Feb. 18, 1941. G. L. DAVIES 2,232,591

MODULATION SYSTEM

Filed June 27, 1938

Fig. 1.

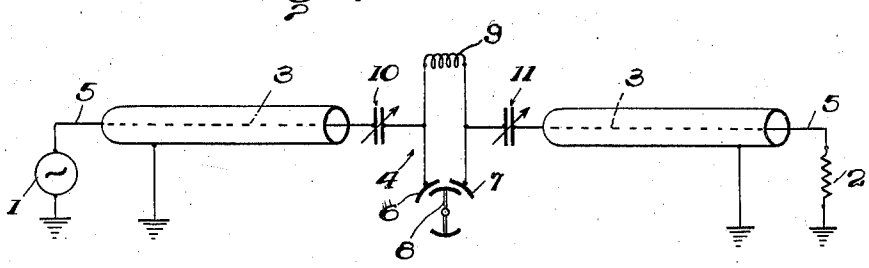



Fig. 2.

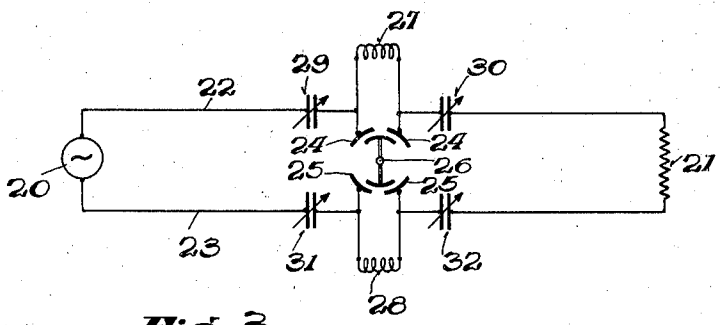



Fig. 3.

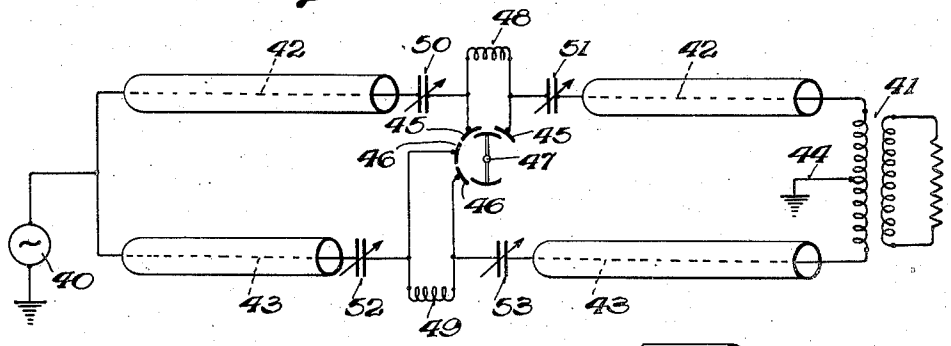



Fig. 5.

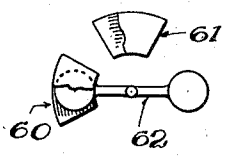



Fig. 6.

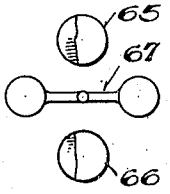
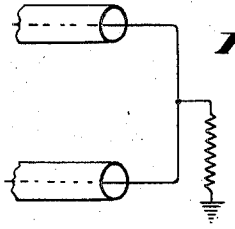



Fig. 4.



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# UNITED STATES PATENT OFFICE

2,232,591

## MODULATION SYSTEM

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Application June 27, 1938, Serial No. 216,125

5 Claims. (Cl. 179—171.5)

This invention relates, generally, to systems and apparatus for effecting the modulation of radio frequency energy and is intended to provide a method and means which will be particularly effective in modulating waves transmitted at ultra-high frequencies.

