Jan. 27, 1942. W. F. KANNENBERG **2,271,078**

MODULATING SYSTEM

Filed April 5, 1939

FIG. 1

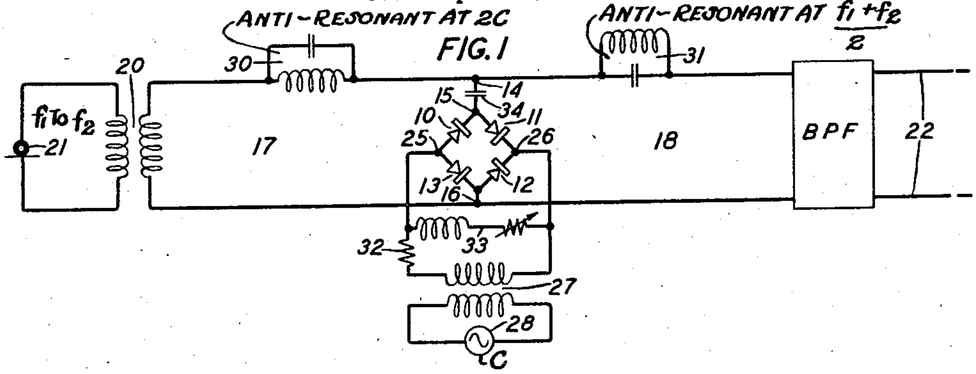


FIG. 2

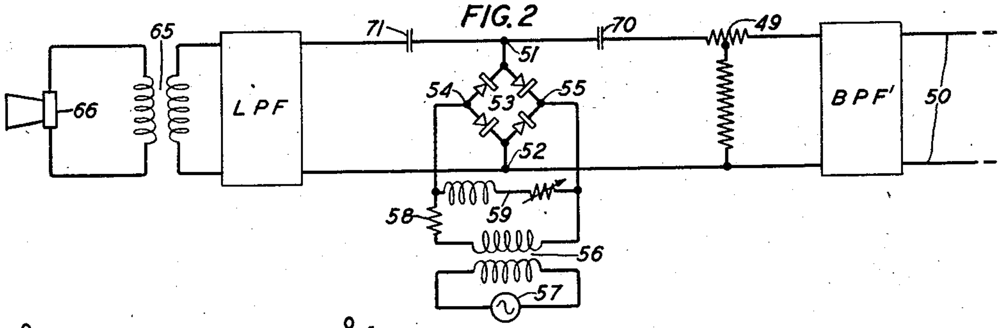


FIG. 3A

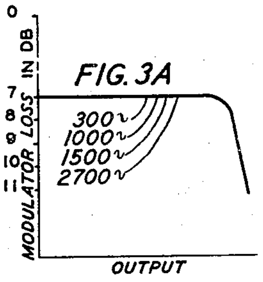


FIG. 3B

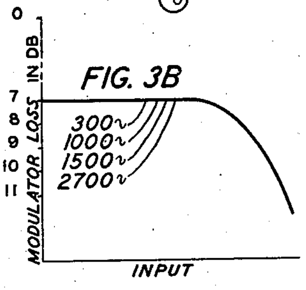


FIG. 3C

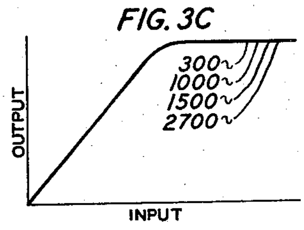


FIG. 3D

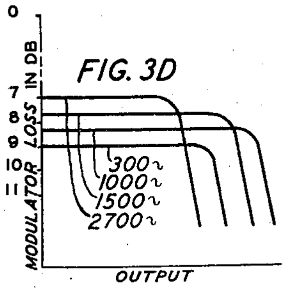


FIG. 3E

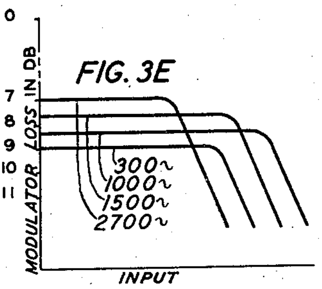
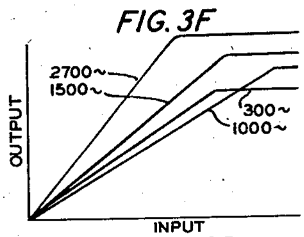


