June 28, 1938. H. M. HORSMAN 2,122,097

BALANCING MEANS FOR MODULATORS

Filed July 27, 1935

FIG. 1.

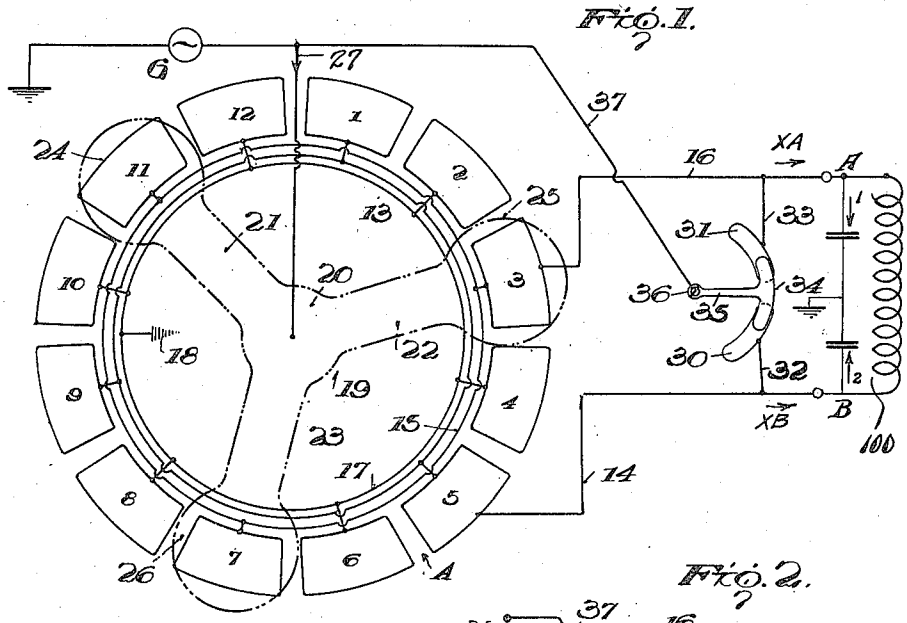


FIG. 2.

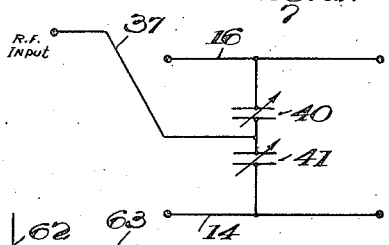


FIG. 3.

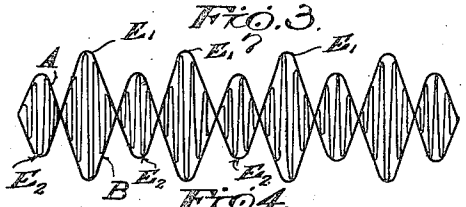


FIG. 4.

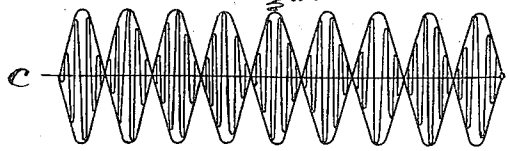
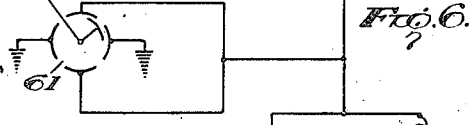
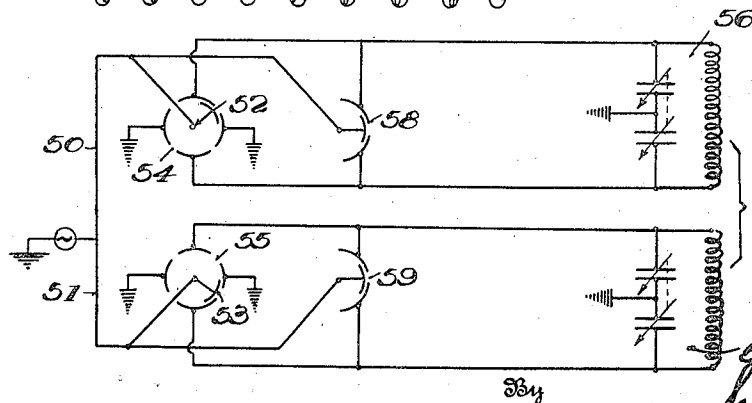


FIG. 6.





