

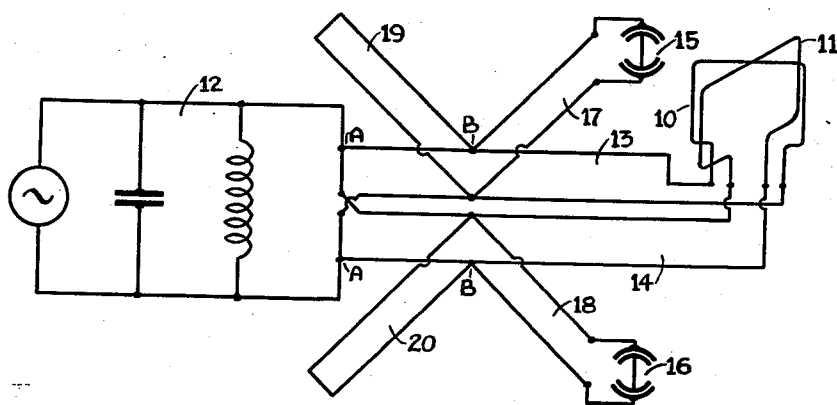
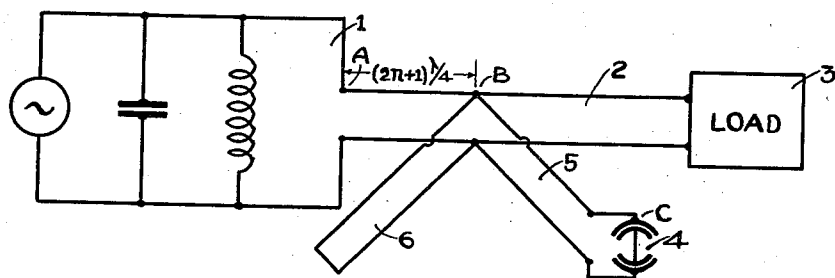
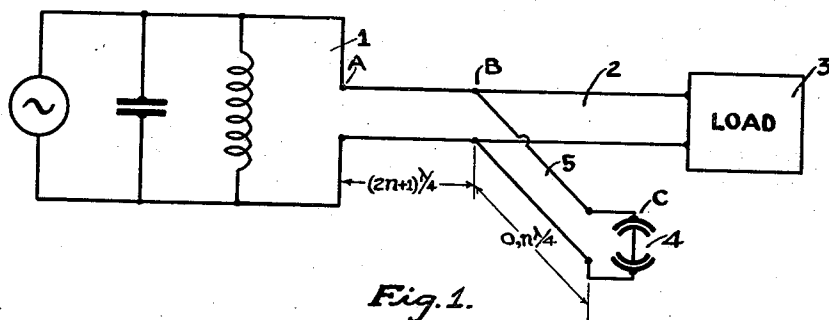
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G. L. DAVIES ET AL

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MODULATION SYSTEM

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INVENTORS.
GOMER L. DAVIES
FRANK G. KEAR
BY Samuel S. Keane
ATTORNEYS.

UNITED STATES PATENT OFFICE

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MODULATION SYSTEM

Gomer L. Davies, Woodside, Md., and Frank G. Kear, Minersville, Pa., assignors to Washington Institute of Technology, Inc., Washington, D. C., a corporation of Delaware

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This invention relates to systems for effecting the modulation of radio frequency energy in any desired degree, and is particularly intended to provide a new method and apparatus whereby such modulation may be obtained. While the present invention is generally applicable to the modulation of radio frequency energy in general, it is particularly intended to be applied to the modulation of energy transmitter at ultra-high frequencies.

It has heretofore been proposed to effect the modulation or suppression of a carrier wave by mechanical means and, as known to the prior art, such mechanical means may employ variable capacitative or inductive coupling means for varying the amplitude or frequency of the carrier wave in order to impress thereon the desired modulation. Such mechanical modulator means, while producing satisfactory modulation or carrier suspension, have the disadvantage of being expensive and bulky and requiring a large number of moving parts. These devices have the advantage, however, of permitting the degree and frequency of modulation to be varied by simple means, which advantage is not inherent in electrical modulating means.

