March 5, 1946. M. E. HIEHLE 2,395,870

IMPEDANCE SWITCHING DEVICE

Filed Dec. 7, 1942

Fig.1.

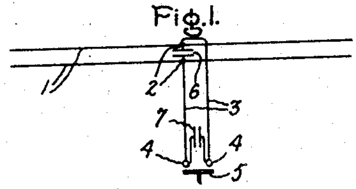


Fig.2.

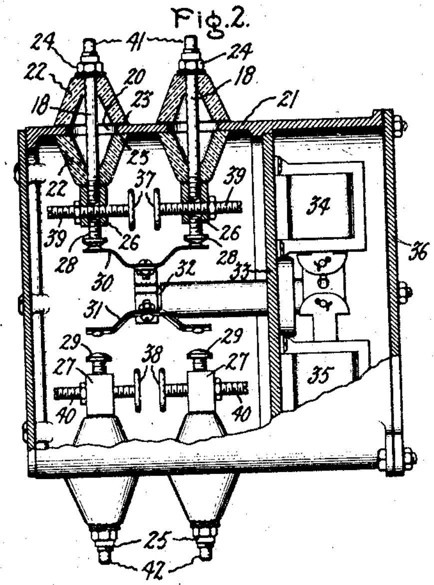
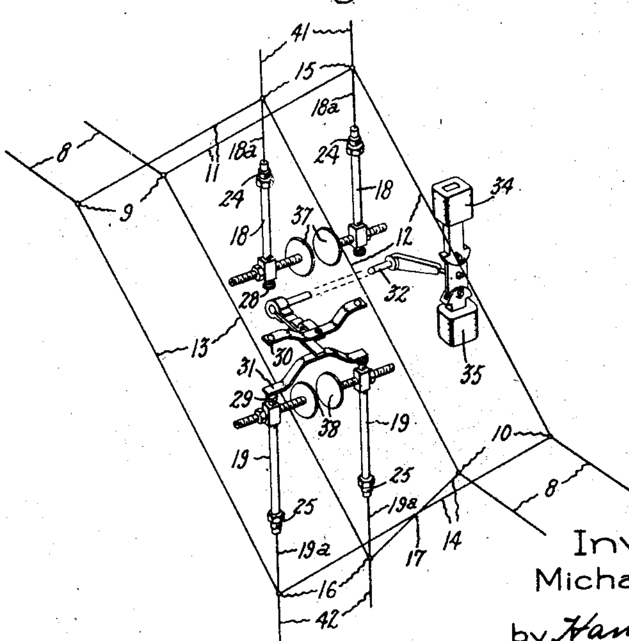


Fig.3.



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IMPEDANCE SWITCHING DEVICE

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Application December 7, 1942, Serial No. 468,120

2 Claims. (Cl. 178—44)

The present invention relates to an impedance switching device for controlling the flow of radio frequence energy.

At high frequencies it has been suggested that switching be accomplished by using the impedance inversion characteristics of quarter wavelength transmission lines, i. e., transmission lines having an electrical length at the frequency to be controlled equal to an odd number of quarter wavelengths. However, due to the inherent reactance of the switch contacts and end effects of the quarter wavelength transmission line, it is difficult to provide the necessary 90 electrical degree phase relationship so that no reaction is presented in the radio frequency circuit to be controlled.

The object of my invention is to provide an improved impedance switching arrangement for preventing reaction in the circuit to be controlled due to the reactance of the switch contacts and leads.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. My invention itself, however, both as to its organization and method of operation, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawing in which Fig. 1 is a diagram illustrating the application of my impedance switching device to a radio frequency circuit; Fig. 2 is a sectional view of an impedance switching device for obtaining a 180 degree phase shift in the controlled radio frequency circuit; and Fig. 3 is a diagram showing the application of the Fig. 2 device.

Referring to the drawing, there is shown a transmission line 1 carrying radio frequency energy to be controlled. This line is connected to terminals 2 at one end of a transmission line 3 having an electrical length at the frequency to be controlled different from an odd number of quarter wavelengths. The other end of the transmission line 3 is provided with terminals 4 which may be short circuited by a switch 5. If the transmission line 3 had an electrical length exactly equal to a quarter wavelength (or odd multiple thereof), shorting of the terminals 4 by the switch 5 would produce the effect of an open circuit at the terminals 2 and accordingly no reaction would be produced in the transmission line 1 to the flow of radio frequency energy. Opening the switch 5 under the same conditions would produce a short circuit at the terminals 2 which would prevent the flow of radio frequency energy along the transmission line 1.

