Dec. 11, 1956 J. F. WILCOX 2,774,045

ULTRA-HIGH-FREQUENCY TUNER

Filed Oct. 17, 1951

Fig. 1.

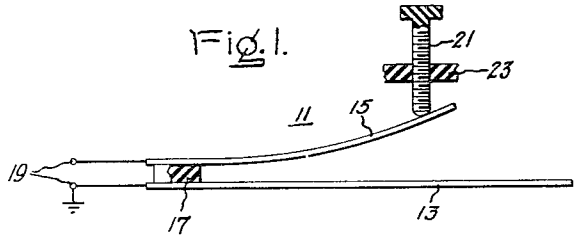


Fig. 2.

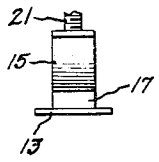


Fig. 3.

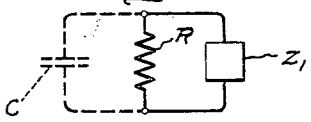


Fig. 4.

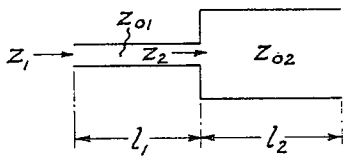


Fig. 5.

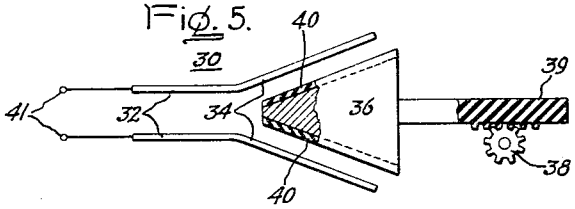


Fig. 6.

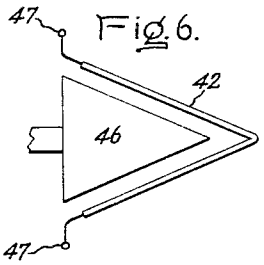


Fig. 7.

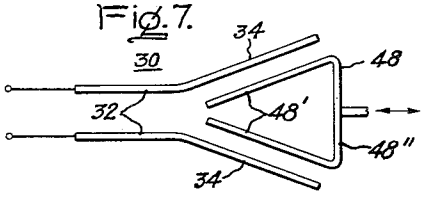


Fig. 8.

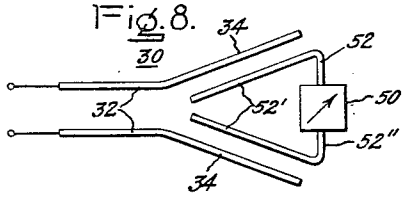
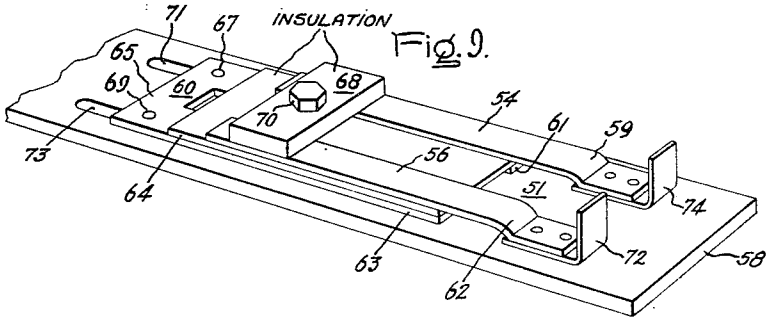


Fig. 9.



Inventor:
James F. Wilcox
by Merton D. Morse
His Attorney.

United States Patent Office 2,774,045 Patented Dec. 11, 1956

2,774,045

ULTRA-HIGH-FREQUENCY TUNER

James F. Wilcox, Syracuse, N. Y., assignor to General Electric Company, a corporation of New York

Application October 17, 1951, Serial No. 251,675

5 Claims. (Cl. 333—82)

My invention relates generally to ultra-high-frequency apparatus, and more particularly to tuning-circuit arrangements operable over a relatively wide band of ultra-high-frequency values.

