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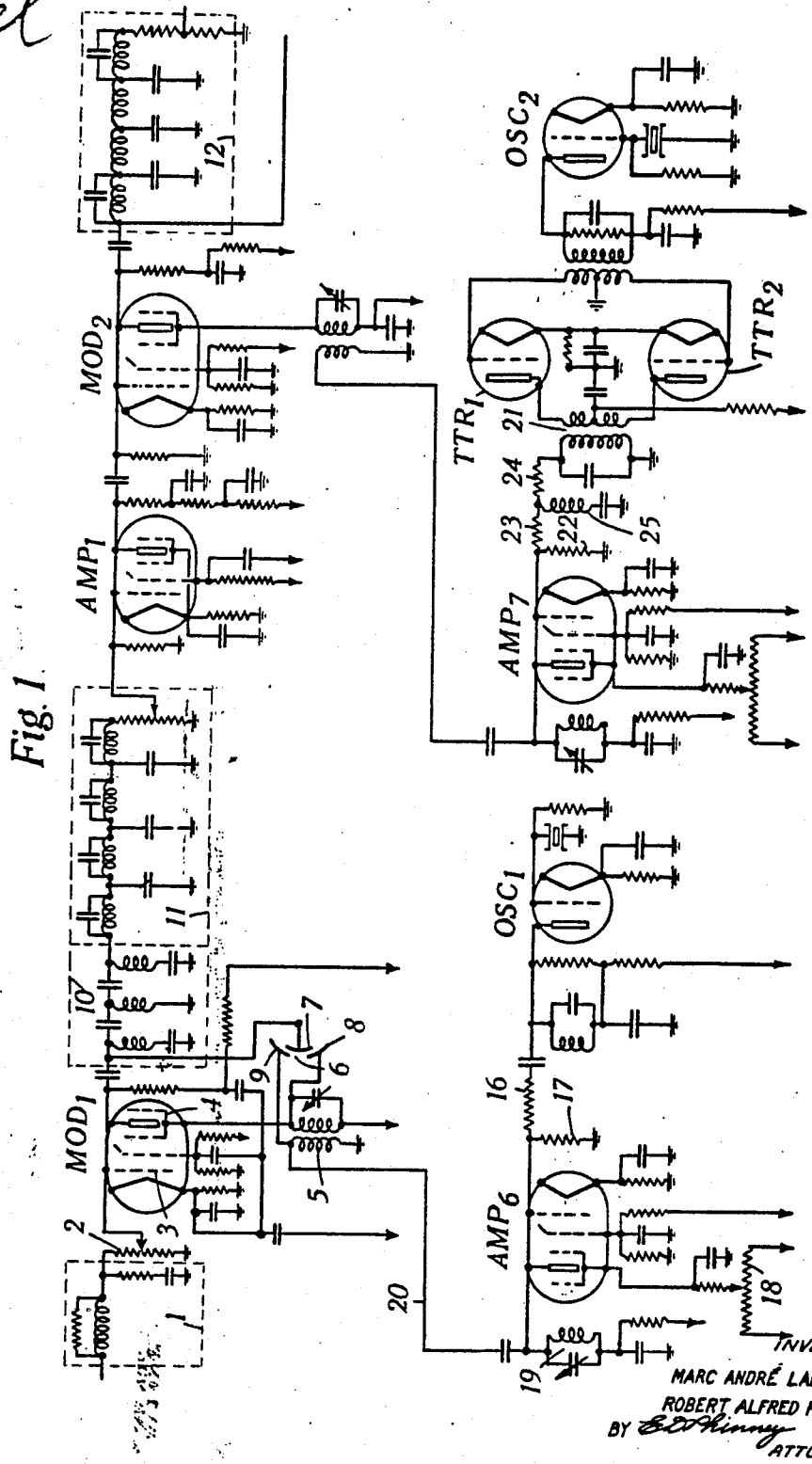
SS Reference

Aug. 20, 1940. M. A. LALANDE ET AL 2,212,240

CARRIER WAVE MODULATING SYSTEM AND APPARATUS

Filed April 16, 1937 5 Sheets-Sheet 1

Fig. 1.



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CARRIER WAVE MODULATING SYSTEM AND APPARATUS

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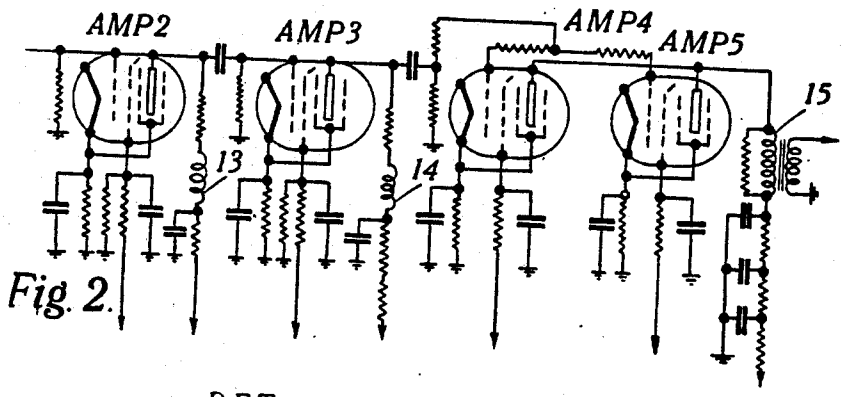

Fig. 2.