FIG. 3F



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2,271,078

MODULATING SYSTEM

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Application April 5, 1939, Serial No. 266,043

8 Claims. (Cl. 179—171.5)

This invention relates to frequency changers which may be either modulators, demodulators or detectors for use in intelligence transmitting systems, and more particularly to such frequency changers embodying non-linear resistance elements.

Heretofore non-linear resistance elements have been used in modulator and demodulator systems as illustrated in the patents of F. A. Cowan No. 1,959,459 and L. R. Cox No. 1,998,119. As disclosed in the patent to L. R. Cox, supra, arrangements have been devised to improve the efficiency of such systems, that is, to improve the economy of operation, particularly with reference to power consumption so that maximum desired side-band power is supplied to a line for transmission thereover.

It is an object of the invention to improve the fidelity of operation of modulator and demodulator systems.

It is another object of the invention to provide in such systems substantially uniform maximum amplitudes for wave components of all frequencies in desired modulated waves.

It is a further object of the invention to provide in such systems substantially identical overload characteristics for all modulating frequencies.

It is a still further object of the invention to enable in such systems transmission of all modulating frequencies substantially with the same amplitude.

It is still another object of the invention to provide in such systems optimum impedance terminations to the non-linear resistance elements embodied in a bridge included therein.

In one type of well-known modulator and demodulator system a plurality of non-linear resistance elements are arranged in the manner of a bridge which has connected to one diagonal an input circuit including a source of modulating waves and an output circuit adapted to select a desired modulated wave. To the opposite diagonal of the bridge is connected a source of carrier waves so that the carrier and modulating waves are combined to form the desired modulated waves.

In accordance with the invention, networks comprising reactive elements are connected in the input and output circuits and a network comprising reactive and resistive elements is connected in the carrier circuit, the several networks effectively terminating with optimum impedance the bridge so as to provide substantially identical overload characteristics for all frequencies in the modulating range of frequencies and thereby establishing substantially uniform maximum amplitudes at which all frequencies in the desired modulated waves may be transmitted.

The nature of the invention will be more fully understood from the following description of a system having it embodied therein and by reference to the accompanying drawing in which:

Fig. 1 is a schematic representation of a modulator and a demodulator system embodying the invention;

Fig. 2 is a schematic representation of a demodulator circuit embodying the invention; and

Figs. 3A through 3F are a group of curves explaining the action of the systems illustrated in Figs. 1 and 2.

Referring to Fig. 1 a plurality of physically inert non-linear resistance elements **10**, **11**, **12** and **13** are arranged in the form of a bridge whose one diagonal **14**—**15**, **16** is connected in shunt relation to an input circuit **17** and an output circuit **18**. The input circuit includes a modulating input transformer **20** for applying modulating frequencies from a suitable source **21** to the output circuit embodying a band-pass filter BPF which applies a desired band of modulated frequencies to a line **22** for transmission thereover. To the other diagonal **25**, **26** of the bridge is connected a carrier input transformer **27** for applying thereto a source **28** of carrier waves.

The operation of the bridge in a modulating system is well known and, briefly, consists in applying modulating waves from the source **21** across the diagonal **14**, **16** and simultaneously therewith impressing carrier waves from the source **28** across the diagonal **25**, **26**. These waves together with the non-linear resistance elements produce an action whereby the modulating and carrier waves are combined to effect modulated waves having a desired range of frequencies for selection by the band-pass filter BPF for transmission over the line **22**.