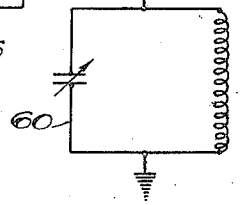


FIG. 5.

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BALANCING MEANS FOR MODULATORS

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17 Claims. (Cl. 179—171)

This invention relates to methods and devices for modulating the amplitude or frequency of radio frequency oscillations and, more particularly, to means for compensating for electrical unbalances in such systems or devices for varying the envelope of the modulated currents in the output thereof.

The modulation of radio frequency currents by either electrical or mechanical means is well known and the present invention may be employed with either of these types of modulators. While the invention is susceptible of operation and use with either type of device, it is described particularly herein with reference to a mechanical modulator, as this type is probably more subject to the variations and unbalances which the present invention is designed to correct. It will be perfectly apparent, however, that the adaptation of the invention to electrical modulating means may be accomplished without departing in any way from the scope of the invention.

Modulating means of the mechanical type, such as heretofore proposed and constructed have employed a member or a plurality of members connected in the radio frequency input circuit of a transmission system and movable with respect to a plurality of fixed members connected in the output circuit, the movable and fixed members being so disposed with respect to each other that capacity coupling between movable and fixed members takes place when the same are adjacent or opposite each other. The frequency of modulation may be varied by controlling the speed of movement of the movable members past the fixed members, and by the number of fixed and movable members, while the amplitude of modulation may be controlled by the spacing between and the sizes and numbers of the fixed and movable members.

While such means form a satisfactory and efficient means for modulating a radio frequency current it has been found that difficulty is encountered in obtaining a desired percentage of modulation due to unbalanced conditions inherent in the construction of the mechanical modulator, which unbalanced conditions cannot be practically removed from the device. This unbalance is particularly troublesome when operating with carrier suppression, since complete suppression is impossible without an accurate balance.

It is, accordingly, proposed by the present invention to provide means for modulating radio frequency currents, which means will include means for compensating for the inherent unbalances of the modulator, whereby any desired percentage of modulation or degree of carrier suppression at the output of the modulator may be secured.

It is also an object of the invention to provide means for supplying to the output circuits of a modulating means, unmodulated radio frequency current from the input side of the modulator in any desired relative amounts. When carrier suppression is desired, it is necessary to compensate for unbalances in the modulator in order to achieve perfect suppression, and this may be effected, according to the present invention, by so adjusting the relative amounts of unmodulated current supplied to the two output circuits that the resultant unmodulated current in the output circuit will be in phase with one or the other of the modulated currents flowing in the output circuit, whereby the amplitude of that modulated current may be increased in a desired degree.

It is also an object of the invention to provide means for compensating for the inherent unbalances of a modulating system, which means may be adjusted during operation of the modulator to vary the percentage modulation or completeness of carrier suppression in the output thereof and which may be retained in adjusted position to maintain such output constant.

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 in no 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 diagrammatic and circuit illustration of a mechanical modulator, including the balancing means according to the present invention;

Fig. 2 is a circuit diagram of a modified form of balancing system according to the present invention;

Fig. 3 illustrates the wave form of the output of a mechanical modulator, with incomplete carrier suppression due to inherent unbalance in the modulator;

Fig. 4 illustrates the wave form of the output of the modulator for complete carrier suppression, which may be secured by employing the present invention;

Fig. 5 illustrates a system for supplying modulated frequencies to two load circuits, such system including mechanical modulating means and bal-

ancing means according to the present invention, and

Fig. 6 illustrates a second circuit employing a mechanical modulator and means for adjusting the percentage modulation of the output current.