Heretofore, tuning-circuit arrangements have been described for use with ultra-high-frequency apparatus, but such arrangements have either been excessively large and bulky and costly to produce, or such arrangements have comprised certain structural features such as sliding conductive contacts that require frequent adjustment and replacement. Other arrangements that have been described comprise lumped-constant circuit elements which are not very feasible in the desired frequency range. It is, therefore, a primary object of this invention generally to improve the art of ultra-high-frequency tuning arrangements.

Another object is to provide such tuning arrangements that are free from sliding conductive connections and relatively simple in construction and economical to produce.

Still another object is to provide novel and improved tuning circuit arrangements operable over relatively wide ranges of frequency values in the ultra-high-frequency band.

Another object is to provide an adjustable tuning circuit including as elements thereof a plurality of sections of resonant transmission line having adjustable reactive coupling therebetween.

Yet another object is to provide such an adjustable filter that is characterized in that a predetermined band of frequencies is readily passed by the filter, the cut off at one end of the pass band being relatively abrupt.

In accomplishing the foregoing objects, I eliminate the undesirable sliding conductive connections characteristic of conventional types of high-frequency tuners by employing a resonant section of transmission line having reactive means of the distributed constant type for varying the characteristic impedance of the transmission line. In accordance with one aspect of this invention, the transmission line is constructed as a non-parallel pair of spaced conductors connected at one end to a reactive circuit to be tuned, and having at the other end, adjustable means for varying the characteristic impedance of the line.

In accordance with another aspect of this invention, the transmission line comprises a pair of parallel-wire or rod conductors connectible at one end to a reactive circuit to be tuned and having adjustable means at the other end for varying the characteristic impedance of the line.

My invention will be better understood from the following description taken in connection with the accompanying drawing and its scope will be pointed out in the appended claims.

In the drawing, Fig. 1 is a side elevational view of one embodiment of my invention; Fig. 2 is a side view of the apparatus shown in Fig. 1; Figs. 3 and 4 are schematic diagrams useful in explaining the operation of the apparatus illustrated in Fig. 1; Figs. 5–8 are plan views illustrative of other embodiments of the invention; and Fig. 9 is a perspective view of a further modification of the invention.

Referring to Figs. 1 and 2 of the drawing, an adjustable tuner constructed in accordance with the present invention is shown, comprising a section of non-uniform transmission line **11** having a ground plate **13**, which may be a flat strip of brass or other suitable conductive material, disposed in cooperative relation to an arcuate strip **15** of spring material. The plate **13** and strip **15** are spaced from each other and secured together by means of a spacer block **17** of any suitable insulation material, the connection of the conductors **13**, **15** to the block **17** being effected in any conventional manner. Input terminals **19** are provided at the end of transmission line **11** adjacent the block **17** for connection to a circuit to be tuned or resonated. To vary the characteristic impedance of the line **11**, the spacing between the plate **13** and strip **15** is adjustable by altering the curvature of strip **15**, as by an insulating screw **21** that is suitably supported in an insulating frame **23**.

An approximate theory of operation of the above-described tuner circuit can be obtained by consideration of the lumped-parameter equivalent circuit shown in Fig. 3, taken in connection with the diagram of Fig. 4, which is illustrative of a distributed-parameter circuit roughly equivalent thereto.

In Fig. 3, the capacitance C represents the effective capacitance of an apparatus which is desired to be tuned by the apparatus of the present invention and the resistance R represents the load resistance. The tuning reactance is represented by the reactance Z_1 equivalent to the reactance of the non-uniform line **13**, **15** of Figs. 1 and 2. The arrangement is, therefore, quite similar to that of a band-pass filter approximating the non-uniform transmission line of Fig. 4 of which the input impedance Z_1, by well-known transmission line theory, may readily be shown to be:

$$Z_1 = jZ_{01}\left(\frac{Z_{01}\tan\beta l_1 - Z_{02}\cot\beta l_2}{Z_{01}+Z_{02}\tan\beta l_1\cot\beta l_2}\right) \qquad (1)$$

where Z_{01} is the characteristic impedance of the first section of transmission line shown having a length l_1, Z_{02} is the characteristic impedance of the second section of transmission line having a length l_2 and β is the phase constant of the line. In the case under consideration,

$$l_1 = l_2 = 1 \qquad (2)$$

whence

$$Z_1 = jZ_{01}\left(\frac{\tan\beta l - \frac{Z_{02}}{Z_{01}}\cot\beta l}{l+\frac{Z_{02}}{Z_{01}}}\right) \qquad (3)$$