It has heretofore been proposed to effect the modulation of radio frequency energy by alternately uncoupling the source of energy from the load and coupling these by capacity coupling means. This principle and mode of operation is employed in the capacity type mechanical modulators. In general, known devices operating in this manner have been found to be satisfactory in modulating energy transmitted at usual radio frequencies, but have not been satisfactory in modulating energy transmitted at ultra-high frequencies. This deficiency of modulators of known types appears, for example, in the ineffectiveness of such modulators in completely blocking the source of power from the load when these are intended to be uncoupled in the operation of the modulator. This deficiency is due to the effect of the stray capacities which become of increasing importance as the frequency increases and, at ultra-high frequencies, prevent entirely the proper operation of the modulators. A further deficiency of modulators of usual types is that they operate only at high impedances and consequently are unsuitable for use with energy at ultra-high frequency. While this invention is operable to effect the modulation of radio frequency currents lying within any range of frequencies, it is particularly intended for use in modulating ultra-high frequency energy and the invention may be said to be of particular use in this field.

It is, therefore, the object of the invention to provide a modulating means of the capacity type which will be completely effective in blocking the source of power from the load when these are intended to be disconnected in the operation of the modulator, and which will operate at any impedance, whereby and by reason of which improvements the present invention provides a modulating means which will be completely operable to effect the modulation of radio frequency energy regardless of the frequency of transmission thereof and including those transmitted at ultra-high frequencies.

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

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

Fig. 1 is a circuit diagram illustrating the application of my invention in effecting the modulation of energy transmitted over an unbalanced line;

Fig. 2 is a circuit diagram illustrating the application of my invention to the modulation of energy transmitted over a balanced line;

Fig. 3 is a circuit diagram showing the application of my invention for carrier suppression modulation;

Fig. 4 is a circuit diagram showing an alternative load circuit connection;

Fig. 5 is a view, partly broken away, showing the modulator elements provided by my invention for effecting transmission with carrier suppression, and

Fig. 6 is a view, partly broken away, showing the elements provided by my invention for modulating energy transmitted over a balanced line or an unbalanced line.

Capacity type modulators as heretofore provided have been found to be operable only with a high impedance load, this being due to the relatively high reactance of the coupling portions of the modulator itself. In the operation of such devices the source is periodically coupled to the load through a capacity coupling device of high reactance, whereby operation is possible only with loads having high impedance with respect to the reactance of the modulator. While it is true that the reactance of the modulator will decrease with increase in the frequency of the transmitted current, whereby a smaller ratio of modulator reactance to load impedance is secured, this does not result in making such modulators effective at ultra-high frequencies. Regardless of the decrease in the ratio referred to, the blocking action of known capacity type modulators is so unsatisfactory at ultra-high frequencies that such devices are entirely unsuitable for that purpose. Furthermore, previous types of modulators utilized the shaft and rotor to carry high frequency energy, which is very undesirable at ultra-high frequencies.

By the present invention I propose to provide a modulating means in which the source of power is connected to and disconnected from the load at the modulation frequency and in which more effective disconnection or blocking is secured by reason of the provision of a circuit coupling the source to the load and which varies from an

approximate series resonance condition, when the modulator is in such position that the source and the load are coupled, to an approximate parallel resonance condition when the source is blocked from the load, thus providing high series impedance when the source and the load are to be disconnected and effectively preventing the transfer of energy at that time. The reactance of the modulator is decreased, at the time of connection of the source to the load, by the low reactance of the coupling circuit described, which at that time is in a condition of series resonance. These resonance conditions are stated to be approximate because it is merely necessary to reduce the series impedance at time of passage of maximum energy through the line to a value of perhaps one-tenth of the load impedance and increase the series impedance at the time of blocking the transfer of energy through the line to a value of perhaps ten times the value of the load impedance.

The application of the invention to the modulation of radio frequency energy transmitted over an unbalanced line is disclosed in Fig. 1 of the drawing. In this figure a source of radio frequency energy is indicated at 1, and a load circuit is indicated at 2, these being connected by a transmission line 3 and a modulator device which is denoted generally at 4 and which includes the present invention. In accordance with usual and known practise the conductor 5 of the transmission line is divided between the source and the load and the sections thereof are connected to the two stator plates 6, 7 of the modulator, which includes also the rotor 8 which is adapted to be rotated in such relation to the stator plates 6, 7 as to cause capacitative coupling therebetween at a pre-determined rate to thereby effect the modulation of the radio frequency current supplied by the source. The variable capacity device described may be located at the output of the source 1 or at any suitable point along the line, preferably at a point which is spaced from the output of the source by an even number of quarter wavelengths of the energy supplied by the source.

