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A. ALFORD
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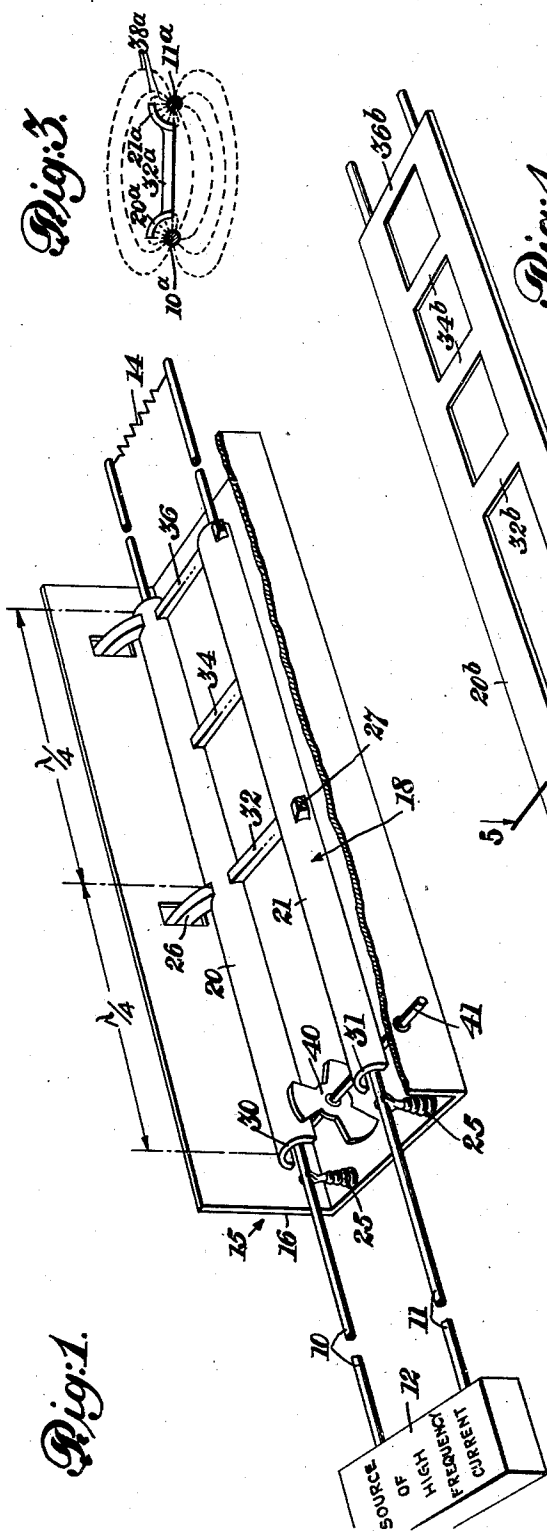


Fig. 4.

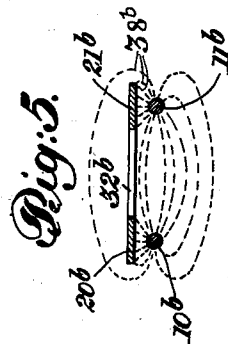
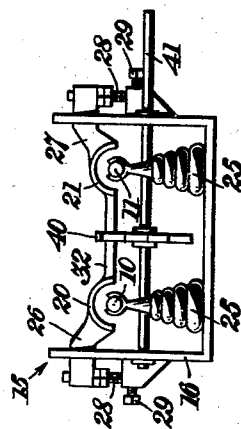


Fig. 2.



INVENTOR
ANDREW ALFORD
BY *Chas. P. Kautz*
ATTORNEY

UNITED STATES PATENT OFFICE

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MODULATOR CIRCUIT

Andrew Alford, New York, N. Y., assignor to
Federal Telephone and Radio Corporation, a
corporation of Delaware

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This invention relates to modulators and more particularly to coupled networks having modulation tuning means therefor for broad band operation.

In my Patent No. 2,159,648 dated May 23, 1939, I disclosed several forms of networks some of which comprise a section of two wire line one quarter wavelength long short circuited at one end and open circuited at the other end. When such a network is located adjacent a transmission line such as the leads of an antenna and tuned to the frequency of a current carried by the line, the network will operate as a current cut-off for the line. That is to say, the resonant condition of the network produces large voltages in the transmission line which effectively block or prevent the flow of the current of such frequency past the point where the network is coupled. However, when the networks, such as heretofore proposed, are slightly detuned from the frequency of the energy carried by the transmission line, they will have substantially no effect upon the transmission along the line of the current having that frequency. It is this phenomenon that I employ for modulation purposes, in my Patent No. 2,244,756 dated June 10, 1941.