In order to avoid energy losses due to variations and imperfections in the non-linear resistance elements and thereby to promote highest efficiency in modulating systems, inductance-capacity networks connected in the input, output and carrier circuits in the manner disclosed in the patent of L. R. Cox, supra, have been heretofore employed. While such inductance-capacity networks tend to maintain low losses, they have been found to be inadequate from the standpoint that they do not improve the fidelity of the systems. This may be readily understood by referring to Fig. 3D wherein it is illustrated that the various frequencies in the desired modulated output have varying modulator losses and different cut-off points; in Fig. 3E that the modulating frequencies have varying modulator losses and different cut-off points; and in Fig. 3F that the various frequencies included in the modulated output corresponding to the various modulating frequencies have varying maximum amplitudes and different cut-off points. Obviously, fidelity does not attain its highest degree when the action in modulating systems is in accordance with the curves shown in Figs. 3D, 3E and 3F, as it is apparent that the amplitudes of certain frequencies in the modulating range of frequencies are cut off ahead of those of other frequencies in the same range. This means that the maximum amplitudes of different modulating frequencies are varyingly reduced so as to be transmitted over the line 22 as if they were originally produced in the source 21 with such variations therebetween. In other words, the ultimate maximum amplitudes at which different modulating frequencies are transmitted are different, regardless of the maximum amplitudes to which it is possible to produce these frequencies in the source 21. This does not provide for high fidelity transmission as the maximum amplitudes of the modulating frequencies are not transmitted over the line with regard to a maintenance of the relation therebetween as produced in the source 21 and further as the maximum amplitudes at which the different frequencies may be transmitted are different. Hence, the different modulating frequencies have different overload characteristics.

This invention contemplates improved fidelity in modulator systems by utilizing an arrangement for substantially equalizing the maximum amplitudes at which all modulating frequencies, and hence all frequencies corresponding thereto and embraced within a desired modulated band of frequencies, may be transmitted, and therefore provides for the establishment of substantially identical cut-off or overload characteristics for such frequencies.

In accordance with the invention, a tuned circuit 30 is inserted in one side of the modulating input circuit embodying the secondary winding of the input transformer 20, a tuned circuit 31 is inserted in one side of the bridge output circuit, and a resistance 32 is inserted in one side of the carrier input circuit embodying the secondary winding of the carrier input transformer and a network 33 comprising in series an inductance and adjustable resistance is connected in bridge of this winding.

A modulating frequency entering the bridge through the input circuit sees the bridge as a full-wave rectifier. In general, for any sinusoidal voltage wave applied to the bridge from the modulating source, the wave shape of the current will not be sinusoidal. As the return path through the bridge includes, in addition to the two conducting non-linear resistance elements, whatever resistance is included in the bridge diagonal therebetween, it is found that for relatively large voltage amplitudes the current wave tends to be peaked when this diagonal resistance approaches zero and flat topped when it approaches a relatively large value. At some critical value of this resistance the current wave will depart a minimum from a sine form. For such critical value of resistance, it has been found that the amplitude of the third harmonic of the modulating frequencies has a minimum value, it being larger and of one phase for larger values of resistance and larger but of opposite phase for smaller values of resistance. Such critical value of resistance exists regardless of the application of carrier waves to the bridge. In addition, it has been found that the amplitude of the fifth harmonic of the modulating frequencies likewise has a minimum value substantially at the same critical resistance. Of all the harmonics of the modulating frequencies, the third and fifth are the chief concern as appreciable energy at these frequencies may be passed into the modulated output circuit, and in certain cases, depending on the frequencies of channel allocation, may fall into the wanted range of modulated frequencies.