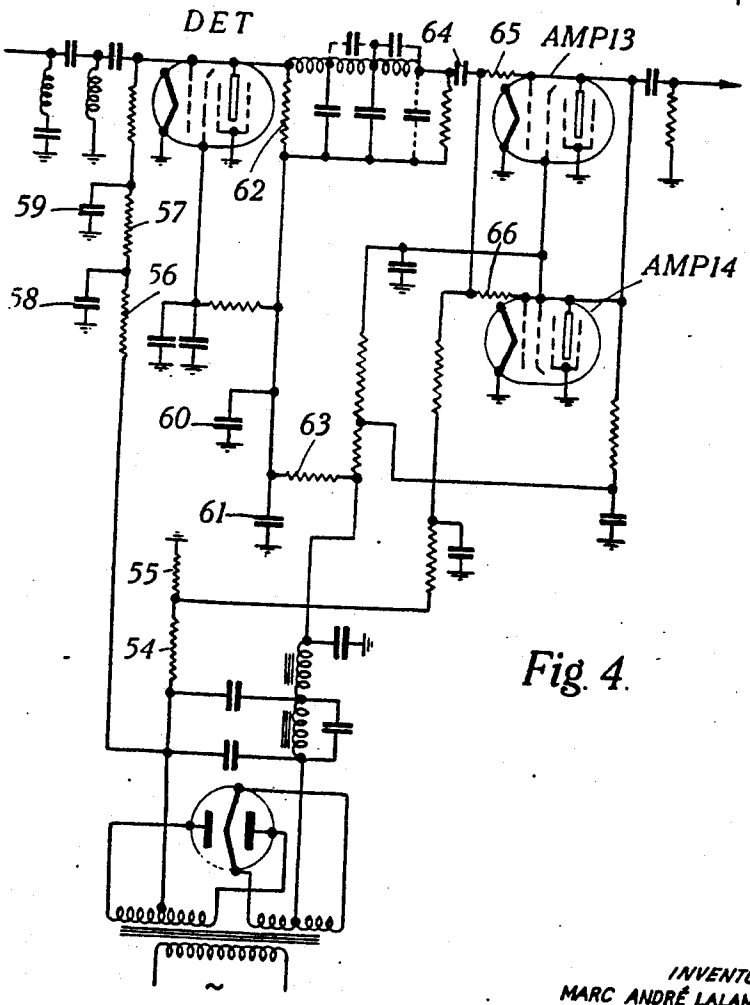

Fig. 4.

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CARRIER WAVE MODULATING SYSTEM AND APPARATUS

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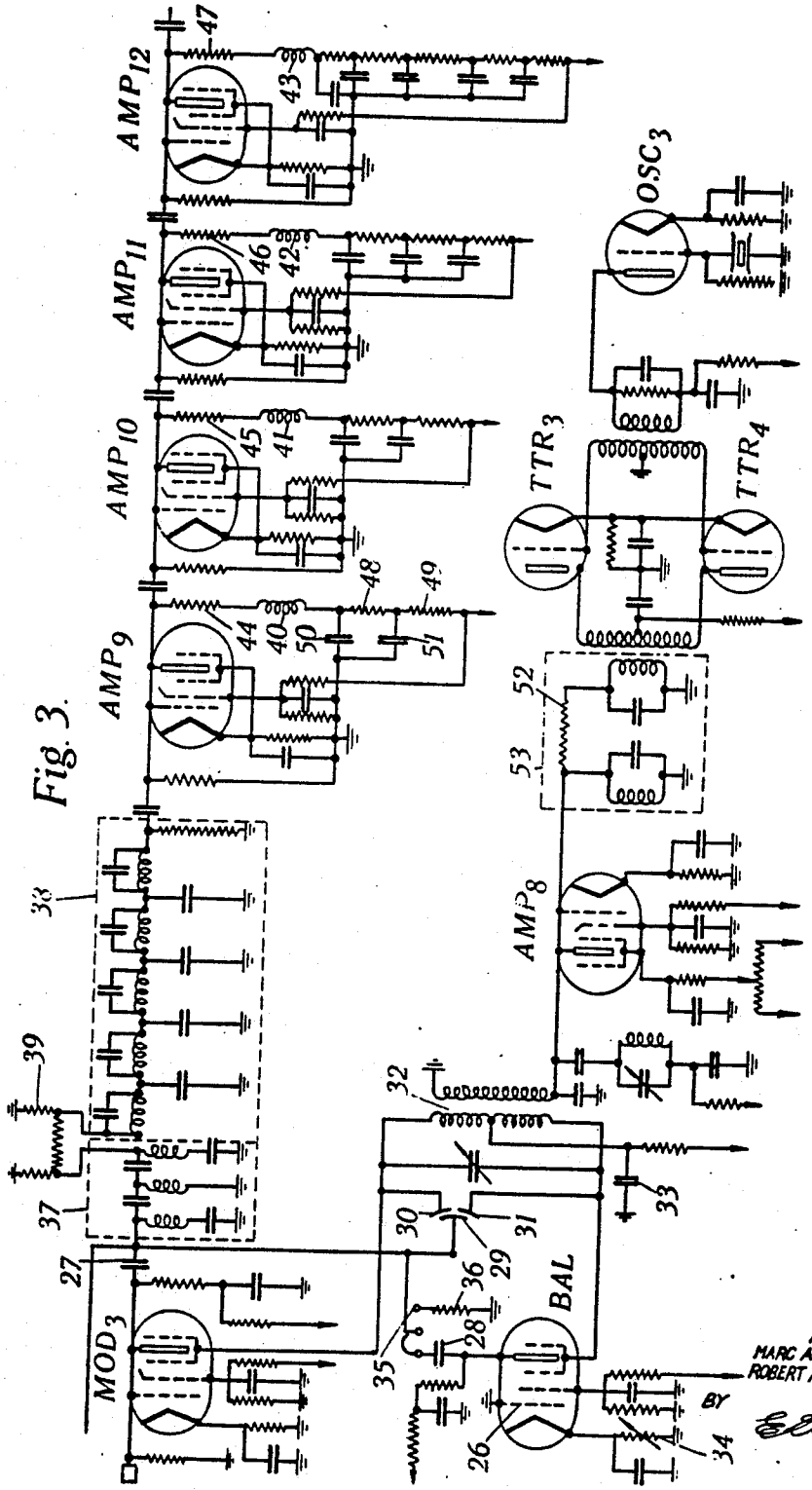