The expression for Z_1 in Equation 3 yields a filter characteristic corresponding to that of a band-pass circuit and similar to that of a lumped tuned circuit for the proper line parameters. An illustrative calculation made with the following values:

$C = 5$ mmf.
$R = 370$ ohms
$Z_{01} = 50$ ohms
$Z_{02} = 100$ ohms
$l = 8.7$ cm.

discloses that the circuit tunes to 700 megacycles per second with a band width, at 70% of the voltage, of 22 megacycles per second. The characteristic of this circuit corresponds to that of a single parallel-tuned circuit with lumped constants.

By suitably changing the line parameters, wider tuning may be obtained, and it can be shown that a band width of tuning equal to 25 megacycles per second at a resonant frequency of 1230 megacycles per second can be obtained. It will be understood that the foregoing calculations are merely exemplary and are not to be considered as limitations of the scope of the invention.

By a suitable choice of values for l_1 and l_2 for the ratio Z_{02}/Z_{01}, Z_1 can be made zero at a desired frequency value. Accordingly, the filter characteristic shows an abrupt cut off or rejection region corresponding to substantially infinite attenuation. For example, in the case where the circuit tunes a capacitative element, such a region can be shown to occur at a frequency substantially equal to 60 megacycles per second below the tuning frequency of 1230 megacycles per second. It will thus be seen that such a characteristic is extremely useful for rejecting undesired image signals commonly encountered in the reception of radio-frequency signals. The rejection or cut-off frequency can be made to track with the tuning of the pass band, thus rendering the filter circuit extremely useful as a tuner for television receivers.

Where the circuit element is employed to tune an inductive element instead of a capacitative element, the rejection region occurs on the high-frequency side of the pass band.

In practice, it is a capacitance that is commonly sought to be tuned. Thus, if the rejection region is desired on the high-frequency side, one needs only to connect an inductive element across the capacitance so that the net reactance presented to the circuit is inductive over the desired tuning range.

Fig. 5 illustrates the principle of the present invention as embodied to an open-circuited transmission line having a flared portion along part of its length. Thus, a transmission line **30** is shown comprising a parallel-wire section **32** and a non-uniform wire section **34** directly coupled thereto. For altering the characteristic impedance of the transmission line **30**, thereby to vary the resonant frequency of the filter, a wedge-shaped conductive slug **36** is adjustably positionable in the space between the non-uniform wire portion **34** as by a rack and pinion drive **38** actuating an insulating rod **39**. To avoid direct or sliding contact between the slug **36** and the flared portion **34**, a thin solid dielectric coating **40** may be affixed to the surfaces of the slug **36** adjacent the portion **34**. The circuit to be tuned is connected at terminals **41** provided at the end of the line section **30** remote from the tuning slug **36**.

Fig. 6 illustrates a similar arrangement for a short-circuited line **42** which, as shown, comprises a bent section of transmission line which may be formed as a V-shape member, or in any other desired configuration. A conformable triangular slug **46** is movable in and out of the V portion to vary the characteristic impedance thereof. Input terminals **47** are provided at the free ends of the transmission line section for connection to an external circuit. If desired, solid dielectric coatings may be applied as described hereinabove in connection with the embodiment of Fig. 5.

Figs. 7 and 8 illustrate further embodiments of the invention, in which the slugs **36** or **46**, shown in Figs. 5 and 6, are replaced by a conductive rod or tube, as at **48** and **52**, bent to form a short-circuited line section having inwardly bent portions **48'** and **52'**, respectively, which are interconnected by cross members **48''** and **52''**, respectively. Such short circuited line sections may be adjustably movable into the space between the flared portions **34** of the transmission line **30** by means similar to the rack and pinion device **38** shown in Fig. 5. In Fig. 8, the arrangement is quite similar to that shown in Fig. 7 with the exception that an adjustable impedance element **50** of any suitable character and magnitude may be connected into the movable short-circuited line section **52**. The impedance **50** affords an additional parameter that can be varied for further control of the filter characteristics.