Referring particularly to Fig. 1 of the drawing there is disclosed diagrammatically at A a device known as a mechanical modulator, the same being employed for modulating radio frequency currents to impress thereon any audio frequency signal. The modulator illustrated in Fig. 1 comprises twelve fixed plates, the same being numbered from 1 to 12, inclusive. Any desired number of fixed plates may be employed, the number of fixed and movable plates being dependent on the modulating frequency and amplitude desired. It will be seen that, in the arrangement illustrated, fixed plates 1, 5 and 9 are electrically connected by wire 13, and that these fixed plates are connected to output lead 14 through plate 5. Plates 3, 7 and 11 are electrically connected by wire 15 and are connected to output lead 16 through plate 3. Plates 2, 4, 6, 8, 10 and 12 are connected together by wire 17 and to ground at 18. The above-described construction illustrates the fixed portion of the mechanical modulator system.

The rotary or movable part of the modulator comprises the rotatable assembly 19 comprising the central portion or hub 20 having the three arms 21, 22 and 23 radiating therefrom and terminating respectively in the plates 24, 25 and 26. The described assembly may be rotated at any desired speed by any known means which may be rotated at a constant rate of speed. The plates 24, 25 and 26 are so disposed with respect to the fixed plates 1–12 that capacity coupling takes place between adjacent movable and fixed plates.

The rotary assembly is connected to a source of radio frequency current through lead 27 and it will be seen that the capacity coupling between movable and fixed plates will cause currents at the frequency of the source and modulated as hereinafter described, to be supplied by the leads 14, 16 to the load circuit 100, where they may be employed for any desired purpose.

In the operation of the modulator illustrated in Fig. 1, the rotary assembly 19 is supplied with current at radio frequency through lead 27 and the rotary assembly hereinbefore described is rotated at a suitable speed to produce the desired frequency of modulation of the radio frequency input. As the plates 24, 25, 26 rotate they pass over the fixed plates in such close relation thereto that capacity coupling takes place between the movable and the fixed plates, whereby a circuit is completed between the source of radio frequency and the load circuit 100 through one or the other of the leads 14, 16. It will be seen that, in the position of the rotary assembly of the modulator as illustrated in Fig. 1, the movable plates 24, 25, 26 are in full coupling relation to fixed plates 11, 3 and 7, respectively, all of which fixed plates are connected, by wire 15 and plate 3 to lead 16.

In this position of the modulator, therefore, current at radio frequency and at the full amplitude of the radio frequency source flows from the source, through lead 27, plates 24, 25 and 26 of the rotary assembly plates 11, 3 and 7 and through wire 15 and plate 3 to the load circuit through lead 16.

As the rotary assembly continues to revolve, preferably in a clockwise direction as illustrated in Fig. 1, the area of fixed plates 3, 7 and 11 covered by plates 25, 26 and 24, respectively, will be progressively decreased, thereby decreasing the amplitude of the radio frequency current supplied to the load circuit through the output lead 16. At the same time, the plates 24, 25 and 26 will progressively cover more of the next adjacent fixed plates 4, 8 and 12 which are connected to ground at 18 through wire 17. Further movement of the rotary assembly will cause current to flow to the load circuit through lead 14, this current increasing to a maximum when the plates of the rotary assembly fully cover the fixed plates 1, 5, 9, and then decreasing to zero as the rotary assembly approaches the adjacent grounded plates. The resulting envelope of the radio frequency current in the load circuit may be theoretically represented by the envelope in Fig. 4, the currents alternately supplied to the load circuit through leads 14 and 16 being represented, respectively, by alternate lobes of the envelope.