Fig. 3.

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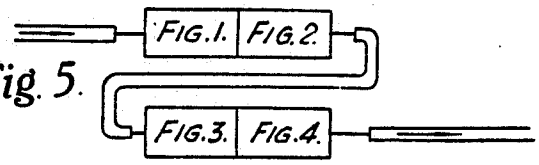
Fig. 5.



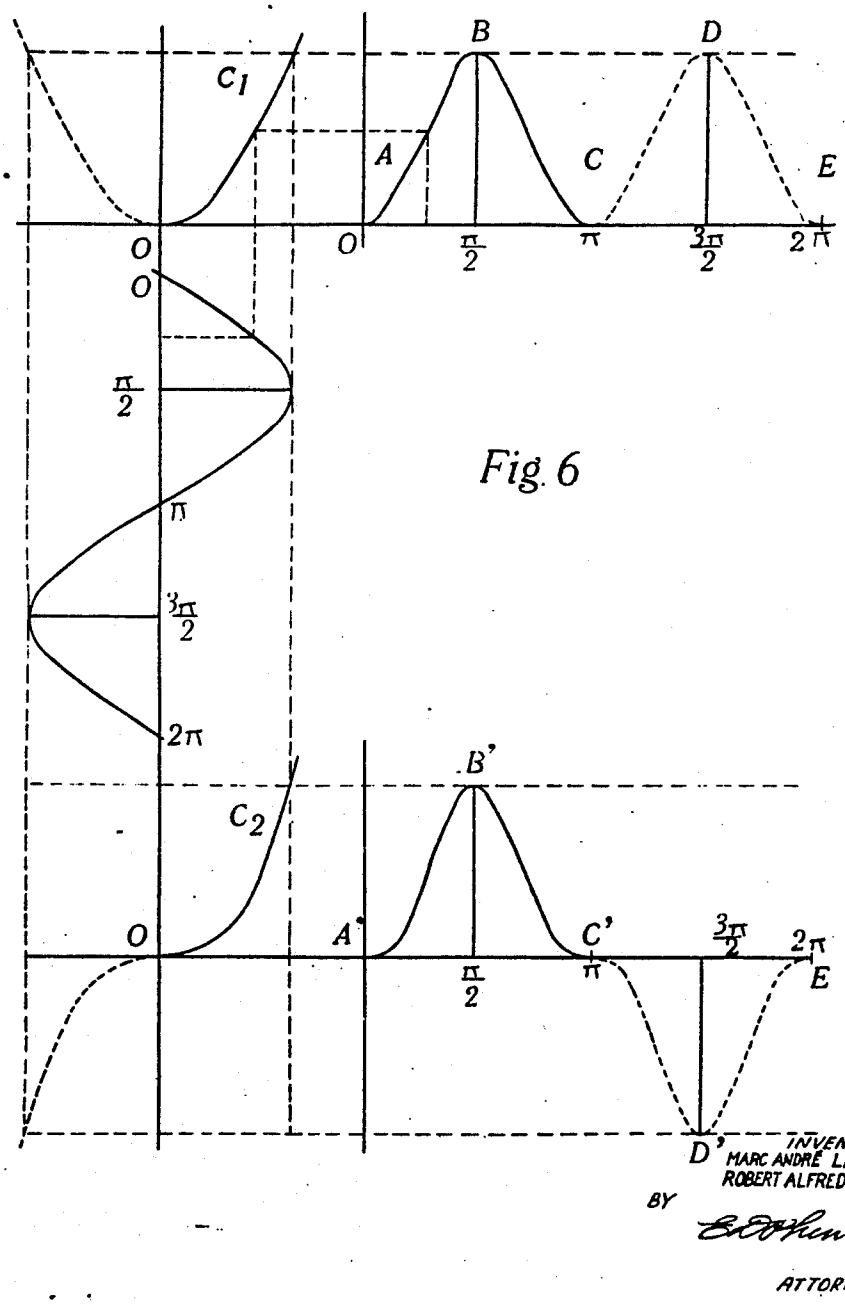


Fig. 6

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Fig. 7.

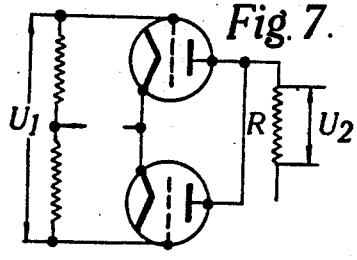


Fig. 8.