Resistance 32 inserted in one side of the carrier input circuit serves to control the impedance of the carrier input circuit for the third and fifth harmonics of the modulating frequencies such that the bridge diagonal embodying the carrier source possesses the critical value of resistance necessary to eliminate or balance out the harmonics as described above. Insertion of resistance 32, particularly when a large value is required, interferes with the sharpness of overloading and, in addition, tends to raise the impedance of the bridge by changing the operating points of the individual non-linear elements. This is so for the reason that the insertion of the resistance 32 cuts down the flow of rectified current in the bridge thereby changing the direct current bias on the individual non-linear elements from some average value. This causes a corresponding change in the impedance of the bridge as seen from the modulating input and the modulated output circuits. Introduction of the shunting network 33 restores the low resistance path for rectified current, hence the direct current bias on the individual elements of the bridge is restored to the average value. This low resistance direct current path controls the sharpness of the knee of the overload or cut-off characteristic of the bridge without appreciably disturbing the impedance of the carrier path for the harmonics of the modulating frequencies as hereinbefore mentioned. By adjusting the resistance of the network 33, the effective bridge impedance may be raised or lowered at will as such adjustment varies the operating point of the individual non-linear elements as previously mentioned. In this manner control of the average impedance of the bridge is obtained.

The modulating input circuit and the wanted side-band or modulated output circuit, particularly the channel band filter serve to terminate the bridge. As above described, the network 33 may be used to improve the impedance match of the bridge and the several circuits connected thereto. As the resistance of the network 33 should be low to provide sharp overload characteristic as mentioned above, it is important that the nominal impedance of the modulated output and modulating input circuits should preferably approximate the bridge impedance under such condition. Also, as the level of the carrier waves affects the impedance of the bridge the above impedance match should obtain at the level of carrier waves necessary to provide the bend of the overload characteristic at the desired level for either the modulating input or modulated output.

The circuits connected to the bridge need be matched thereto in the above manner only at those frequencies which are considered to be useful. Thus, the bridge must approximately match the modulated output circuit at the frequencies of the wanted modulated output and the modulating input circuit at modulating frequencies. Such impedance match is a necessary but not a sufficient condition. If these circuits have finite impedance at certain other frequencies initially present or produced at relatively large levels, then impedance networks must be interposed therein to so modify the impedance of the bridge at the certain other frequencies that an appreciable flow thereof is precluded in the respective circuits.

The impedance of the modulating input circuit tends to be low at frequencies of the order of second harmonic of carrier. As the bridge appears to the carrier input circuit like a half-wave rectifier, it should be expected that the bridge diagonal opposite the carrier input circuit should therefore tend to contain second harmonics of carrier of relatively large amplitudes. The network **30** inserted in the modulating input circuit is tuned to be anti-resonant at twice carrier frequency, thus providing the modulating input circuit with an impedance characteristic which is sufficiently high at twice carrier frequency to reduce the flow thereof in the modulating input circuit to a negligible amount.

At modulating frequencies, however, the modulated output circuit tends to have a relatively low impedance. The network **31**, which is embodied therein and tuned to be anti-resonant at the middle of the range of modulating frequencies, tends to raise its impedance over the range of modulating frequencies substantially to a sufficient amount to reduce the flow of modulating frequencies in the modulated output circuit to a negligible amount.

In the manner indicated above an impedance adjustment is achieved whereby the bridge is fitted to the connecting circuits from an impedance standpoint such that an approximate match is simultaneously obtained at certain desired frequencies, a maximum mismatch is provided at certain undesired frequencies which tend to be strongly present and cannot readily be balanced out, and a balance is obtained at the third and fifth harmonics of the modulating frequencies.

In other words, the impedance networks interposed in the modulating input, carrier supply and modulated output circuits are proportioned to provide terminating impedances for the non-linear bridge which have the most favorable magnitudes and frequency characteristics for certain wanted frequencies and certain unwanted frequencies tending to flow in the respective circuits. As such impedance adjustments are set for a given carrier level which is required to fix the knee of the overload curve at the desired input and output values, these adjustments shall provide (*a*) flattest transmission of all desired frequencies, (*b*) sharpest overload or cut-off characteristic, (*c*) overload or cut-off characteristic most uniform at all frequencies transmitted and (*d*) a loss approaching the minimum consistent with high quality performance. These characteristics are illustrated in Figs. 3A, 3B and 3C.

