between said partition and said discontinuity, and said electrodes and said discontinuity, being equal, respectively, to the length of an odd number of quarter-waves and slightly less than the length of an integral number of half-waves at the operating frequency of said wave guide; and the electrical distance between said electrodes and the closed end of said wave-guide section being equal to slightly less than the length of an odd number of quarter-waves at said operating frequency; and means to alter the spacing between said electrodes.

5. A switch tube for changing the impedance of a discontinuity in a hollow wave guide from infinity to a short circuit, comprising: a wave-guide section closed at one end and open at the other; said open end being adapted to communicate with the interior of said hollow wave guide at said discontinuity; a partition, including a conducting frame having an iris closed by a glass window, disposed within said wave-guide section to form, in cooperation with the walls and closed end thereof, a chamber containing a mixture of helium and hydrogen at reduced pressures; and a pair of spaced electrodes disposed within said chamber and adapted to have a voltage applied thereto to cause an electrical discharge therebetween; the electrical distances between said partition and said discontinuity, and said electrodes and said discontinuity, being equal, respectively, to the length of an odd number of quarter-waves and slightly less than the length of an integral number of half-waves at the operating frequency of said wave guide; and the electrical distance between said electrodes and the closed end of said wave-guide section being equal to slightly less than the length of an odd

number of quarter-waves at said operating frequency; and means to alter the spacing between said electrodes.

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