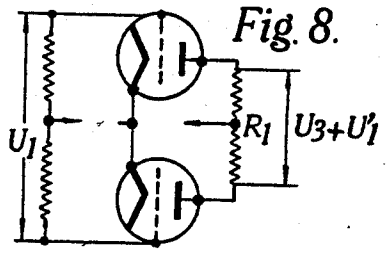


Fig. 9.

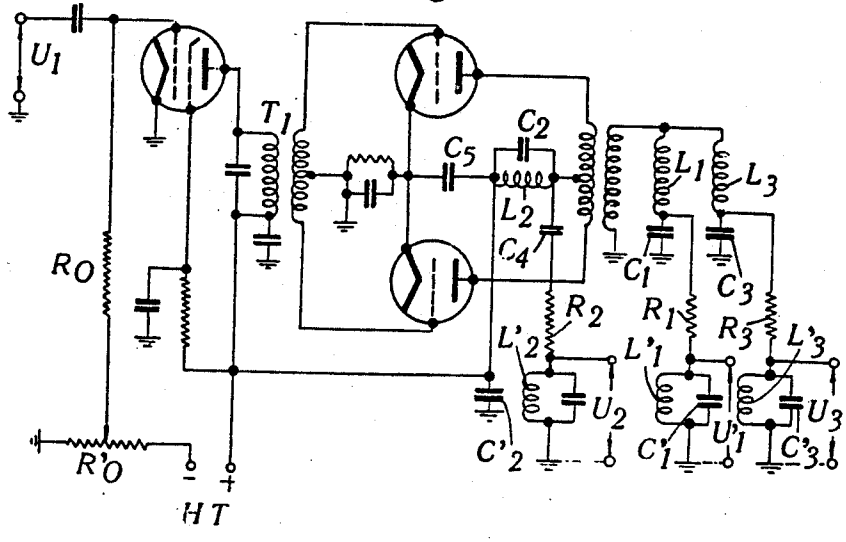
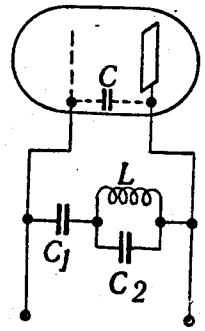


Fig. 10.



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Patented Aug. 20, 1940

2,212,240

UNITED STATES PATENT OFFICE

2,212,240

CARRIER WAVE MODULATING SYSTEM AND APPARATUS

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Application April 16, 1937, Serial No. 137,200
In France May 5, 1936

14 Claims. (Cl. 178—44)

The present invention relates to systems of transmitting electric signals.

The invention particularly relates to the transmission by cable of signals occupying a very wide frequency band without substantial attenuation or distortion inside such a band.

The system applies particularly well to the transmission of television signals on long distance concentric cables. As in cases of this type it is practically impossible to ensure good transmission for a frequency band extending from several periods per second to 2 megacycles per second, this range of frequencies has been transposed to a higher range, but of the same extent. In the embodiment which is now to be described, a band has been chosen between about 350 kc. and 2350 kc. As it is impossible to avoid an inversion when effecting this shift in a single operation, the following method is employed: A television frequency band is modulated first of all at about 5200 kc. thus giving rise to two bands, one composed of 5200 to 3200 kc., the second from 5200 to 7200 kc. The transmission of this latter band is prevented. The first band, which alone is kept, forms the object of a second modulation by a frequency of about 5550 kc. giving rise to two frequency bands, one of 350 to 2350 kc. the other from 10750 to 8750 kc. The transmission of the latter band is prevented and the lower band alone maintained, is transmitted on the cable, where it can be suitably amplified from distance to distance. At the receiving station this band is modulated by a frequency in the vicinty of 5550 kc. which gives a band comprised between 5200 and 3200 kc. and a higher band which is eliminated.

In the first heterodyne stage at the transmitting station the 5200 kc. carrier is not eliminated but is passed with the lower side band of 5200–3200 kc. and thus this carrier is converted to a frequency of 350 kc. in the second heterodyne stage of the transmitting station and is transmitted over the cable as a 350 kc. wave. The first heterodyne stage at the receiving station restores this carrier to a frequency of about 5200 kc. A detector stage in the receiver station is now supplied with this 5200 kc. carrier as well as with the side band extending from 5200 kc. to 3200 kc. and consequently the detection restores the original band of from 0 to 2000 kc.

The invention as a whole, as well as the various features it comprises will be understood well by means of the following description of an embodiment made in connection with the attached drawings in which:

Fig. 1 shows the transmitter system excluding the output amplifier;

Fig. 2 shows the output amplifier of the transmitter system;

Fig. 3 shows the receiver system excluding the detector and output amplifier system;

Fig. 4 shows the detector portion and the output amplifier of the receiver system with their supply;

Fig. 5 shows a method of assembling the circuits shown in Figs. 1 to 4;

Fig. 6 shows curves employed in order to explain the invention of a frequency amplifier device in accordance with one of the aspects of the invention;

Figs. 7 to 8 partially show the method of connection of the input and output electrodes of the valves employed in such a device;

Fig. 9 shows the detailed diagram of the multiplier device, and finally

Fig. 10 shows the diagram of a corrector device for modulator in accordance with features of the invention.

The principle of modulation employed in the whole of the system is that of the modulation by application of the carrier frequency to the suppressor electrode of a pentode, the signal to be modulated being applied to the normal control grid.