It is an object of this invention to provide a method and apparatus for modulating a carrier wave to any degree, which method and apparatus will retain the recognized advantages of so-called mechanical modulators but which will be more simple in construction and operation.

An object of the invention is to provide means for impressing modulation of any desired degree or type on the output wave of a source of radio frequency energy, in the operation of which the current supplied by the source will be short-circuited through a network or supplied to the load by reason of the variation of the impedance of the transmission line at the point where the network is connected to the line.

A further object is to provide a method and means for modulating radio frequency energy, in which the transmission line connecting the source to the load is alternately connected to the load or short-circuited, in accordance with the position of a variable coupling device connected to the transmission line through a line of predetermined length.

A further object is to provide a method of modulating the energy output of a source of radio frequency energy, in which variable capacity means are connected to the transmission line connecting the source to the load at any point which is so separated from the output of

the source that the source will be connected to the load when the capacity means is in a position of minimum capacitance, and will be disconnected from the load and itself unloaded when the capacity means is in a position of maximum capacitance.

Other objects and features of novelty will be apparent from the following description and the annexed drawing, it being clearly understood, however, that the invention is not limited in any way by such description and drawing, or otherwise than by the appended claims.

Referring to the drawing, in which similar reference characters refer to like parts:

Fig. 1 is a circuit diagram illustrating a modulating system according to the invention;

Fig. 2 is a circuit diagram illustrating a second form of the invention, and

Fig. 3 is a circuit diagram of a beacon system employing modulating means according to the present invention.

In carrying out the invention, we propose to modulate the output of a source of radio frequency energy by short-circuiting the transmission line which connects the source and the load, this being done at such a rate and in such a degree as to provide the desired modulation, the short-circuiting of the transmission line being effected at a point on the line which is so separated from the source that the source will not be loaded when the line is short-circuited. This is effected by short-circuiting the line at any point on the line which is separated from the source by any odd number of quarter wavelengths of the output wave of the source. It has been found that the termination of the transmission line, as by short-circuiting, at any odd quarter wavelength point along the line will effectively remove current from the load and will, at the same time, prevent the overloading of the source during the period of short-circuiting.

A circuit for effecting modulation by the means according to this invention is disclosed in Fig. 1 of the drawing. In this figure, 1 represents a source of radio frequency current which is connected at point A to a transmission line 2, to the end of which is connected a load 3 which may be an antenna or other load to which modulated energy is to be supplied and which is made equal to the surge impedance of the line.

In carrying out our invention we propose to short-circuit the transmission line 2 at any point B along the length thereof which is spaced from the input end A of the transmission line by any quarter wave length of the energy output of the

source. The short-circuiting of the line is effected by connecting to the transmission line at any point B along the length thereof a variable capacity device 4, the terminals C of which are connected to the point B of the transmission line by a line 5, the length of which is equal to any even or odd quarter wavelength of the output wave of the source, or is equal to zero, the length of the line 5 including the loading effect of the variable capacity device 4. The capacity device 4 is preferably a motor-driven rotary condenser, the plates of which may be suitably shaped to provide any desired wave shape.

It will be seen that the operation of the variable capacity device 4 will cause the transmission line 5 to be alternately opened and short-circuited and that the impedance of the line 5 at the point C will be reflected at the input end of this line, i. e. at point B, in a manner dependent upon the length of the line 5, this being due to the quarter-wave relationship between points B and C. The transmission line 2 will therefore be alternately opened and short-circuited at point B. During periods when it is opened, i. e. when the variable capacity device 4 is in its position of minimum capacitance, there will be no effect on the transfer of power from the source to the load and during such periods the full carrier output of the source is transmitted to the load. When the variable capacity device 4 is in position of maximum capacitance and the line 2 is therefore short-circuited, no power will be transferred to the load. Between these full-load and no-load conditions, the current transmitted to the load will be dependent upon the position of the rotating elements of the device 4 with respect to the fixed element thereof and upon the shape of the plates of the device 4. The wave shape of the modulated current at the load will be dependent upon the shape of the plates of the capacity device 4, while the frequency of modulation will be dependent upon the speed of the rotating element of the capacity device. In another method of controlling the modulation, the degree of modulation may be controlled by regulating the capacity of the condenser device 4 or by regulating the ratio of maximum to minimum capacitance thereof.