In carrying out my invention I balance the capacitative reactance of the modulator 6, 7, 8 by an inductive reactance 9, it being noted that this inductance may be provided by a piece of short-circuited transmission line. In order to provide the proper conditions of resonance I connect a variable capacity 10 between the source I and the circuit including the capacity 6, 7, 8 and the inductance 9 and a variable capacity 11 between the load 2 and such circuit. Either of these capacities may be eliminated, and proper operation may be secured if both are eliminated. It is preferable, however, that at least one of the capacitors be retained.

It will be seen that when the capacitor 6, 7, 8 is in maximum capacity position, as illustrated, the capacitor and the inductance 9 are approximately in a condition of parallel resonance thereby preventing the transmission of any power from the source to the load. When the capacitor is in minimum capacitance position, i. e. when the rotor 8 covers only one of the stator plates 6, 7, the series condensers 10, 11 are in series resonance with the circuit comprising the inductance 9 and the minimum capacitance of the rotary condenser, thereby presenting an extremely low impedance in series with the line and permitting the transmission of power from the source to the load.

The application of the invention to a balanced line circuit is disclosed in Fig. 2, in which there is illustrated the source 20 which is connected to load 21 through balanced transmission lines 22, 23. Modulation of the radio frequency energy supplied by the source 20 is effected by a modulator which includes the stator plates 24, which are connected in the line 22, the stator plates 25 which are connected in the line 23, and a rotor 26 which is provided with two plates which are so disposed with respect to each other and with respect to the stator plates 24, 25 as to periodically effect the simultaneous capacitative coupling of the plates 24 and the coupling of the plates 25.

In accordance with the invention, an inductance 27 is connected between the stator plates 24 and an inductance 28 is connected between the plates 25. Variable capacities 29 and 30 are connected in series between the circuit including the capacity 24 and inductance 27 and the source 20 and the load 21, respectively, and variable capacities 31 and 32 are connected in series between the circuit including the capacity 25 and the inductance 28 and the source and the load respectively. The operation of the circuit illustrated in Fig. 2, including those elements thereof provided by this invention, is similar in all respects to the operation of the circuit illustrated in Fig. 1, the circuit of Fig. 2 being employed when a balanced line is preferable to an unbalanced line.

Means are provided by the invention for transmitting the carrier suppression, and a circuit for effecting this is illustrated in Fig. 3 of the drawing. In this circuit, radio frequency energy is supplied by a source 40 to the primary winding 41 of an output circuit through transmission lines 42, 43, the winding 41 being balanced to ground at 44. Modulation with carrier suppression is effected by a modulator comprising the stator plates 45 which are connected in the line 42 between the source and the load, the stator plates 46 which are connected in the line 43 between the source and the load, and a rotor 47 which is provided with diametrically opposed coupling plates. The plates 45, 45 and 46, 46 are so arranged that they will be successively covered by the plates of the rotor during the rotary movement thereof, and these plates are further so arranged that when one of the plates of the rotor is in full coupling position with respect to one set of stator plates, the opposite plate of the rotor is entirely removed from the second set of stator plates, such arrangement and disposition being as clearly illustrated in Fig. 3.

In accordance with the invention an inductance 48 is connected across the stator plates 45 and an inductance 49 is connected across the stator plates 46. Variable capacities 50 and 51 are connected in series between the circuit including inductance 48 and capacity 45 and the source 40 and load circuit 41, respectively, while variable capacities 52 and 53 are connected in series between the circuit including inductance 49 and capacity 46 and the source and the load circuit, respectively.

In the operation of the circuit illustrated in Fig. 3, the movement of the rotor 47 will cause plates 45 to be capacitatively coupled at a time when the plates 46 are uncoupled, whereby current will be caused to flow with full amplitude through line 43 at a time when no current flows through line 42. At this point the load current is maximum. As the rotor moves, the coupling

between plates **45** will be reduced, and that between plates **46** increased, thus allowing current to flow through line **42** and decreasing the current through line **43**. This continues until equal currents flow in each line, at which time the current in the load becomes zero as the two line currents balance out in the primary of transformer **41**. As the rotor motion continues, the coupling between plates **45** decreases to minimum, and that between plates **46** increases to maximum, thus allowing current to flow through line **42** and stopping the current flow through line **43**. At this time the load current is again maximum, but in opposite phase to that of the preceding maximum. Operation continues in a similar manner until the load current is again maximum and in the original phase, after which the cycle is repeated. The arrangement shown is used for coupling an unbalanced source to a balanced load. A similar arrangement may be used with balanced source and unbalanced load.