The television or other signals are led to the control grid 3 of a modulator valve MOD_1 shown in Fig. 1 through an attentuator corrector comprising the network 1 followed by a potentiometer 2. The carrier frequency is brought to the suppressor electrode 4 through a transformer 5 whose secondary winding, connected to the modulator, is tuned. Moreover, in view of the high frequency of about 5 megacycles employed in the example chosen for the modulation, it was necessary to compensate the current passing from the suppressor to the plate circuit by capacity.

The electrode capacity of the device employed to modulate the carrier wave by a modulator wave gives rise in effect to a passage of carrier current into the output circuit which is particularly harmful to the high frequencies owing to the fact that this capacitatively transmitted current is not in phase with the normally transmitted carrier current, which has the result of creating a dephasing between the output carrier current and the sideband which the system is to transmit. This effect may be overcome by the

use of a compensating condenser 6 whose movable plate 7 is connected to the plate circuit of the modulator valve and whose two fixed plates 8 and 9 are connected, the one, 8, to the suppressor grid, and the other, 9, to the end of the primary winding, so that the potentials applied to the two fixed plates 8 and 9 of the condenser are in phase opposition. The plate 9 may be connected to the other end of the secondary winding of the transformer 5 in which case the mid-point of the secondary winding would have to be earthed through a condenser of low impedance.

Elimination of the carrier current transmitted in the output circuit by capacity between electrodes of the modulator valve might be obtained in another way which will now be explained:

Let us first of all note that in the case in which the detection is effected by systems with parabolic characteristics it can be shown that the drawback indicated above is practically cancelled and that everything takes place as though that portion of the carrier wave which is in phase were alone transmitted.

Further in the case in which the detection is effected by systems with linear characteristics, there results from the above phenomenon after detection:

1. A reduction of current at modulated frequency;

2. The appearance of a certain percentage of harmonics of this frequency.

The arrangement described hereafter permits the flux of the carrier current through the harmful capacity of the modulator system to be cancelled, while offering a high impedance to the waves produced by the modulation and if need be to the modulation waves themselves. Such a device is shown in Fig. 10.

It consists of a circuit placed in shunt to the electrode capacity C, and composed of a condenser C_1 in series with an anti-resonant circuit C_2L whose elements are such that it behaves at the carrier frequency like a positive reactance, equal in absolute value to that of the electrode capacity C.

Under these conditions, the system in shunt to the electrode capacity constitutes:

1. A very high impedance to the modulation currents of low frequency on account of the series condenser C_1, which is chosen for this reason—

2. A positive reactance equal to the electrode capacity C at the carrier frequency, and

3. In combination with the electrode capacity C, a reactance which can be made very high compared to the internal resistance of the modulator in the range of frequencies of the modulation bands. It is well to note that the use of the anti-resonant circuit C_2L permits a very high positive reactance to be obtained for the unit C_1, C_2, L using simple and readily available elements which would not be the case if it were desired to compensate the harmful capacity by a simple self inductance, the inductance of which would in general have to be considerable.

A similar result to that described could also be obtained by the use of other circuits or systems acting as negative capacities, such as, for example, electron valves.

Reverting to the modulation equipment shown in Fig. 1 it should be noted that in order to obtain correct modulation, it is necessary for the plate current to vary as linearly as possible with the tension applied to the control grid and with the tension applied to the suppressor electrode. This necessitates the use of a suitable type of modulating valve and a suitable choice of polarising potentials for the control grid and the suppressor grid.

The band filter of the modulator intended to eliminate on the one hand the direct television frequencies and on the other hand, the upper band of modulation, is for practical reasons composed of a high-pass filter 10 followed by a low-pass filter 11.

In order to eliminate the upper band and to preserve the carrier, it would be necessary for the filter to have a vertical cut-off which cannot be obtained in practice.

The difficulty has been obviated by taking as a basis the following considerations:

1. Only that part of the upper band which extends more than 700 kc. above the first carrier is actually liable to disturb the useful frequencies, in view of the fact that the second carrier is spaced 350 kc. from the first. However, it is well to attenuate all frequencies which are more than 350 kc. above the first carrier, as the latter might possibly cause certain difficulties. Consequently, the filter has been arranged so as to have its cut-off frequency approximately midway between the frequencies of the first and second carriers, and to have as high an attenuation as possible for the frequencies above and including the frequency of the second carrier.

In practice, in the frequency region adjacent the first carrier the filter transmits both sidebands, so that the signal delivered from the filter includes not only a complete sideband below the first carrier but also a partial sideband immediately above this first carrier. This partial band accompanies the complete band through the successive stages of transmitter and receiver, and finally in the second heterodyne stage of the receiver this partial band is superposed on the low frequency portion of the complete band to reinforce the latter. It should be noted, however, that in this same frequency region both the complete and the partial bands are slightly attenuated because of the shape of the attenuation characteristic of the filter near its cut-off. The result is that, after detection, the low frequencies arrive at the same level as the high frequencies, although they have been transmitted in duplicate by the two bands. The corrector 1 placed at the input of the system serves to equalise the transmission of the high and low frequencies.

Moreover, in view of the order of the frequencies concerned it will be noted that the self inductances employed in the filters have their characteristics modified to a certain extent by their distributed capacity. Consequently it is necessary, whenever possible, to employ circuits in which the self-inductance coils are shunted by condensers. It is obvious that in these conditions the distributed capacity of the coils is practically in parallel with the capacity placed on the terminals and that it is consequently possible to employ it or at least to reduce its harmful effects. Finally in the calculation of the condensers for connection to ground, the capacity of the coils with respect to ground has also been taken into account.