The cycle of operation during one complete revolution of the rotary assembly from the position illustrated in Fig. 1, is therefore as follows: At the instantaneous position illustrated the current in lead 16 is a maximum while that in lead 14 is zero. As the plates rotate, the current in lead 16 will decrease while that in lead 14 will remain at zero. When the rotary plates fully cover the ground-connected plates 4, 8 and 12, the current in both output leads will be zero. Further rotation will cause increase of current in lead 14 while current in lead 16 will remain at zero. It will be seen that one complete revolution of the rotary assembly will cause three maximums of current and three periods of zero current in each output lead.

By varying the number of fixed plates and the number of rotating plates and the speed of rotation of the rotary assembly, it will be seen that any frequency of modulation or modulation amplitude desired may be secured in the load circuit.

It has been found in practice that the currents delivered to the load circuit through leads 14 and 16 are not balanced as shown in the curves of Fig. 4 but are unbalanced as illustrated in Fig. 3, and balanced currents as represented in Fig. 4 have not heretofore been secured in the operation of a mechanical modulator. It is probable that this defect is due to inherent capacity unbalances in the modulator itself and is partly due to the relatively intricate wiring required for such modulators, in particular those employing a large number of fixed and rotary plates, although the defect has been observed in modulators employing a lesser number of plates. It has also been found to be practically impossible to remove this effect by more careful arrangement of the internal wiring of the modulator, and it will be obvious that such an expedient would balance the output currents only accidentally.

This condition may be understood by considering the modulated currents in the output or tank circuit 100 of Fig. 1. Due to the construction of the modulator capacity coupling effects are found in almost all portions thereof, such as between the various wires in the relatively intricate wiring system, between adjacent plates, and between the rotating blades and plates which are substantially removed from the plate or plates covered at any specific instant. Certain of these capacity coupling effects exist between oscillator G and point A of the tank circuit 100. Such capacity coupling effects may be referred to as the stray capacity C_{s1} and this stray capacity will cause a current

to flow in the tank circuit which at a given instant will be in the direction of arrow 1, regardless of the location of the plates of the rotary assembly of the modulator. Other capacity coupling effects exist between the oscillator and point B of the tank circuit and these effects, which may be termed C_{s2}, cause a current to flow in the tank circuit which at a given instant will be in the direction of arrow 2.

When the rotary assembly of the modulator is in the position shown in Fig. 1, in which current is being delivered to the tank circuit through lead 16, the total voltage E_1 in the tank circuit will be proportional to the algebraic sum of the capacitances, or

$$E_1 \alpha C_1 + C_{s1} - C_{s2}$$

in which C_1 is the total capacitance between plates 3, 7 and 11 and plates 24, 25 and 26. Inasmuch as the stray capacitance C_{s2} tends to transmit a current through the tank circuit in a direction opposite to that of the current transmitted by the capacitances C_1 and C_{s1}, the value of C_{s2} must be subtracted in order to secure the resultant current in the tank circuit.

When the rotary assembly is in such a position that current is transmitted to the tank circuit through lead 14, the resultant voltage E_2 in the tank circuit will be proportional to the algebraic sum of the capacitances, or

$$E_2 \alpha C_2 + C_{s2} - C_{s1}$$

in which C_2 is the total capacitance between plates 24, 25, 26 and plates 1, 5 and 9.

It will be seen that for E_1 to be equal to E_2 the algebraic sums of the capacitances tending to transmit the two voltages must be equal, and this result cannot be practically accomplished because the stray capacities are never equal. The wave forms of the voltages E_1 and E_2 in the tank circuit are illustrated in Fig. 3. If it be assumed that the capacitances C_1, C_2, C_{s1} and C_{s2} are such that E_1 is greater than E_2, then the wave envelopes E_1 of Fig. 3 will represent the voltages in the tank circuit when the rotary assembly is capacitatively coupled to plates 3, 7 and 11 and lead 16, while the smaller envelopes E_2 will represent the wave form of the current in the tank circuit when the rotary assembly passes current through the plates 1, 5 and 9 and lead 14. The current in the tank circuit will pass through zero between maximum current values therein, giving the wave form shown in Fig. 3.

