June 10, 1947. O. M. WOODWARD, JR 2,422,160

VARIABLE REACTANCE DEVICE FOR COAXIAL LINES

Filed June 13, 1944

Fig. 1.

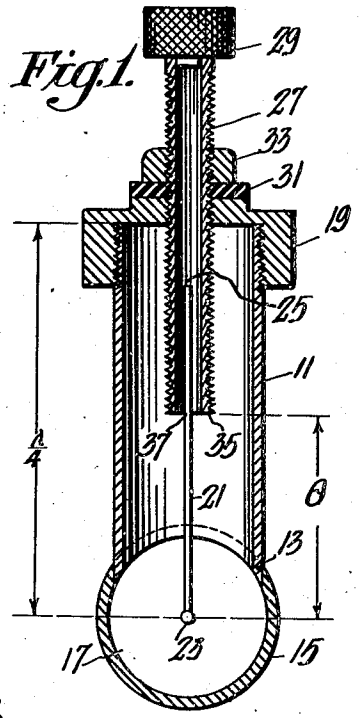



Fig. 4.

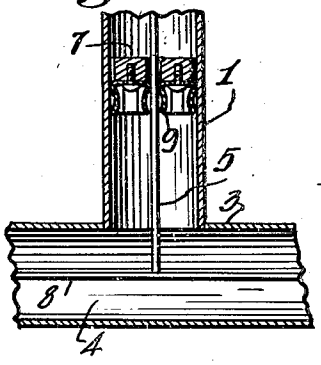



Fig. 2.

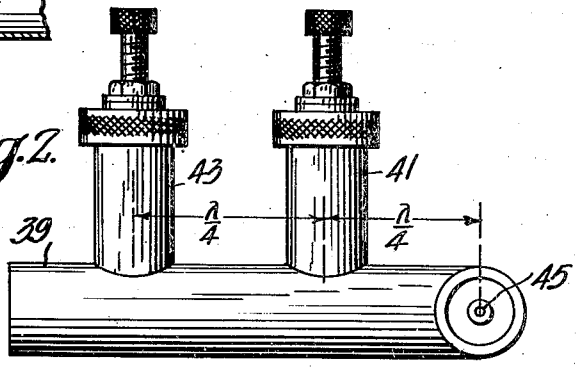
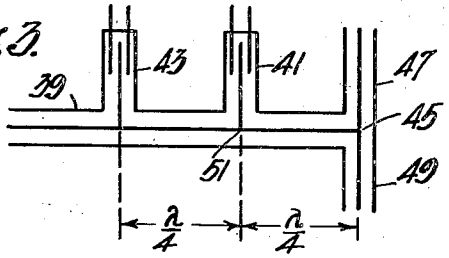



Fig. 3.




INVENTOR.
Oakley M. Woodward, Jr.
BY
C. D. Ruska
ATTORNEY

Patented June 10, 1947 2,422,160

# UNITED STATES PATENT OFFICE

2,422,160

## VARIABLE REACTANCE DEVICE FOR COAXIAL LINES

Oakley M. Woodward, Jr., Princeton, N. J., assignor to Radio Corporation of America, a corporation of Delaware

Application June 13, 1944, Serial No. 540,108

4 Claims. (Cl. 178—44)

1

This invention relates to variable or adjustable reactance devices of the type used in radio frequency transmission line circuits for impedance matching and the like.

The principal object of the instant invention is to provide an improved variable reactance stub structure capable of withstanding severe vibration and exposure to weather conditions, as encountered in aircraft antenna installations.

Another object is to provide a device of the described type which is readily adjustable, but does not include sliding fingers or contacts.

A further object is to provide an improved variable reactance stub which may be locked mechanically secure and watertight at any required setting.

These and other objects will become apparent to those skilled in the art upon consideration of the following description, with reference to the accompanying drawing, wherein Figure 1 is a sectional elevation of a variable reactance stub in accordance with the present invention; Figure 2 is a view in elevation of a pair of reactance stubs similar to that shown in Figure 1, in operative position upon a coaxial transmission line; Figure 3 is an outline drawing indicating the electrical connections of the system of Figure 2; and Figure 4 is a sectional view of a typical prior art reactance stub structure.

The term reactance stub as used herein is defined as a transmission line section connected at one of its ends to the points across which reactance is to be inserted, and open-circuited or short-circuited at its other end. It is well known that such transmission line sections, or stubs, will exhibit the properties of reactances which may be made of substantially any required value by proper adjustment of the effective stub length. Reactance stubs find application particularly at high frequencies, since lumped pure reactance elements for high frequencies are difficult or impossible to construct, and stubs for high frequency use are of reasonably small dimensions and relatively easy to make.

Referring to Figure 4, an inductive stub typical of prior art practice includes an outer cylindrical conductor 1 connected to one of the terminals across which inductive reactance is desired; for example, the outer conductor 3 of a coaxial transmission line 4. An inner conductor 5 is disposed coaxially within the conductor 1 and connected at one end to the inner conductor 8 of the coaxial line 4. A conductive plug 7 is provided within the conductor 1, for short-circuiting the free end of the stub. The plug 7 is adjustable in

2

position lengthwise of the stub for adjusting the magnitude of the reactance across the line 4. If repeated adjustment is not required, the plug 7 is soldered or otherwise permanently secured in position. Otherwise, spring contact fingers 9 are provided for ensuring electrical connection of the plug 7 to the members 1 and 5. The outer conductor 1 may be provided with a longitudinal slot for introduction of a tool, such as a screw driver, for adjusting the plug 7.