Modulation of a high frequency current carried by the transmission lines is effected by alternately tuning and detuning the network to effect the desired control of the current. In a radio beacon system such as disclosed in my aforesaid Patent No. 2,244,756, the alternate tuning and detuning is accomplished by rotating a slotted condenser plate between the open ends of the conductors of the network, the modulating frequency being determined by the speed of rotation and the number of slots in the plate.

It is clear that the coupling coefficient of the resonant network varies inversely to the distance between the conductors of the network and the conductors of the transmission line. As hereinbefore suggested, the network has been loosely coupled, and blocking control of networks has therefore required close tuning; thus, should the frequency of the blocked current vary from the frequency at which the network is tuned the resonance voltages will rapidly decrease and permit the flow of current. In other words, the effective blocking of current is limited to a very narrow wave band and the effective blocking of a current along the transmission line is dependent upon the maintenance of a substantially constant frequency. It is not always possible, however, to obtain a source of high frequency

current the frequency of which is constant. The frequency of most such sources drifts somewhat from time to time. Furthermore, there are circuits in which the carrier frequencies are purposely varied or wobbled as disclosed in my Patent No. 2,241,897, of May 13, 1941. Still other circuits are intended for broad frequency bands such as where modulation is imposed upon a carrier frequency. I find that the effective width of frequency responsiveness of a network may be slightly increased by decreasing the spacing between the network and the line but this is not satisfactory because of the tendency of the high voltages to cause arcing when the spacing is small.

It is one of the objects of this invention, therefore, to provide an improved coupled network which is capable when tuned to resonance to block without arcing, currents having relatively wide variations in the frequency thereof. This object of the invention is accomplished by so constructing the conductors of a quarter wavelength network section as to increase the capacitance coupling relationship thereof with respect to the transmission line without reducing the distance between the network and the transmission line below a safe minimum. The increased capacitance is effected by increasing the size or crosswise dimension of the conductors of the network so that they are wider than and having overlapping relation either horizontal, vertical, or otherwise with the conductors of the transmission line with which the network is associated. More particularly, the conductors of the network may be extended in lateral dimensions and either curved or otherwise suitably shaped to partially encircle or encompass the conductors of the transmission line. In this way, the laterally extended conductors provide a greater conductive area in the path of the electrostatic lines of force between the conductors of the transmission line. This increased condenser effect greatly increases the energy transfer between the network of the conductors over and above a network in which the conductors thereof are of substantially the same or smaller cross-sectional size than the conductors of the line. This increased transfer of energy is thus made possible by this feature of my invention without reducing the spacing between the network and the line below a safe minimum, and this greatly increased transfer of energy between the network and the line increases the frequency band controlled by resonance tuning of my improved network.

When a network is coupled to a transmission line by electrostatic induction as above described, and even though not tuned to resonance, the surge impedance of the line for the length of the coupling will be different from the surge impedance for the rest of the line, the amount depending upon the closeness and condensive relation of the network with respect to the line. This change in surge impedance of a line at the coupled network produces wave reflections at the points where the value of the impedance changes. For any wavelength network section, reflections occur at both ends of the section in opposite phase relation and for a quarter wavelength section, the return flow of the reflection of a given wave at the furthest point along the line is 180° out of phase with respect to the reflection occurring at the first point of reflection. For a quarter wavelength section, therefore, the two reflections combine and the resultant thereof for a high frequency produces standing waves of objectionable amplitude.

Another object of the invention, therefore, is to provide an improved network coupling so constructed as to substantially eliminate wave reflections and standing waves along the transmission line between the source of energy and the coupling, such as due to change in surge impedance of the transmission line by the presence of the network.

The substantial elimination of standing waves in the transmission line due to changes in surge impedance at the ends of the network is accomplished by my invention by extending the conductors of the network for another quarter wavelength beyond the short circuited end of the active quarter wavelength coupled section. The extended conductors, of course, would normally have the effect of a second active coupled section except that I short circuit the conductors at points along the lengths thereof. In this way, substantially no current will flow in the extended quarter wavelength of network, and this extended portion will not alter the resonance effect obtained by the tuning of the open ended section. It is important, however, that the extended conductor section have substantially the same impedance effect upon the line as the first or active section of the network, otherwise additional points of reflection may be established. A wave reflection of any given part of a wave from the far end of the extended section will occur 180° later in time than a reflection of the corresponding part of the wave from the open circuited end of the network; and by the time the far-end reflected component of the wave reaches the open end, a second 180° in time will be consumed, thereby making the far-end reflected component 360° later in time than the component reflection of the wave occurring at the near open end of the network. Since the near-end reflection is caused by an abrupt decrease in effective surge impedance while the far-end reflection is caused by an abrupt increase thereof, the reflections are of opposite sign. This being of opposite sign and 360° apart in time they are 540° out of phase and therefore balance out. It will thus be clear that the extension of the network to one half wavelength avoids the occurrence due to changes in impedance by the presence of the network of standing waves in the transmission line between the network and the source of power. The component of the wave energy reflected from the short circuit end of the coupled section may cause standing waves to occur in the line along

the network, but these are of such small amplitude as not to be objectionable, and as above indicated, they do not extend over the rest of the line.