It will be seen now that if sufficient capacity is connected between the source of current and one or the other of points A, B of the tank circuit to make the total capacitance effects equal, then the currents transmitted to the tank circuit through leads 14 and 16 will be equal. In other words, if $C_2 < C_1$ and $C_{s2} < C_{s1}$ then, as explained above, $E_2 < E_1$. If an added capacitance C_{B2} is now added to the circuit transmitting E_2 to the tank circuit then E_2 will be increased and if C_{B2} is made sufficiently great E_2 may be made to equal E_1. The adjustable capacitance provided by the present invention is adapted to provide this result.

The present invention is therefore directed to a method of and means for balancing the output currents of the modulator in order to vary the envelopes of the modulated currents in the load circuit to provide any desired degree of balance or unbalance thereof. By the method according to the invention unmodulated radio frequency current is supplied to the input terminals of the load circuit in such relative amounts that the resultant unmodulated current in the output circuit will combine with one or the other of the modulated currents alternately supplied to the load circuit to thereby effect any desired condition of balance or unbalance of the modulated currents in the load circuit.

The described method may be carried out by the means disclosed in Fig. 1. According to this embodiment of the invention there are connected to the output leads 14, 16, the fixed plates 30, 31 respectively, the same being connected to their respective output leads by wires 32, 33. A movable plate 34 is arranged in capacitative relation to the plates 30, 31 and is so mounted that its position with respect to the plates 30, 31 may be varied. For this purpose the movable plate 34 may be carried by an arm 35 which is rotatably mounted on a screw support 36, such support being so arranged that the arm 35 and plate 34 may be moved through any desired angular adjustment and locked therein. The plate 34 is connected directly to the source of radio frequency current by a lead 37 which may be connected to input lead 27 on the input side of the mechanical modulator. It will be seen that the movable plate may be moved to any desired position with respect to the fixed plates 30, 31, in order to overlap such fixed plates in any desired relative proportions, either equally or unequally.

In the operation of the mechanical modulator, current at radio frequency is supplied to the rotary assembly through lead 27, and such rotary assembly is caused to rotate by some means, such as a motor, connected to the hub 20. The speed of rotation may be varied to provide, in conjunction with the number of fixed and movable plates, the desired frequency of modulation or modulation amplitude. The modulated currents are supplied to the terminals A and B of the load circuit through output leads 14, 16, as hereinbefore fully explained.

The envelope of the current in the output leads or in the load circuit may be observed by known means, such as an oscillograph and, in the absence of some balancing means, the envelopes of the currents in the load circuit will generally be unbalanced as shown in Fig. 3, due to inherent unbalances in the modulator.

Unmodulated radio frequency current from the source G is also supplied to the movable plate 34 of the balancing device through lead 37. If it is observed that the modulated current supplied to the load circuit through lead 16 is of less amplitude than that supplied to the load circuit through lead 14, this condition may be corrected by adjusting the movable plate 34 toward the fixed plate 31 which is connected to lead 16. This adjustment of the movable plate causes an increased flow of radio frequency current between movable plate 34 and fixed plate 31 and decreases the flow between the movable plate and fixed plate 30.