It will be apparent that proper operation of the modulating system disclosed in Fig. 1 will be dependent upon the electrical lengths of the transmission lines 2 and 5, and the range of reactance variation of the capacity device 4. In order to improve the range of reactance variation of the capacity device 4, we propose to connect an additional circuit element to transmission line 2 at the point B. In its preferred form, which is disclosed in Fig. 2 of the drawing, the additional element takes the form of a short-circuited line 6 the terminals of which are connected to transmission line 2 at point B. The electrical length of this short-circuited line is made such that the impedance across the line 2 at point B varies from zero to infinity. It will be seen that the length of the line 6 may be adjusted to provide the conditions hereinbefore stated as requisite to the proper operation of the modulating system.

The transmission line 5 is adjusted to such length that the reactance of the capacity device 4 will be reflected, in a manner dependent upon the length of the line, at the input end of this line, i. e. the point B. Thus, if the line 5 is equal in length to an even number of quarter

wavelengths of the energy supplied by the source the total impedance at point B is a minimum when capacity device 4 is in a position of maximum capacitance, while if the line 5 is equal in length to an odd number of quarter wavelengths this condition obtains at B when the capacity device 4 is in a position of minimum capacitance. When the impedance at B is a minimum there is a very high impedance looking into the line 2 from the source and no energy will be transmitted from the source to the load. The short-circuited line 6 is so adjusted that at the minimum capacitance position of capacity device 4, when line 5 is an even number of quarter wavelengths, or at the maximum capacity position thereof, when line 5 is an odd number of quarter wavelengths, the impedance across line 2 at point B is a maximum, thus having no effect on the transmission of power from the source to the load.

In the operation of this system it will be seen that when the capacity device 4 is in a position of minimum capacitance, when line 5 is an even number of quarter wavelengths, or in a position of maximum capacitance, when line 5 is an odd number of quarter wavelengths, there is a fairly high capacitative reactance in line 5 when this is viewed from point B and, at the same time, when looking into the short-circuited line 6 from the same point there is an inductive reactance of equal magnitude. These reactances being in parallel, the resultant impedance across the line 2 is very high and there is, consequently, no effect on the transfer of power along the line. When the capacity device is in a position of maximum capacitance, when line 5 is an even number of quarter wavelengths, or in a position of maximum capacitance, when line 5 is an odd number of quarter wavelengths, a condition of series resonance obtains when line 5 is viewed from point B and consequently there is a very low impedance at point B which amounts practically to a short-circuit. At this time the condition of short-circuited line 6 is immaterial. In view of the low impedance across line 5 at this time no current will flow from the source through the transmission line 2 to the load. In theory there will be no power loss in line 5 at this time, but this condition probably cannot be achieved, due to imperfect elements and connections in the system.

Due to the fact that point B is separated from the output of the source by any quarter wavelength of the output wave of the source, when short-circuiting occurs at B due to the condition of maximum capacitance of the device 4, there is a very high impedance when looking into the line 2 from the source and consequently no power will be delivered from the source to the line 2.

In Fig. 3 of the drawing there is disclosed the adaptation of the present invention to the operation of a radio beacon of the equi-signal type in which overlapping directional fields are radiated, the currents causing the radiated fields being impressed with characteristic modulations or signals which may be received to provide an indication of position with respect to the source of the radiated fields. In the circuit disclosed in Fig. 3 two antennas 10, 11 are connected in parallel to a source of radio frequency energy by transmission lines 13 and 14. To these transmission lines there are connected capacity coupling devices 15, 16 by transmission lines 17, 18, respectively, and short-circuited lines 19, 20. The lines 17, 19 and 18, 20 are connected to the re-

spective transmission lines 13 and 14 at points E, both of which points are spaced from the output terminals of the source 12 by any odd number of quarter wavelengths of the energy output of the source. The disclosed system constitutes, in effect, a duplication of the system disclosed in Fig. 2 of the drawing and hereinbefore described.