Non-linear bridges of different characteristics may be compensated for by the network **33** which serves to raise or lower the average impedance of each thereof until it matches substantially the connecting circuits in the manner aforedescribed.

Figs. 3A, 3B and 3C indicate, respectively, that all frequencies in the modulated output have substantially the same modulator loss and cut-off point, all frequencies in the modulating range of frequencies have substantially the same modulator loss and cut-off point, and all frequencies in the modulated output corresponding to the frequencies in the modulating range may attain substantially uniform maximum amplitudes and therefore have substantially identical cut-off points. As a result the fidelity of the system is substantially improved as it is readily apparent in Figs. 3A, 3B and 3C that all frequencies in the modulating range may attain the same cut-off points. This means that all frequencies of the modulating waves have equal opportunity for transmission over the line **22** at the same maximum amplitude and therefore such frequencies may be transmitted with particular regard to a maintenance of the relation between the amplitudes thereof as produced in the source **21**.

A condenser **34** interposed between points **14** and **15** tends to balance the bridge so as to preclude a leak of unmodulated carrier waves to the output circuit and also to prevent a circulation of rectified current in the input and output circuits.

Referring to Fig. 1, the carrier waves may traverse two parallel paths through the non-linear bridge, each path constituting a half-wave rectifier. Thus, one such path would comprise the non-linear elements **10** and **11** included in series and poled in the same direction between the terminals **25**, **15**, **26** while the other such path would comprise the non-linear elements **12** and **13** included in series and poled in the same direction as the previously mentioned non-linear elements between the terminals **25**, **16**, **26**. These non-linear elements possess resistance characteristics which vary in response to the magnitude of the voltage applied thereto. Assuming, for the moment that the condenser **34** is omitted, which means terminals **14** and **15** are the same, and the resistance characteristics of the non-linear elements are identical, then such resistance characteristics would vary in like manner, and consequently the junction terminals **14**—**15** and **16** would possess the same potential, regardless of the magnitude of the carrier voltage applied across the terminals **25**, **26**. As the carrier leak voltage is the difference between the potentials of the terminals **14**—**15** and **16** and as this is zero, no unbalance current would tend to flow between the terminals **14**—**15** and **16** during the conducting part of the carrier cycle. Accordingly, no unbalance current would tend to flow in the input and output circuits for the reason which will now be explained.

However, it may happen in the situation assumed above that commercial non-linear elements, due to impurities and methods of manufacture, may possess dissimilar resistance characteristics so that a difference of potential may exist across the junction terminals **14**—**15** and **16** when a voltage is applied across the terminals **25** and **26**. Consequently, unbalance current, that is, rectified and carrier current as will be hereinafter explained, may tend to flow in the circuits connected to the terminals **14**—**15** and **16**. The parallel path embodying non-linear elements having the greater dissimilarity of resistance characteristics will determine the direction of flow of such unbalance current in the circuits applied to the terminals **14**—**15** and **16**.