As the capacity coupling between plates 34 and 31 is increased by continued movement of the movable plate toward plate 31, the amount of unmodulated radio frequency current supplied to the load circuit in the direction of arrow 1 will increase, while the amount supplied to the load circuit in the direction of arrow 2 will decrease. Due to the action of the modulator and the connection thereof to the load circuit the modulated current flowing in the load circuit in the direction of arrow 1 and represented by lobes A of Fig. 3 will be displaced 180° in phase from the modulated current flowing in the load circuit in the di-

rection of arrow 2 and represented by the lobes B of Fig. 3. Due to the capacity unbalance existing between the two sides of the modulator, as hereinbefore described, the amplitude of the modulated current flowing in the direction of arrow 1 of Fig. 1 will be less than that of the current flowing in the direction of arrow 2. Unmodulated radio frequency current will be supplied to the load circuit through capacity 34, 31, 30 in the directions of the arrows XA and XB of Fig. 1 and, if this capacity device is adjusted in accordance with the invention to cause more of such current to flow in the direction of arrow XA than in the direction of arrow XB then the resultant unmodulated current flow in the load circuit will be XA—XB and at a given instant this resultant will be in phase with the modulated current flowing in the direction of arrow 1 and will accordingly increase the amplitude of that modulated current to any desired degree determined by the adjustment of the capacity 34, 31, 30. At a succeeding instant the flow of modulated current in the load circuit will be reversed and will be in the direction of arrow 2, while the relative amounts of unmodulated current supplied to the opposite input terminals of the load circuit will not have changed and the resultant unmodulated current in the load circuit will accordingly be opposed in phase to the modulated current flowing at this instant in the load circuit. The amplitude of the modulated current flowing in the direction of arrow 2 will accordingly be decreased. It will therefore be seen that the amplitudes of the modulated currents which alternately flow in opposite directions in the load circuit will be dependent upon the relative amounts of unmodulated current permitted to flow to the input terminals of the load circuit and will therefore depend upon the adjustment of the movable plate 34 with respect to the fixed plates 30, 31 of the variable capacity device.

It will be apparent that the adjustment of the movable plate, and consequently the adjustment of the envelope of the current in the output circuit may be made during operation of the modulator, and this is the preferred mode of operation.

A modified form of balancing device is disclosed in Fig. 2 and it will be seen that in this embodiment the unmodulated current is supplied to the output leads 16 and 14, respectively, through separate variable capacity devices 40, 41 which may be differentially adjusted to supply unmodulated current in desired proportionate amounts to the opposite input terminals of the load circuit.

In Fig. 5 there is disclosed a circuit arrangement to which any desired load may be coupled and including two mechanical means for supplying to two loads circuits radio frequency current modulated at two different frequencies to the load, balancing means according to the present invention being associated with each modulator for balancing the output of each modulator.

In this system it will be seen that current at radio frequency is supplied through leads 50 and 51 to the rotary assemblies 52, 53 of two mechanical modulators 54, 55, the output circuits of which supply modulated current to two tank or load circuits 56, 57 which act as coupling circuits for supplying currents modulated at two different frequencies to the load. The modulating devices 54, 55 may be either electrical or mechanical and, if mechanical, may be constructed in any desired or necessary manner and may include a sufficient number of fixed and movable plates to provide any desired modulation frequencies, such as the 65 cycle and 86⅔ cycle frequencies ordinarily employed for radio range beacon courses. The balancing devices 58, 59 are provided, one being connected in the output circuit of each modulator in the manner and form disclosed in Fig. 1, although the form illustrated in Fig. 2 may be employed if desired. Each of the balancing devices may be separately adjusted to provide the desired balance for each output circuit of each modulator.

In Fig. 6 there is disclosed a circuit which is adapted to supply modulated current to a load circuit 60, a modulating device 61 being provided between the source of radio frequency current 62 and the load circuit. A variable condenser or other variable capacity means 63 is connected between the source 62 and the load circuit 60. By means of this arrangement an adjustable amount of radio frequency current is supplied to the load circuit and is there combined with the output of the modulator to vary the percentage modulation of the current in the load circuit. If the modulator is operated without the provision of any balancing means the percentage modulation provided will be approximately 100%, the deviation from this value being due to unbalances inherent in the modulating means. The adjustable balancing means provided permits compensation for small errors and unbalances in the modulator whereby exactly 100% modulation may be obtained or, if desired, less than 100% modulation may be secured.