Fig. 9 illustrates a modification of the basic principles of the present invention as embodied in a parallel-wire transmission line. As shown, an open-circuited parallel-wire transmission line section **51** is provided consisting

of a pair of flat strips **54, 56** of suitable conductive material, which are suitably fastened to a support **58** in any conventional manner. For a major portion of their length, the strips **54, 56** are spaced from the support **58** as by downwardly-curved terminal parts **59, 62**, thus defining a space between the strips **54, 56** and the support **58** into which a short-circuited line section **60** may be slidably positioned and in spaced relation to the overlying strips **54, 56**. The short-circuited line section **60** consists of a pair of conductive strips **61, 63**, of substantially the same size and shape as strips **54, 56** of the open-circuited line. A shorting bar **65** interconnects strips **61, 63** and is provided with a pair of downwardly projecting studs **67, 69** which ride in associated slots **71, 73** in the support **58**. The reactive coupling between the open- and short-circuited line sections **51, 60** is readily varied in accordance with the degree of overlapping of the line sections **51** and **60**. With large coupling, the lines sections **51** and **60** can be dimensioned to cooperate to act like a shorted quarter wave line. As the coupling is decreased, there is a gradual transition from the quarter-wave line mode to a half-wave line mode.

If desired, a strip of solid dielectric material **64** may be disposed between the adjacent surfaces of the strips **54, 61** and **56, 63** to alter the magnitude of the reactive coupling. A dielectric block **68** is provided for securing the short-circuited line **60** in any desired position with respect to the open-circuited line **51**. To this end, an adjusting screw **70** passes through suitable aligned openings in the block **68** and the insulation strip **64**, and into a threaded portion (not shown) in the support **58**. Connection to a circuit to be tuned may be made at the terminals **72, 74**.

While I have shown and described various specific embodiments of my invention, and certain modifications thereof, it will, of course, be understood by those skilled in the art that other modifications may be made without departing from the principles of the invention. I, therefore, contemplate by the appended claims to cover any such modifications as fall within the true spirit and scope of my invention.

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

1. An ultra-high-frequency filter circuit comprising a first section of two-conductor transmission line having a parallel conductor part and a flared conductor part connected thereto, a second section of two-conductor transmission line of which the conductors are conformably disposed relative said flared part, said second section being movable relative said first section to define therewith a filter having variable tuned-circuit characteristics, and variable reactance means connecting corresponding ends of the conductors of said second section remote from said first section thereby to affect alterations in the tuned-circuit characteristics of said filter in accordance with the value of the reactance of said variable reactance means.

2. An ultra-high-frequency apparatus embodied in a non-uniformly spaced transmission line comprising a section of parallel-conductor transmission line having a flared portion and a conductive member positioned in said flared portion, said transmission line and said conductive member being movable relative to one another to vary the characteristic impedance of said line, and said conductive member comprising a short circuited section of two-conductor transmission line having portions conformable with said flared portion.

3. An ultra-high-frequency apparatus embodied in a non-uniformly spaced transmission line comprising a section of parallel-conductor transmission line having a flared portion, a conductive member movable in said flared portion to vary the characteristic impedance of said line, said conductive member comprising a short-circuited section of two-conductor transmission line having portions conformable with said flared portion, and a reactive load included in said short-circuit line section.

4. An ultra-high-frequency apparatus embodied in a non-uniformly spaced transmission line having a flared portion, a conductive member conformable to and positioned in said flared portion, said conductive member and said flared portion being movable relative to one another, said conductive member being reactively coupled to said flared portion to vary the characteristic impedance of said line.

5. The apparatus as in claim 4 wherein said conductive member is a wedge-shaped slug.

References Cited in the file of this patent

UNITED STATES PATENTS

2,246,928	Schick	June 24, 1941
2,247,779	Keister	July 1, 1941
2,370,423	Roberts	Feb. 27, 1945
2,395,441	Alford	Feb. 26, 1946
2,405,437	Leeds	Aug. 6, 1946
2,411,858	Harvey	Dec. 3, 1946
2,415,141	Malling	Feb. 4, 1947
2,435,442	Gurewitsch	Feb. 3, 1948
2,557,686	Rado	June 19, 1951
2,581,680	Martenot	Jan. 8, 1952
2,601,445	Murakami	June 24, 1952