As the alternating and rectified current resistance characteristics of the non-linear elements during the conducting part of the carrier cycle tend to exhibit similar trends, it is found that a change of the rectified current characteristics due to a control of the magnitude of the rectified current tending to flow in the two aforesaid parallel paths will cause a corresponding change in the alternating current resistance characteristics. From the above it is understood that substantially no rectified current would tend to flow in the input and output circuits when the non-linear elements possess substantially identical rectified current resistance or voltage current characteristics and rectified current would tend to flow in the input and output circuits when the non-linear elements possess dissimilar rectified current resistance or voltage current characteristics. In the latter case the flow of rectified current would be of such direction as to tend to increase the amount thereof in the low resistance elements and to decrease the amount thereof in the high resistance elements over the amounts that would tend to be present if no rectified current could flow between the junction terminals **14**—**15** and **16**. In other words the resistances of the non-linear elements carrying the aforementioned increased and decreased amounts of rectified current are tended to be decreased and increased, respectively. Accordingly, this tends to decrease the rectified current difference of potential between the terminals **14**—**15** and **16**. At the same time the alternating current resistance characteristics tend to change similarly to those of the rectified current, but now, however, the alternating current difference of potential across the terminals **14**—**15** and **16** is increased. These changes of the rectified and alternating current differences of potential in such opposite sense is due to the fact that in the rectified current case current flows across the terminals **14**—**15** and **16** while in the alternating current case no current flows across these terminals. Hence in the rectified current case, the potential across any non-linear element is not proportional to the resistance thereof whereas in the alternating current case the potential across any non-linear element is proportional to the resistance thereof.

The insertion of the condenser **34** as above stated interrupts the flow of rectified current to the input and output circuits and in addition is charged with such polarity as to oppose the increased amount of rectified current in the non-linear elements of decreased resistance and to aid the decreased amount of rectified current in the non-linear elements of increased resistance. Such charge therefore tends to increase the resistance of the former non-linear elements and to decrease the resistance of the latter non-linear elements. In other words such charge tends to regulate the flow of rectified current in the parallel paths **25**, **15**, **26** and **25**, **16**, **26** so as to bring the bridge more closely to a resistance balance therefor. As the alternating current resistance characteristics tends to follow closely the rectified current resistance characteristics of the non-linear elements during the conducting part of the carrier cycle as hereinbefore mentioned, it is apparent that a corresponding improvement in alternating current resistance balance of the bridge is likewise effected. As the alternating current voltage is proportional to the resistances of the non-linear elements as hereinbefore pointed out, it is now apparent that the alternating current difference of potential across the terminals **14**—**15** and **16** substantially approaches zero. This tends to diminish substantially or to obviate entirely a leak of unmodulated carrier current to the circuits connected to the junction terminals **14**—**15** and **16**.

Fig. 2 represents a demodulator system in which modulated waves received over a transmission line **50** are applied through receiving band-pass filter BPF′ and T-shaped resistance pad **49** to diagonal **51**, **52** of a non-linear bridge **53** comprising a plurality of physically inert non-linear resistance elements that are similar to those embodied in the non-linear bridge in Fig. 1. Impressed across the other diagonal **54**, **55** is the secondary winding of a carrier input transformer **56** whose primary winding is connected to a source **57** of carrier waves. Included in one side of the carrier circuit is a series resistance **58** and bridging the secondary winding of the carrier input transformer **56** is a series network **59** consisting of an inductance and an adjustable resistance. The series resistance **58** and network **59** serve the purpose of eliminating the harmonics of the modulating waves as described above in connection with Fig. 1. Also connected to the diagonal **51**, **52** in shunt of the demodulator band-pass filter is a receiving low-pass filter LPF whose output is applied through a receiving transformer **65** across whose secondary winding is connected a suitable translating apparatus **66**.

The operation of the demodulator system is well known and is, briefly, that modulated waves incoming from the transmission line **50** are applied to the bridge diagonal **51**, **52**, while at the same time carrier waves are impressed across the opposite bridge diagonal **54**. **55**. These waves together with the non-linear resistance elements produce an action whereby the incoming modulated waves and the carrier waves are combined to effect modulation products of which the modulating waves that originated at the transmitting end of the system, not shown, is one. These modulating waves are applied through the receiving low-pass filter and the transformer **65** to the translating apparatus **66**. As pointed out above regarding Fig. 1, the non-linear bridge may discriminate in such fashion that the various frequencies in the modulating range have different overload characteristics, being similar to those shown in Figs. 3D, 3E and 3F. Hence the fidelity of the system is relatively low.