The above-described type of reactance stub structure is widely used, notwithstanding the difficulties in making and maintaining accurate adjustment of the position of the shorting plug, the undesirable characteristics of spring contact fingers, and the susceptibility to the entrance of moisture, dirt, etc.

The present invention contemplates the use of an inductive stub, effectively in series with a capacitance, and coupled to the point of utilization through a concentric line section. The inductive stub is varied in length by adjustment of the inner conductor, rather than the shorting plug. This adjustment simultaneously varies the length of the coupling line and the capacitance in series with the stub. The use of three simultaneously variable elements, rather than the single variable of stub length, enables the designer to select dimensions such that the variation of reactance as a suction of adjustment position is substantially linear over a wider range than is possible with the usual short-circuited adjustable stub.

Refer to Figure 1. An outer conductor 11 is connected at one end 13 to one side of the circuit where reactance is required, for example, the outer conductor 15 of a coaxial transmission line 17. The conductor 11 is preferably made one-quarter wavelength long at the frequency at which the system is to operate, although other lengths may be used, for example, three-quarter wavelength. The other end of the conductor 11 is closed with a plug 19, threaded or soldered or otherwise permanently secured to the conductor 11. An inner conductor 21 is connected at one end to the other side of the utilization circuit, in this case the inner conductor 23 of the line 17, and is open-circuited at its other end 25.

A tubular conductor 27 extends through, and is in threaded engagement with, an aperture in the plug 19. The conductor 27 is coaxial with the conductor 21, and may be adjusted longitudinally with respect thereto by rotation in the plug 19. A knurled adjusting knob 29 is provided at the end of the conductor 27. A washer 31 and a lock nut 33 are provided for fixing the adjustment of

the conductor 27 and preventing the entrance of water through the screw threads in the plug 19.

The operation of the above-described device is as follows:

The outer conductor 11 and the tubular conductor 27, with the plug 19, cooperate to function as a short-circuited stub, presenting reactance between the lower end 35 of the conductor 27 and the outer conductor 11. Since this stub is shorter than one-quarter wavelength, the reactance is inductive. The inner conductor 21 and the tubular conductor 27 act as an open-circuited stub presenting capacitive reactance between the lower end 35 of the conductor 27 and the adjacent point 37 on the inner conductor 21. This capacitive reactance is electrically in series with the inductive reactance of the shorted stub.

The outer conductor 11 and the inner conductor 21, from the point 37 to the point 23, constitute a section of coaxial line of length $\theta$. The net reactance between the point 37 and the outer conductor 11 is transformed as a function of the length $\theta$ to another value of reactance, which appears between the point 23 and the outer conductor 15 of the line 17. The latter reactance is positive (i. e. inductive) for any position of the conductor 27, if the outer conductor 11 is one-quarter wavelength. Any positive reactance from zero to substantially infinite value may be obtained across the line 17 by adjustment of the conductor 27.

Referring to Figures 2 and 3, two devices 41 and 43 of the type illustrated in Figure 1 are connected to a coaxial line 39 at points respectively one-quarter and one-half wavelength distant from a junction point 45. Coaxial lines 47 and 49 lead from the point 45 to matched loads such as antennas, not shown. The other end of the line 39 extends to a radio transmitter or receiver or other load, not shown. The parallel connection of the lines 47 and 49 to the point 45 produces a standing wave having a low voltage point at 45 and a high voltage point at 51, one-quarter wave away. By proper adjustment of the two reactance devices 41 and 43, the feed line to the transmitter may be matched, preventing the appearance of standing waves thereon. A mismatch of the lines 47 and 49 caused by the installation of the feed system may be corrected also by adjustment of the stubs 41 and 43.

The invention has been described as an improved variable reactance device, comprising concentric conductors arranged to act as an inductive stub in series with a capacitor and coupled to the utilization point through a line impedance transformer. Reactance devices may be readily designed in accordance with the invention to have the advantages of greater stability and ease of adjustment than similar prior art devices.



I claim as my invention:

1. A variable reactance device comprising, in unitary structural combination, a short-circuited concentric line section substantially less than one-quarter wavelength long, an open-circuited concentric line section substantially less than one-quarter wavelength long electrically in series therewith, the inner conductor of said first line being integral with the outer conductor of said second line, a third concentric line section connected at one of its ends to said series-connected sections, and means for adjusting the longitudinal position of said integral conductors to adjust simultaneously the lengths of said three line sections.

2. The invention as set forth in claim 1, wherein the sum of the lengths of said short-circuited section and said third section is substantially one-quarter wavelength at operating frequency.

3. A variable reactance device comprising an outer tubular conductive member substantially one-quarter wavelength long at operating frequency, a second tubular conductive member extending coaxially within said outer member and connected thereto at one end of said outer member, and an innermost conductor extending coaxially within said outer conductor and into said second conductor, said second conductor being adjustable longitudinally with respect to said outer and innermost conductors.

4. A variable reactance device including a tubular outer conductor substantially an integral odd number of quarter wavelengths long, a second tubular conductor connected to one end of said first conductor and extending coaxially within said outer conductor by an adjustable amount, and an innermost conductor extending coaxially within said second conductor and spaced radially therefrom, whereby said first and second conductors cooperate to function as an inductive short-circuited concentric line stub, said second and third conductors cooperate to function as a capacitive open-circuited concentric line stub in series with said short-circuited stub, and said first and third conductors cooperate to function as a concentric line transformer section connected to said series-connected stubs.

OAKLEY M. WOODWARD, JR.


REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

| Number | Name | Date |
|---|---|---|
| 2,159,648 | Alford | May 23, 1939 |
| 2,181,901 | Lindenblad | Dec. 5, 1939 |
| 2,171,219 | Malter | Aug. 29, 1939 |