While the present invention has been described only in connection with a mechanical modulating device, it may be employed with electrical modulating means such as the modulator tube circuits commonly employed, without departing in any way from the scope of the invention. If it is desired to employ the balancing means of the present invention in connection with electrical modulating means, the balancing means and circuits as disclosed herein may be employed without change to supply variable amounts of radio frequency current to the output side of the electrical modulating circuits.

It will be apparent that the present invention will be susceptible of a wide variety of uses and it is to be understood that while two forms of the invention have been disclosed, each being associated with a mechanical modulating device, the invention is not in any way limited by such disclosure or the description thereof, nor in any way other than by the appended claims.

I claim:

1. In an electrical system, a source of radio frequency current, a load circuit, means for producing from radio frequency current supplied by said source two modulated out-of-phase currents which are alternately supplied in opposite directions to said load circuit, and means for adjusting the amplitudes of said modulated currents to any predetermined relationship, said means comprising means for selectively combining with said modulated currents pre-determined amounts of unmodulated radio frequency current from said source.

2. In an electrical system, a source of radio frequency current, means for modulating current from said source, a load circuit connected to said modulating means and having input terminals to which the modulated current is alternately applied, and means for supplying unmodulated radio frequency current from said source to one or the other of the input terminals of said load

circuit to thereby combine unmodulated radio frequency current with modulated current in said load circuit to adjust the amplitude of said modulated current in a pre-determined manner.

3. In a modulating system, a source of radio frequency current, a load circuit, means for modulating current from said source, means for supplying modulated current alternately in opposite directions to said load circuit to produce two modulated out-of-phase currents in said load circuit, and means for adjusting the amplitudes of said modulated currents to a desired relationship, said means comprising variable capacity coupling means connected between said source and each of the input terminals of said load circuit whereby variable amounts of unmodulated radio frequency current from said source may be supplied to the terminals of said load circuit.

4. In an electrical system, a source of radio frequency current, means for modulating currents from said source, a load circuit, means connecting said load circuit to said modulating means to cause two out-of-phase modulated currents to be alternately supplied in opposite directions to said load circuit, and means for adjusting the amplitudes of said modulated currents to a desired relationship, said means comprising a fixed member connected to each input terminal of said load circuit, and a member mounted in capacitative relationship to said fixed members and movable with respect thereto and being connected to said source, said movable and fixed members being adapted to cause unmodulated radio frequency current to be combined with said modulated currents in desired proportions.

5. In an electrical system, a source of radio frequency current, means for modulating current from said source, a load circuit, means for connecting said modulating means to said load circuit to cause two out-of-phase modulated currents to be alternately supplied in opposite directions to said load circuit, and means for adjusting the amplitudes of said modulated currents to desired values, said means comprising selectively variable coupling means connected between said source and the input terminals of said load and adapted to cause predetermined amounts of unmodulated radio frequency current to be combined with said modulated currents.

6. In electrical systems, a source of radio frequency current, means for modulating current from said source, a plurality of output leads connected to said modulating means, a fixed member connected to each of said output leads, a member mounted in capacitative relation to said fixed members and movable with respect thereto to cover said fixed members in inversely proportional amounts, said movable member being connected to said source of radio frequency, whereby currents at radio frequency are supplied to said output leads in inversely proportional amounts.

7. In electrical systems, a source of radio frequency current, means for modulating current from said source, a plurality of output leads connected to said modulating means, and a plurality of relatively movable elements disposed in capacitative relation to each other and including a member connected to each of said output leads and a member connected to said source, for supplying current at radio frequency in inversely proportional amounts to each of said output leads.

8. In electrical systems, a source of radio frequency current, means for modulating current from said source, a plurality of output leads connected to said modulating means, a fixed condenser element connected to each of said output leads, a movable condenser element disposed in capacitative relation to each of said fixed elements and connected to said source of radio frequency current, said movable element being adjustable to different relative positions with respect to said fixed elements to thereby supply radio frequency currents in different amounts to said output leads.