Due to the inherent reactance associated with the contacts 4 and switch 5, it is difficult to obtain the exact quarter wavelength relation necessary for the above described operation. In the present construction the desired relation is obtained by tuning reactances 6 and 7, indicated as condensers, respectively shunted across terminals 2 and 4.

The tuning reactance 6 has a value such that when the switch 5 is closed against the contacts 4 the electrical length of the transmission line 3 is tuned to an odd number of quarter wavelengths and, as explained above, causes an open circuit to appear at the terminals 2. The tuning reactance 7 has no effect since it is shorted by the switch 5.

The tuning reactance 7 has a value such that when the switch 5 is open the transmission line 3 is tuned to an odd number of quarter wavelengths. Since the terminals 4 are open circuited, a high impedance appears at these terminals, while a low impedance (short circuit) appears at the terminals 2, shorting the reactance 6.

The reactance 6 tunes the transmission line for the condition in which a high impedance appears at the terminals 2 and the reactance 7 tunes the transmission line 3 for the condition in which a short appears at the terminal 2. When one of the reactances is effective for tuning, the other reactance is shorted. The reactances 6 and 7 accordir ly are independently adjustable.

In Figs. 2 and 3 is shown an application of the impedance switching arrangement of Fig. 1 to a circuit in which a 180 degree phase shift may be produced in the controlled radio frequency energy. The radio frequency energy to be controlled flows through a transmission line 8 (equivalent to transmission line 1 in Fig. 1) connected in series with input terminals 9 and output terminals 10 of an impedance switching device comprising four quarter wavelength transmission lines 11, 12, 13, and 14 (transmission lines having an electrical length equal to an odd multiple of a quarter wavelength at the frequency to be controlled) connected in a bridge circuit between the terminals 9 and 10. The transmission lines 11 and 12 form a series circuit from the input terminals 9 through intermediate terminals 15 to output terminals 10. The transmission lines 13 and 14 form another series circuit between the input terminals 9 through intermediate terminals 16 to output terminals 10.

One of the transmission lines, for example the transmission line 14, has a transposition 17 so that a 180 degree phase shift is obtained by shifting the flow of radio frequency energy to one or the other of the series paths.

The flow of radio frequency energy is controlled by quarter wavelength transmission lines respectively connected to the intermediate terminals 15 and 16 of the bridge. As shown in Figs. 2 and 3, the transmission lines comprise conductors 18 and 19 extending through openings 20 in side walls of a metal casing 21 and leads 18a and 19a connecting the conductors 18 and 19 to the terminals 15 and 16. The conductors 18 and 19 are supported by conical insulators 22 having bases 23 abutting opposite sides of the casing side walls. The outer ends of the conductors 18 and 19 are provided with threaded terminals 24 and 25 for connection with the conductors 18a and 19a. At the inner ends of the conductors 18 and 19 are threaded metal bushings 26 and 27 in the outer ends of which are threaded contacts 28 and 29 which cooperate with switch blades 30 and 31 carried on a rock shaft 32 journaled in a partition 33 in the casing 21 and controlled by solenoids 34 and 35 arranged between the partition 33 and the end wall 36 of the casing. Upon energizing the solenoid 34, the switch blade 30 is moved into engagement with the contacts 28 and the switch blade 31 is moved away from the contacts 29. Upon energizing the solenoid 35 the switch blade 31 is moved into engagement with the contacts 29 and the switch blade 30 is moved away from the contacts 28.

The transmission lines 18, 18a, and 19, 19a serve the same function as the transmission line 3 in the Fig. 1 construction, i. e., are transmission lines having an electrical length different from an odd multiple of a quarter wavelength at the controlled frequency. The contacts 28 and 29 correspond to the terminals 4, the terminals 15 and 16 correspond to the terminals 2, and the switch blades 30 and 31 correspond to the switch 5. The function of the tuning reactance 7 is obtained by condenser plates 37 and 38 carried by adjusting screws 39 and 40 respectively threaded into the metal sleeves 26 and 27. The function of the tuning reactance 6 is obtained by transmission line stubs 41 and 42 projecting respectively beyond the terminals 15 and 16. The condenser plates 37 and 38 are so adjusted that when the switches 30 and 31 are open the electrical length of the transmission lines 18, 18a and 19, 19a is tuned exactly to an odd multiple of a quarter wavelength of the radio frequency to be controlled. The transmission line stubs 41 and 42 are of such length that when the switches 30 and 31 are closed the electrical length of the transmission lines 18, 18a and 19, 19a is tuned exactly to an odd multiple of a quarter wavelength.