For a better understanding of the invention, reference may be had to the following detailed description to be read in connection with the accompanying drawing, in which:

Fig. 1 is a view in perspective of a modulator of the coupled section type with parts broken away to show one form of coupled network in accordance with this invention;

Fig. 2 is a view in vertical elevation of the left hand end of the modulator shown in Fig. 1;

Fig. 3 is a view in vertical elevation of the open end of a modified form of network;

Fig. 4 is a view in perspective of another form of network; and

Fig. 5 is a view in vertical section taken substantially along line 5-5 of Fig. 4.

Referring to Figs. 1 and 2 of the drawing, a transmission line is shown comprising conductors 10 and 11 connected to a suitable source 12 of high frequency alternating current and to a load 14 which may be an antenna. A modulator 15 comprising a housing 16 containing a network 18 of two parallel half wavelength conductors 20 and 21 is shown suitably disposed for inductive association with the conductors 10 and 11.

The conductors 20 and 21 may be of any suitable shape to provide an extended crosswise area greater than the diameter of the conductors 10 and 11. As shown in Figs. 1 and 2, the conductors 20 and 21 may be arcuate in cross-section for partial encirclement of the conductors 10 and 11. In order to properly space the arcuate conductors 20 and 21 with respect to the transmission line conductors, the line conductors may be suitably held in a fixed relation by insulators 25 and the conductors 20 and 21 may be adjustably supported by a plurality of arms 26 and 27 having in cooperative association therewith vertical and horizontal adjustable threaded elements 28 and 29.

The ends 30 and 31 of the conductors 20 and 21 are open circuited while the midpoint thereof is short circuited by a short circuiting conductor 32 disposed approximately one-quarter wavelength from the ends 30 and 31. The remaining length of the conductors 20 and 21 extending beyond the short circuiting conductor 32 is short circuited at spaced points therealong by conductors such as 34 and 36. While I have shown but two short circuiting conductors 34 and 36, a larger number of short circuiting conductors may be used as indicated in the form shown in Fig. 5. No particular spacing of the short circuiting conductors is necessary other than to avoid an unshorted length approximately a quarter wavelength. This shorted relation of the conductors 20 and 21 provides one-quarter wavelength of active network and a second quarter wavelength of short circuited inactive network.

The arcuate crosswise shape of the network conductors 20 and 21 may be of a dimension anywhere between the diameter of the line conductors 10 and 11 to about a half circle or even more depending upon the effective width of the frequency band modulation desired. Fig. 3, for example, shows arcuately shaped conductors 20a and 21a in the order of about 45° . Other shaped conductors may also be used. In Figs. 4 and 5 another form of network is shown made up of two parallel flat shaped conductors 20b and 21b. These conductors are shorted along one-half of

the lengths thereof by cross-bars 32b, 34b and 36b in a manner similar to the form shown in Figs. 1 and 2. Network conductors, whether flat, arcuate, or otherwise shaped, can be used according to my invention so long as they provide laterally extended crosswise areas cutting an extended area of the field of electrostatic lines of force emanating from the corresponding conductor of the transmission line with which the network is coupled. It will therefore, be understood that the conductors may be formed in various shapes and the shapes shown and described herein are to be regarded as illustrative only.

As hereinbefore pointed out, the extended conductor encircling areas of the network conductors increases greatly the capacitive inductive relationship between the network and the transmission line so that for a given spacing, these extended areas provide a greatly increased energy transfer relationship over and above conductors of the size and shape of the conductors of the transmission line. From this, it will be clear that the electrostatic coupling between the network and the transmission line as indicated by the lines of electrical force represented by the broken lines 38a and 38b (Figs. 3 and 5), is considerably greater for the crosswise extended conductor than for cylindrically shaped conductors the size of the transmission line conductors.

This increased energy transfer increases correspondingly the width of the frequency band effectively blocked. That is to say, when the network is tuned for a given frequency, the establishment of high voltages in the transmission line due to the resonant condition of the network effectively blocks currents of frequencies within a short range above and below such frequency. Thus, when the carrier current of the transmission lines drifts or is wobbled or is modulated, such variation will not pass beyond the current blocking function of the network constructed in accordance with my invention.

The tuning and detuning of the network may be accomplished by the provision of a slotted condenser plate 40 disposed between the open ends of the conductors 20 and 21 and carried by a shaft 41 adapted to be driven by any suitable source of power such as an electric motor. The number of slots and the speed of rotation determines the modulation frequency of the system, that is, the rate of tuning and detuning of the network. The use of this modulation feature is described in detail in my aforesaid Patent No. 2,244,756.