9. In electrical systems, a source of radio frequency current, means for modulating current from said source, a plurality of output leads connected to said modulating means, a plurality of fixed condenser elements, one connected to each of said output leads, a movable condenser element disposed in capacitative relation to all of said fixed elements and adjustable with respect thereto to simultaneously cover all of said fixed elements in variable amounts, said movable element being connected to said source of radio frequency current to thereby supply current at radio frequency to each of said output leads in different amounts.

10. In electrical systems, a source of radio frequency current, means for modulating currents from said source, a plurality of output leads connected to said modulating means, a plurality of fixed elements, one connected to each of said output leads, a screw support, a member adjustably carried by said screw support and disposed in capacitative relation to all of said fixed elements and movable with respect thereto to a plurality of positions in which it may be retained by said screw support, said movable member being connected to said source whereby currents at radio frequency may be supplied to said output leads in any desired relative amounts.

11. In an electrical system for modulating current from a source of radio frequency current to alternately supply modulated, out-of-phase currents to a load circuit, the method of adjusting the amplitudes of the modulated currents to a desired relationship which consists in combining with the modulated currents radio frequency current from such source and in such proportions as to cause the amplitudes of said modulated currents to vary as desired.

12. In an electrical system, a source of radio frequency current, means for modulating current from said source to provide two out-of-phase modulated currents which are alternately supplied by said modulating means to a load circuit, said modulating means and said system being capacitatively unbalanced and therefore being capable of supplying modulated currents of unequal amplitudes to said load circuit, and means for compensating for the capacitative unbalance of said modulating means and said system whereby modulated currents of equal amplitudes may be supplied to said load circuit and comprising means for combining unmodulated radio frequency current from said source with either one or both of said modulated currents in such amounts or proportions as to cause the amplitudes of said modulated currents to vary as desired.

13. In a modulating system, a source of radio frequency current, means for modulating current from said source to provide two out-of-phase modulated currents which are supplied alternately in opposite directions to a load circuit, and means for correcting for any unbalance between the modulated currents flowing in said load circuit and comprising means for supplying current at radio frequency from said source to one

or the other of the input terminals of said load circuit.

14. In an electrical system, the method of producing modulated waves of balanced wave form, which consists in modulating current from a source of radio frequency oscillations to provide two out-of-phase modulated waves which may be unbalanced due to inherent unbalances in the modulating means or other parts of the system, and combining with said modulated waves radio frequency current from said source in such proportions as to balance the modulated waves.

15. In an electrical system, the method of producing modulated waves which are of pre-determined relative amplitudes, which consists in modulating current from a source of radio frequency to provide modulated out-of-phase waves which are alternately supplied in opposite directions to a load circuit and which may be of unequal amplitudes due to unbalances in the modulating means or other parts of the system, and combining with said modulated waves radio frequency current from said source in such proportions as to adjust the amplitudes of said modulated waves to any pre-determined relation.

16. In a modulating system, a source of radio frequency current, means for modulating current from said source to provide two out-of-phase modulated currents which are supplied alternately in opposite directions to a load circuit, and means for correcting for any unbalance between the modulated currents flowing in said load circuit and comprising means for supplying to the input terminals of the load circuit unmodulated radio frequency current in such relative amounts that the resultant unmodulated radio frequency current in the load circuit will be in phase with that one of the modulated currents in the load circuit the amplitude of which is to be increased.

17. In an electrical system for modulating current from a source of radio frequency current to alternately supply modulated, out-of-phase currents to a load circuit, the method of adjusting the amplitudes of the modulated currents to a desired relationship which consists in combining with the modulated currents in the load circuit an unmodulated radio frequency current which is in phase with that one of the modulated currents the amplitude of which is to be increased and is out of phase with that one of the modulated currents the amplitude of which is to be decreased.

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