The operation of the rotor at a pre-determined speed, together with the number of rotor plates, determines the frequency of the modulation, while the shape of the stator and rotor plates determines the resultant wave form.

Fig. 4 illustrates an unbalanced load circuit which may be substituted for that illustrated in Fig. 3.

In Fig. 5 there is illustrated a form which the variable capacity device may take for modulation with carrier suppression. Two pairs **60**, **61** of superposed, sector-shaped stator plates are provided, the rotor having circular plates at each end thereof which pass between the stator plates of each pair. In accordance with the disclosure of Fig. 3, the axes of the pairs of stator plates are arranged an an angle of 90°.

In Fig. 6 there is illustrated the form which the variable capacity device may take for a single line or balanced line system such as illustrated in Figs. 1 and 2. One or two pairs **65**, **66** of superposed, circular stator plates and a rotor **67** having two circular plates at the extremities thereof, are provided. In accordance with the disclosures of Fig. 1, only one pair of plates **65** is provided if a single line circuit is to be employed, while both pairs **65**, **66** are provided if a balanced line circuit, as disclosed in Fig. 2 is employed.

While a number of embodiments of my invention have been disclosed, it will be apparent to those skilled in the art that these disclosed embodiments are only illustrative and that further modifications and improvements may be made without departing in any way from the spirit or scope of the invention, for the limits of which reference must be had to the appended claims.

What I claim is:

1. A transmitting system comprising a source of high frequency energy, a load circuit, transmission lines connecting the source and the load circuit, simultaneously variable capacities connected in each of said transmission lines and operable to periodically connect and disconnect the source and the load circuit, and means connected to each of said variable capacities and operable therewith to provide approximate series resonance conditions in each of said transmission lines when said capacities are in position to transmit energy and operable therewith to provide approximate parallel resonance conditions in each of said transmission lines when said capacities are in position to disconnect the source and the load circuit.

2. A transmitting system comprising a source of high frequency energy, a load circuit, transmission lines connecting the source and the load circuit, simultaneously variable capacities connected in each of said transmission lines and operable to periodically connect and disconnect the source and the load circuit, an inductance connected in parallel with each of said variable capacities and adjustable capacities connected in each of said transmission lines between said parallel circuits and the source and the load circuit.

3. A transmission system comprising a source of high frequency energy, a load circuit, variable capacity coupling means operable to periodically connect and disconnect the source and the load circuit, and means connected to said coupling means and operable therewith to provide approximate series resonance conditions between the source and the load circuit when said coupling means is in position to transmit energy and operable therewith to provide approximate parallel resonance conditions between the source and the load circuit when said coupling means is in position to disconnect the source and the load circuit.

4. A transmission system comprising a source of high frequency energy, a load circuit, variable capacity coupling means connecting each of the output terminals of the source to one of the input terminals of the load circuit and being simultaneously operable to periodically connect and disconnect the source and the load circuit to thereby provide modulated current in the load circuit, and means connected to each of said coupling means and operable therewith to provide approximate series resonance conditions between each of the output terminals of the source and the connected input terminals of the load circuit when said coupling means are in position to transmit energy and operable to provide approximate parallel resonance conditions between said terminals when said coupling means are in position to disconnect the source and the load circuit.

5. A modulating system comprising a source of radio frequency energy, a load circuit, transmission lines connecting the source and the load circuit, variable capacity coupling means connected in each of said transmission lines, means for progressively varying the capacity of each of said coupling means in such a manner that when the capacitance of one of said devices is a maximum the capacitance of the other is a minimum, and means connected to each of said coupling means and operable therewith to provide a condition of approximate series resonance when the connected coupling means is in condition to transmit energy and operable therewith to provide a condition of approximate parallel resonance when the connected coupling means is in condition to disconnect the source and the load circuit.

GOMER L. DAVIES.