The extended portion of my improved network between the two end cross-wise shorting conductors (32 and 36 Figs. 1 and 2, for example) does not enter into the resonance tuning of the network. This extended portion is provided, as hereinbefore mentioned, as an inactive short circuited network section to make the overall length of the network (when the network is not tuned to resonance) equal to substantially a half wavelength of the applied frequency. I have found that this extension of the network has the same surge impedance effect as if the transmission line had inserted therein an enlarged conductor section a half wavelength long or a multiple thereof. It is known that while such an enlarged conductor section will produce reflections at the ends thereof, that such reflections balance each other so that while standing waves may occur in the enlarged conductor section of the line, no standing waves will be produced in

the line beyond the ends of the enlarged section. This, I believe, follows for the improved network section of my invention because standing waves are found not to occur in the transmission line beyond the ends of the network when the network is not tuned to the frequency of the current carried by the transmission line.

While three forms only of the improved network of my invention have been herein shown and described, I recognize that many additional forms and variations of the network are possible without departing from the invention. For example, the capacity relation between the network and the conductors of the line may be further increased by providing on the inner surfaces of the conductors of the network a dielectric material having a higher dielectric constant than air. It will be understood, therefore, that the forms herein shown and described are to be regarded as illustrative of the invention only and not as restricting the appended claims.

What I claim is:

1. A network for resonance use in conjunction with a high frequency two-conductor transmission line comprising a section having a pair of quarter wavelength parallel conductors open circuited at one end and short circuited at the other end, said parallel conductors being spaced apart a distance related to the spacing of the conductors of the transmission line so that the network is adapted to be coupled to said line, a second section having parallel conductors forming a continuation of the first mentioned section beyond the short circuited end thereof for substantially a quarter wavelength, and means short circuiting the conductors of the second section so that it has the effect of an elongated shorted end for the first mentioned section giving the network an overall length of substantially a half wavelength.

2. A network for resonance use in conjunction with a high frequency two-conductor transmission line comprising a section having a pair of quarter wavelength parallel conductors open circuited at one end and short circuited at the other end, a second section having parallel conductors forming a continuation of the first mentioned section beyond the short circuited end thereof for substantially a quarter wavelength, and means short circuiting the conductors of the second section so that it has the effect of an elongated shorted end for the first mentioned section giving the network an overall length of substantially a half wavelength, said parallel conductors being spaced apart a distance related to the spacing of the conductors of the transmission line so that the network is adapted to be coupled to said line.

3. A network for resonance use in conjunction with a high frequency two-conductor transmission line comprising two substantially half wavelength parallel conductors having crosswise conductors short circuiting said parallel conductors at substantially the mid-points thereof and at at least one other place spaced from said mid-points, and each of said parallel conductors being extended in shape crosswise with respect to the corresponding conductor of the transmission line as to at least partially encompass it.

4. A network for resonance use in conjunction with a high frequency two-conductor transmission line comprising two substantially half wavelength parallel conductors having crosswise conductors short circuiting said parallel conductors at substantially the mid-points thereof and at points spaced therefrom toward one end of the

parallel conductors, and said parallel conductors each being arcuate in cross-section and adapted to be so disposed with respect to one of the conductors of the line as to at least partially encircle it.

5. A network for resonance use in conjunction with a high frequency two-conductor transmission line comprising a pair of substantially half wavelength parallel conductors and crosswise conductors short circuiting said parallel conductors at the midpoints thereof and at points spaced therefrom toward one end of the parallel conductors, said parallel conductors each being arcuate in cross-section and adapted to be so disposed with respect to one of the conductors of the line as to at least partially encircle it, and means to adjust the position of the network to equally space the conductors thereof from the conductors of the line.

6. A resonatable network in combination with a two-conductor transmission line wherein the network comprises a pair of substantially half wavelength parallel conductors and crosswise conductors short circuiting said parallel conductors at the mid-point thereof and at points spaced

therefrom toward one end of the parallel conductors, said parallel conductors each being of an extended shape in cross-section and adapted to be so disposed with respect to one of the conductors of the line as to at least partially encompass it, and means to adjust the position of the network to equally space the parallel conductors thereof from the conductors of the line.

7. A resonatable network in combination with a two-conductor transmission line wherein the network comprises a pair of quarter wavelength parallel conductors open circuited at one end and short circuited at the other end and coupled to said transmission line, a second section of network forming a continuation of the parallel conductors of the first mentioned section beyond the short circuited end thereof for substantially a quarter wavelength, and means short circuiting the conductors of the second section at at least two points along the length thereof so that the impedance effect upon the transmission line by the network when untuned is equal to a half wavelength of line of dissimilar impedance.

ANDREW ALFORD.