Therefore, it is contemplated by the invention explained above with respect to Fig. 1 to promote fidelity in the system and thereby to provide in Fig. 2 the action represented in Figs. 3A, 3B and 3C. This is accomplished by serially connecting a capacity **70** in one side of the demodulated wave or side-band input between the bridge terminal **51** and the T-shaped path **49** and also serially connecting a capacity **71** in a corresponding side of the modulating wave output between the same bridge terminal and the receiving low-pass filter. The T-shaped path serves to improve the impedance presented to both the non-linear bridge and the band-pass filter while the receiving low-pass filter prevents modulated waves from passing into the translating apparatus **66**.

Capacities **70** and **71** interrupt a flow of rectified current in the respective circuits thereby preventing a leak of carrier waves thereinto. Confining modulating waves and modulated waves to their respective circuits is desirable so as to avoid unnecessary dissipation of energy. This is accomplished by making capacity 70 relatively small so as to have low impedance for modulated waves of high frequencies and high impedance for modulating waves of low frequencies, and by making capacity 71 relatively large so as to have low impedance for modulating or signaling waves of low frequencies. While such conservation of energy is a prime consideration in modulating-demodulating systems, another consideration of vital importance is the attainment of high fidelity transmission therein.

In accordance with the operation of the invention as explained above in connection with Fig. 1, high fidelity is achieved in Fig. 2 by further adjusting capacities 70 and 71 so as to terminate the input, output and carrier circuits in optimum impedance relative to the non-linear bridge to obtain the action represented in Figs. 3A, 3B and 3C. This means that all modulating waves have equal opportunity for reception at the same maximum amplitude. Thus, the unfavorable discrimination of the non-linear bridge for certain frequencies in the modulating range is obviated and all such frequencies have the same overload characteristics. This therefore promotes a substantial improvement in the fidelity of the modulating system as explained above in connection with Fig. 1. It has been found that whatever energy is sacrifled in the further adjustment of capacities 70 and 71 it is more than adequately compensated for by the improved fidelity.

What is claimed is:

1. In a modulating system comprising a source of modulating frequency waves, an input circuit selective to the modulating waves, a load circuit selective to desired modulated waves, a plurality of non-linear resistance elements arranged in the form of a bridge which has one diagonal connected to the modulating input and load circuits, and a source of carrier frequency waves connected to the other diagonal of the bridge so that the modulating and carrier waves are combined in the desired modulated waves; means comprising a capacity connected in the bridge diagonal to which the modulating input and load circuits are connected to interrupt a direct current path to both latter circuits to balance the bridge against a leak of unmodulated carrier waves into the load circuit.

2. In combination in a wave combining system, a plurality of non-linear rectifier elements arranged in a bridge network, an input circuit including a source of modulating waves, an output circuit selective to a range of desired output frequencies, a source of carrier waves, said input and output circuits applied to one diagonal of said network said source of carrier waves onnected to the other diagonal of said network to cause side-band wave products of said carrier waves and modulating waves to flow in said output circuit and to produce rectified current flow in circuit with said network, and means to selectively control the magnitude of said rectified current flowing in said network comprising a shunt path around said other network diagonal, of low impedance to said rectified current but of high impedance to harmonics of said modulating waves.

3. In a modulating system comprising a plurality of non-linear rectifier elements arranged in a bridge network, a source of modulating waves of a range of frequencies connected to one diagonal of said network, a source of carrier waves connected to the other diagonal of said network so that the modulating and carrier waves are combined in a desired band of modulated waves and rectified current is produced in circuit with said network, and an output circuit selective to the desired band of modulated waves and connected to said one diagonal of said network, means to provide for said network terminating impedances which have substantially the most favorable magnitudes and frequency characteristics for transmitting wave components of all frequencies in the desired band of modulated waves with substantially uniform maximum amplitudes, said terminating means comprising an impedance in series with said modulating source to suppress waves having the frequency of the second harmonic of the carrier waves while freely passing the modulating waves, an impedance in said output circuit to attenuate waves of the modulating frequencies while freely passing the desired band of modulated waves, a resistance in series relation to a portion of said network and to said source of modulating waves and in circuit with said source of carrier waves, said resistance proportioned to minimize distortion of the wave form of the modulating current and tending to impede the flow of said rectified current and an inductive impedance in shunt relation to said and other network diagonal to afford a path for the flow of said rectified current to limit to a desired amount the flow of said rectified current in said network.