The variable capacity devices 15, 16 of the beacon system of Fig. 3 may be so constructed and driven at such speeds as to provide any desired modulation of the energy supplied by the source 12. In the usual type of double-modulation beacon, the energy radiated from one antenna may be given a characteristic modulation of 65 cycles, while that radiated from the second antenna may be given a characteristic modulation of 86.7 cycles, although any other desirable characteristic modulations may be impressed on the radiated carriers. Regardless of the specific nature of the modulations desired, the capacity devices 15, 16 may be shaped and constructed and driven at such speeds as to provide the desired result, all in the manner hereinbefore described.

While we have illustrated and described various forms and embodiments of our invention, it will be apparent to those skilled in the art that other modifications, embodiments and improvements may be made, all without departing in any way from the spirit or scope of the invention as disclosed herein, for the limits of which reference must be had to the appended claims.

We claim:

1. In an electrical system comprising a source of radio frequency energy, a load, and a line connecting the source and the load, means for modulating the energy supplied by the source to the load and comprising reactance means connected across the line at a point separated from the input end of the line by any odd number of quarter wavelengths of the supplied energy, and means for cyclically varying said reactance means to cause the reactance at said point to vary from a condition of parallel resonance to a condition of series resonance, to thereby cause the impedance across the line at said point to vary from infinity to zero.

2. In an electrical system comprising a source of radio frequency energy, a load, and a transmission line connecting the source and the load, means for modulating the energy supplied by the source to the load and comprising means connected across the line at a point separated from the input end of the line by any odd number of quarter wavelengths of the energy output of the source and operable to vary the impedance of the line at the point across connection thereto from zero to infinity, said means comprising a variable capacity device and a short-circuited line connected in parallel and both connected to the line at said point of connection, the short-circuited line having such an electrical length that it presents an inductive reactance across its terminals.

3. In an electrical system comprising a source of radio frequency energy, a load, and a transmission line connecting the source and the load, means connected in parallel and to the line between the source and the load and comprising electrical means operable to vary from a capacitive reactance to series resonance when viewed from the connection thereof to the line, and a second electrical means connected to the line and operable to provide an inductive reactance, whereby the impedance across the line at the said point of connection varies from infinity to zero, to thereby modulate the energy supplied by the source to the load.

4. An electrical system comprising a source of radio frequency energy, a load, a transmission line connecting the source and the load, means for modulating the energy supplied by the source to the load comprising a variable capacity device connected across said transmission line by a second transmission line having an electrical length of K degrees and a short-circuited transmission line having an electrical length of R degrees, said second transmission line and said short-circuited transmission line being connected in parallel and both being connected across the first transmission line at said point of connection, K and R being so chosen that the impedance across the first transmission line at said point of connection is caused to vary substantially from zero to infinity as the capacity of said variable device is varied.

5. A modulating system comprising a source of radio frequency energy, a load, a transmission line connecting the source and the load, the load being approximately equal to the surge impedance of the transmission line, a continuously variable capacity device connected across the transmission line at a point spaced from the input end of the line by any odd number of quarter wavelengths of the energy output of the source, and means for cyclically varying the capacity of said variable device to continuously and progressively vary the impedance across the transmission line at said point of connection substantially from zero to infinity.

6. A modulating system according to claim 5, in which the variable capacity device is connected to the transmission line through a second transmission line which is equal in length to any number of quarter wavelengths of the energy output of the source.

7. A modulating system according to claim 5 in which the variable capacity device comprises a rotary capacitor having two fixed members which are respectively connected to the transmission line members, and a rotatable member which may be moved into capacitative relation to either of said fixed members.

8. A modulating system according to claim 5, in which the variable capacity device is connected directly across the transmission line.

GOMER L. DAVIES.
FRANK G. KEAR.