The solenoids 34 and 35 are arranged so that one or the other is alternatively energized so as to close one or the other of the switches 30 and 31. In the position shown in Fig. 2 the switch 30 is closed and the switch 31 is open. Since the inner end of the transmission line 18, 18a is shorted, a low impedance appears at the inner end and a high impedance appears at the terminals 15. At the terminals 15 no resistance is offered to the flow of radio frequency energy through the transmission lines 11 and 12 and no reaction appears in the transmission line 8. Under this condition the switch 31 is open, causing a high impedance to appear at the inner end of the transmission line 19, 19a and a short circuit to appear at the terminals 16. Shorting of the terminals 16, due to the impedance inversion characteristics of quarter wavelength transmission lines, causes a high impedance to appear at the terminals 9 and 10 to the flow of radio frequency energy through the transmission lines 13 and 14. In the Fig. 2 position, radio frequency energy accordingly flows through the transmission lines 11 and 12.

In the position shown in Fig. 3 the solenoid 35 is energized, closing the switch 31 and thereby causing a high impedance to appear at the terminals 16 so that no resistance is offered to the flow of radio frequency energy through the transmission lines 13 and 14. The switch 30 is open, causing a short circuit to appear at the terminals 15 which causes a high impedance to appear at the terminals 9 and 10 to the flow of radio frequency energy through the transmission lines 11 and 12. In the Fig. 3 position, radio frequency energy therefore flows wholly through the transmission lines 13 and 14, and, due to the transposition 17, has a 180 degree phase displacement. Since the transmission lines 11 and 12 are of the same length as the transmission lines 13 and 14, the impedance between the terminals 9 and 10 is constant and is independent of which path the radio frequency energy flows. The 180 degree phase displacement is accordingly obtained without producing any reaction in the transmission line 8.

In the construction of Figs. 2 and 3 the transmission line stubs 41 and 42 and the condensers 37 and 38 which respectively perform the functions of the tuning reactances 6 and 7 of the Fig. 1 construction are not wholly independent due to the fact that the condensers 37 and 38 are not connected directly at the contact surfaces of the contacts 28 and 29. When the switches 30 and 31 are closed, the condensers 37 and 38 are not completely shorted, although shorting is sufficient for practical purposes. This means that when the switches 30, 31 are closed, the transmission lines 18, 18a and 19, 19a are tuned to a very minor extent by the condensers 37 and 38. When the switches 30, 31 are open, tuning of the transmission lines is wholly by the condensers 37 and 38.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. An impedance switching device for controlling the flow of radio frequency energy, comprising a transmission line having an electrical length different from an odd number of quarter wavelengths of the frequency to be controlled, terminals at one end of the line for connection to the source of radio frequency energy, terminals at the other end of the line shunted by a galvanic switch means, a reactance shunting said first terminals of a value such that the electrical length of the line when the switch means is closed is tuned to an odd number of quarter wavelengths, and an adjustable reactance shunting the switch means of a value such that the electrical length of the line when the switch is open is tuned to an odd number of quarter wavelengths.

2. An impedance switching device for controlling the flow of radio frequency energy, comprising a pair of series connected quarter wavelength transmission lines for connection in series with the source of radio frequency energy to be con-

trolled, an arrangement for selectively producing a high or low impedance at the common junction of said pair of lines to cause respectively a low and a high impedance to the flow of radio frequency energy through said lines comprising, a third transmission line having terminals at one end connected to said junction and terminals at the other end shunted by galvanic switch means, said third transmission line having an electrical length at the frequency to be controlled different from an odd number of quarter wavelengths, a reactance shunting said first terminals of a value such that the electrical length of said third line when the switch means is closed is tuned to an odd number of quarter wavelengths, causing a high impedance to appear at said junction, and an adjustable resistance shunting said switch terminals of a value such that said third line when the switch means is open is tuned to an odd number of quarter wavelengths causing a low impedance to appear at said junction.

MICHAEL E. HIEHLE.

Certificate of Correction

Patent No. 2,395,870. March 5, 1946.

MICHAEL E. HIEHLE

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 3, second column, line 6, claim 2, for "resistance" read *reactance*; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 15th day of October, A. D. 1946.

[SEAL]

LESLIE FRAZER,
First Assistant Commissioner of Patents.