4. In a modulating system, a source of input waves of a band of frequencies, a four-terminal network of non-linear rectifier elements arranged in bridge form and having one pair of diagonally opposite terminals connected to said source of input waves, an output circuit selective to a different band of frequencies connected to said one pair of terminals, and a source of carrier waves connected to the two remaining diagonally opposite terminals of said network, said network serving to produce modulated carrier waves in said output circuit, representing modulation products of said carrier and input waves, said network being also traversed by direct current resulting from rectification of carrier waves by said non-linear rectifier elements, and means to control the magnitude of said direct current comprising an inductive impedance connected across said two remaining terminals of said network.

5. In combination, an input circuit selective to waves in a certain band of frequencies, an output circuit selective to waves of a different band of frequencies, a plurality of non-linear rectifier elements arranged in a bridge network and having one diagonal connected across said input and output circuits, a source of carrier frequency waves applied to the other diagonal of said network so that the input waves and the carrier waves are combined in output waves in said different band of frequencies, and rectified current flow is produced in said network, and means to terminate said network with impedances of such magnitude and frequency characteristic that all waves in the different band of output frequencies are transmitted with substantially uniform attenuation, said terminating means comprising in each of said input and output circuits means to suppress waves having a certain order of frequency and to pass a wanted band of frequencies with substantially uniform attenuation, and in circuit with said carrier source a further network comprising a resistance embodied in series with said source to suppress

waves having harmonic frequencies of the input waves of said certain band of frequencies, and an inductance and a variable resistance in series applied in shunt relation to said source and said other diagonal of said network to control the amount of rectified current flowing in said network.

6. In a wave translating system, comprising a plurality of non-linear rectifier elements arranged in the form of a bridge network, a plurality of circuits for supplying alternating current waves to said network to be translated into waves of certain frequency and rectified current, a load circuit to utilize said waves of certain frequency, and circuit means to connect said supplying circuits and said load circuit to the diagonals of said network; impedance means to balance said network to preclude a leak of waves from a circuit connected to one network diagonal to circuits connected to an opposite network diagonal, said impedance means comprising a reactive element connected in series with said opposite network diagonal to prevent a flow of said rectified current from said network to said circuits connected to said opposite network diagonal.

7. In a wave translating system, comprising a plurality of non-linear rectifier elements arranged in the form of a bridge network, a plurality of circuits for supplying alternating current waves to said network to be translated into waves of certain frequency and rectified current, a load circuit to utilize said waves of certain frequency, and circuit means to connect said supplying circuits and said load circuit to the diagonals of said network, said rectified current flowing in said network and one of said circuits; means comprising an impedance network between one network diagonal and said one circuit to control the magnitude of the said rectified current flowing in said network, said impedance network comprising a resistance in series in one side of said one circuit and a resistance and an inductance in series applied in shunt of both said one network diagonal and said one circuit.

8. In a wave translating system, comprising a plurality of non-linear rectifier elements arranged in a bridge network, a plurality of circuits for supplying alternating current waves to said network to be translated into waves of certain frequency and rectified current, a load circuit to utilize said waves of certain frequency, and circuit means to connect said supplying circuits and said load circuit to the diagonals of said network; said rectified current tending to flow in said network and said circuits, means comprising an impedance network to control the flow of said rectified current in said network and said circuits, comprising a capacitor in series with one network diagonal, a resistor in series with the other network diagonal, and an inductor and a resistor in series applied in shunt of said other network diagonal.

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