The second modulator is preceded by an amplifier valve AMP_1 simply intended to give a reasonable voltage level on the grid of the second modulator. The grid of this amplifier valve is connected to a suitable point on the terminal resistance of the low-pass filter 11. The method

of modulation in the second modulator is the same as in the first. It has however not been considered necessary to compensate the capacity between the suppressor electrode and the plate of the modulating valve MOD_2. The frequency of modulation is about 5,500 kc. This modulator is followed by a low pass filter 12 which eliminates the frequencies higher than 2600 kc.

The output amplifier shown in Fig. 2 comprises three stages and gives an amplification of about 50 db., for the band of frequencies transmitted. The two first stages respectively comprise the valves AMP_2 and AMP_3, and the third stage employs two valves in parallel AMP_4 and AMP_5.

In order to obtain the desired amplification, it is equipped with high-slope pentodes and the anode circuits of the two first stages comprise correction inductances 13 and 14, adapted to maintain the amplification in the range to be transmitted. The output of the amplifier is coupled in the example chosen to the concentric cable by means of screened step-down transformer 15 designed to transmit the band 350–2350 kc. with negligible loss. This special transformer which has a transformation ratio of 5:1 is provided with an iron dust core which completely surrounds the windings.

The two oscillators of the transmitter circuit which are shown in the lower part of Fig. 1 are of the type having a quartz crystal connected in the grid circuit of a triode. The plate circuit of the oscillator valve comprises an anti-resonant circuit tuned approximately to the frequency of oscillation; the frequency of the oscillator, however is practically independent to the tuning of the latter circuit and is determined by the quartz crystal. In the first oscillator the oscillating valve OSC_1 is coupled to an amplifier valve AMP_6 by means of a potentiometric device composed of the resistances, 16, 17, which serve to adjust the tension applied to the grid of the amplifier AMP_6.

The capacity of the grid with respect to earth, is also taken into account in making this adjustment. If need be an additional anti-resonant circuit, which however is tuned as exactly as possible to the frequency of the oscillator, may be placed between the grid and earth in order to eliminate the frequencies other than the natural frequency of the oscillator. The amplifier valve AMP_6 is a pentode whose suppressor electrode instead of being connected to the cathode as is usual, is connected to the potentiometer 18 permitting the application to the suppressor of an adjustable negative potential so as to vary the amplification of the valve in a continuous manner and to supplement the adjustment provided by the resistances 16, 17 mentioned above.

An anti-resonant circuit 19 placed in the plate circuit of the amplifier is designed to allow for the capacity to earth of the connection 20 between the oscillator and the modulator. Moreover, in order to render possible the transmission of the current between the oscillator and the modulator, the method has been adopted of connecting the valve AMP_6 of the oscillator to the suppressor electrode 4 of the modulator valve MOD_1 by the tuned transformer 5 which has already been described. This device permits the existence of a relatively high capacity to earth of the connection 20.

The second oscillator, like the first, comprises a quartz-controlled oscillator valve OSC_2, which, however, oscillates at a third of the frequency which it is finally desired to obtain. The plate circuit of the oscillator OSC_2 is coupled to a system of two valves TTR_1 and TTR_2 operating as frequency trebler in a manner which will be described later. The output circuit of this system comprises a transformer 21 whose secondary is connected to the grid circuit of an amplifier valve AMP_7 by means of a potentiometer 22, 23, 24, the two latter elements forming a part of a circuit for elimination of the fundamental frequency, which circuit comprises also the resonant series circuit 25.

The operation of the system TTR_1, TTR_2, and its associated circuits will now be explained.

Certain types of frequency doubling or trebling devices are known, each having advantages and disadvantages. The device hereinafter described permits either an oscillatory voltage of double the frequency of the applied oscillation, or an oscillatory voltage of treble frequency superposed on an oscillatory voltage of the applied frequency to be obtained and in both cases with a low percentage of undesirable harmonics. Moreover, a similar device permits the collecting in two separate circuits of the oscillation of double frequency and that of treble frequency mixed with that of initial frequency, means being indicated for effectively sorting these tensions and eliminating the undesirable ones. Finally another feature of the system consists in the fact that the operation as frequency doubler or trebler is not theoretically changed by a variation of the applied oscillatory voltage.

The device comprises two electron valves as similar as possible, each comprising at least one cathode, one grid and one anode and whose grids at any moment receive oscillatory voltages which are equal and of opposite sign. If the device is employed as frequency doubler the anodes are connected in parallel (Fig. 7) and if the device operates as frequency trebler in opposition (Fig. 8). On these figures, the letters bearing the subscripts 1, 2, 3 represent the oscillatory voltages of the various frequencies. The grid and plate characteristic of each of the two electron valves must be chosen or adjusted in a manner which will be clear from the following:

Assume a simple harmonic oscillatory voltage of amplitude A and angular frequency p:

$$u=A \sin pt \qquad (1)$$

Assume a further oscillatory volage v of amplitude B, and angular frequency $2p$ represented by

$$v=B\ (1-\cos 2pt) \qquad (2)$$

The elimination of sin pt between these two equations gives

$$v=\frac{2B}{A^2}u^2 \qquad (3)$$

Now considering an electron valve having a characteristic represented by the Equation 3 where u represents the grid voltage and v the plate current, the curve C_1 of Fig. 6 represents such a characteristic, plotted with u as abscissa and v as ordinate. The sinusoidal curve S, given by $u=A \sin pt$, is plotted also with u as abscissa, about a time axis which forms an extension of the v axis of curve C_{10}. This curve S represents the variations of grid potential of the valve which has the characteristic C_1. For the moment only the positive variations of u will be considered. There corresponds to each point of the positive branch of this curve a point of the plate current which is obtained in the usual manner by reading

the proper value from the characteristic C_1. There is thus derived for a half-wave of S, the half-wave A, B, C, representing the variation of the plate current. The negative half-waves of S do not correspond to any variation of the plate current, the grid being too negative. If these half-waves are applied inverted to a valve of identical characteristic to C_1, however, the latter valve will be active during the idle periods of the first. Thus a current will be produced in the plate circuit of the second valve of the same value as in the first, but whose phase will be lagging behind that of the current of the first valve. Now, the variations of grid potential in the two associated valves can be obtained by suitably connecting their grids in opposition and their plates in parallel as indicated in Fig. 7. We thus find in the circuit of the resistance R the two half-waves mentioned. The resulting wave in an outer circuit will have the form A, B, C, D, E, and the equation representing these half-waves as a function of u is precisely the Equation 2.

Now assume an oscillatory voltage w, of amplitude C, represented by the function:

$$w=C\left(\sin pt-\frac{1}{3}\sin 3pt\right) \qquad (4)$$

The elimination of sin pt between the Equations 4 and 1 gives the relation:

$$w=\frac{4C}{3A^3}u^3 \qquad (5)$$

Assume an electron valve having a characteristic C_2 represented by the Equation 5, u being the grid voltage and w the plate current. Curve C_2 of Fig. 6 represents this characteristic plotted similarly to curve C_1. The application to the grid of such a tube of the positive waves of voltage $u=A \sin pt$ as shown in curve S will determine variations of plate current which result immediately from the curves S and C_2, and can be represented by a curve such as A', B', C'.

As for the previous case, by associating a second valve of characteristic identical with the first, it is possible to obtain in this plate circuit under the action of the negative half-waves of grid voltage, a half-wave C', D', E' identical with A', B', C'. If the grids are connected in opposition and the plates also connected in opposition, as shown in Fig. 8, on the terminals of the double resistance R', a voltage will be obtained whose variation can be represented by the Equation 4. Characteristics such as C_1 and C_2 can be obtained quite exactly with valves of commercial type by choosing a negative polarisation almost cancelling the plate current with the grid at normal.

It will be seen that for any suitable choice of the values of the coordinates, the two characteristics can differ only a little, that is to say, the values of v and w corresponding to the same value of u, are fairly adjacent. Under these conditions, the application to the grids of the two associated valves of the tension of u, would cause to appear in the plate circuits a complex wave, which if the plates are connected in parallel will practically correspond to the Equation 2 and, if they are connected in opposition, to the Equation 4. The use in the plate circuits of a differential transformer as shown in Fig. 9 permits the collection, in the common return, of the wave whose angular frequency is $2p$, and on the secondary of the transformer the waves whose angular frequencies are p and $3p$.

Fig. 9 illustrates a practical embodiment of a device supplying the three frequencies indicated above and further comprising a corrector of amplification and two different frequency selecting devices. The first, represented in the branch common to the two anodes, consists of two tuned circuits L_2, C_2 and L'_2, C'_2 loosely coupled by means of a resistance R_2 of high value. The second, effectively connected between the two anodes by means of the secondary of the transformer T_2, comprises two resonant circuits in parallel, one L'_1, C'_1 tuned to the fundamental frequency, the other L'_3, C'_3 to the treble frequency. Each of these circuits is connected as in the first case by means of a high resistance R_1 or R_3 to the point common to the inductance and condenser of the corresponding one of the resonant circuits L_1 C_1 and L_3 C_3 tuned to the same fundamental or treble frequency. If necessary, a coupling condenser, such as C_4 can be placed in series with the coupling resistance R_2 in order to stop the passage of the direct current in this tuned circuit.

In the case in which the real characteristics of the valves are pratically the same as the characteristics C_1 or C_2 previously defined, it results from the Equations 4 and 5 that if the amplitude A of the voltage of fundamental frequency varies, the form of the oscillatory voltage v (or w) as a function of time is not changed, but only its amplitude varies. As the current passing through the common return path of the two anodes comprises a direct current component which is a function of the amplitude, it is possible to utilise this component in order to control an amplification correcting device acting on a valve preceding the frequency doubler or trebler and thus to obtain oscillatory voltages of fundamental, double and treble frequency of constant value. Finally, if the applied oscillatory voltage varies only slightly or is already stabilized, the grids can be self-biased.

At the receiving station, whose circuits are shown in Figs. 3 and 4, the coupling with the line is effected by means of a special transformer similar to the transformer 15 and an amplifier similar itself to the output amplifier already described and intended to give a suitable level in order to drive the demodulator. This amplifier, moreover, comprises an equalising circuit, compensating the inequality of the transmission losses of the cable for the various frequencies. This amplifier, not shown in Fig. 3, has its output circuit, coupled to drive the grid of the demodulator valve MOD_3 of the demodulator. This demodulator is similar to the second modulator of the output circuit, but further comprises a feature permitting the practical elimination of the demodulation current from the demodulation products collected at the output of the demodulator. This feature consists in the use of two valves of identical construction; the valve acting as demodulator MOD_3 acts exactly like the demodulator valve MOD_2 of the output circuit; the other BAL is a balancing tube whose control grid 26 is connected to earth and whose suppressor electrode is driven in phase opposition with respect to that of the demodulator valve MOD_3. The plates of the demodulator valve MOD_3 and of the balancing valve BAL are connected in parallel through coupling condensers 27 and 28. In order to obtain the most perfect balancing possible, the common point of the circuits of the plates is connected to the moving plate 29 of a compensating condenser, whose fixed plates 30 and 31 are connected to the two opposite ends of the secondary of the trans-

former for the supply of demodulation current 32. The middle point of the secondary of this transformer is connected to earth through a condenser 33, of negligible reactance at the frequency of the demodulation current. Moreover, the cathode circuit of the balancing valve BAL contains a variable resistance 34 permitting the demodulation current to be cancelled in the output circuit of the demodulator.

In order to permit certain adjustments to be effected, a switching device 35 has been provided which permits the complete circuit of the balancing valve to be replaced by an equivalent resistance 36 so as to be able to test the operating characteristics of the modulator valve without interference from the balancing effect of the balancing valve. It is actually necessary to unbalance in this manner in order to be able to determine in a correct manner the value of the demodulation voltage applied to the suppressor electrode.

The output filter is similar to the filter of the first modulator. It comprises a high pass filter 37 and a low pass filter 38 connected to each other by a resistance attenuator 39.

The oscillator serving for the demodulation by the demodulation system which has just been described, is quite similar to the second oscillator of the output circuit and also comprises a quartz-controlled oscillator valve OSC_3, a couple of valves TTR_3 and TTR_4 operating as frequency trebler as for the output oscillator, followed by an amplification valve AMP_8 whose output circuit is connected to the transformer 32, which transmits the demodulation current to the demodulator system described.

The only difference between the input oscillator and the output oscillator consists in the fact that the tuned secondary of the output transformer of the frequency trebler system is connected to the grid of the amplifier valve AMP_8 by a resistance 52 composing with the anti-resonant circuit 52' a potentiometric device which at the same time exercises a selective action upon the modulation frequency.

The intermediate amplifier which follows the filter 38 is intended to provide a sufficient signal level on the grid of the detector. This amplifier comprises four stages, giving a gross amplification of about 70 decibels in the band of 3200 to 5200 kc. transmitted.

It is equipped with valves having a high slope characteristic with the smallest possible inter-electrode capacities.

The parts of the inter-coupling circuits have been chosen and arranged by actual experiment so as to reduce the parasitic capacities to the strict minimum. The harmful influence of the latter on the transmission of the high frequencies has been cancelled by the use of inductances 40, 41, 42, 43 placed in series with coupling resistances, 44 to 47, inserted in the anode circuits of the four valves of the amplifier.

Finally, recoupling circuits of high attenuation have been introduced into the circuits feeding those valve electrodes which carry a high potential.

The circuits are composed of resistances such as 48, 49 for the first stage, placed in series, and of condenser such as 50, 51 connecting the common points of the two resistances of each pair to earth; these condensers and these resistances are determined so as to obtain a sufficient attenuation between the circuits connected to the electrodes and the feed circuits so as to avoid reactance between stages which is all the more harmful the higher the amplified frequency and the gain.

The output detector and amplifier circuits are shown in Fig. 4.

The detection is effected by virtue of a curved plate characteristic of a valve DET, this characteristic being of as parabolic a shape as possible so as to avoid the creation of harmonics for grid swings of several volts. The required negative grid bias may in particular be obtained by a drop of potential in the resistances 54 and 55 inserted in the return of the anode circuit of the rectifier feeding the detector DET and the amplifiers AMP_{13} and AMP_{14} of television signals which follow it. An extremely strict filtering of the negative tension of grid polarisation is necessary and is obtained by means of successive resistances 56 and 57, by-passed to earth by condensers 58 and 59.

In view of the fact that the television signals comprise extremely low frequencies of the order of several periods per second, it is necessary in all the circuits of the detector and of the amplifier to carry out extremely careful filtering so that no interference frequency or its harmonics can be transmitted to the electrodes of the valves of the detector-amplifier unit.

The condensers 60 and 61 and the resistances 62 and 63 placed in the plate circuit of the detector are calculated so as to ensure transmission without distortion of phase or amplitude of the low frequencies down to a predetermined minimum frequency. One difficulty in transmitting frequencies of the order of several periods per second is due to the fact that the coupling capacity 64 between the plate of the detector and the grid of the amplifier valves must be relatively high in order to pass a very low frequency while offering an extremely low capacity with respect to earth in order not to shunt unduly the circuit for the high frequencies of the order of 1 and 2 megacycles. Moreover, it is possible to employ no condenser between the detector and the amplifiers and this would have the advantage of transmitting the continuous component of the television signals on the condition of employing suitable feed tensions for the electrodes of the amplifier valves.

The two amplifier valves AMP_{13} and AMP_{14} are used in parallel so as to obtain without transformer, a sufficient voltage on the input of the outgoing cable, whose impedance is of the order of 60 to 100 ohms. Nevertheless, in order to avoid the starting of ultra-short wave oscillations, it has been found necessary to introduce resistances 65, 66 in series with each of the grids of the two amplifier valves. If need be, additional capacities of the order of some microfarads could also be inserted between one of the grids and earth or between a suitably chosen point and earth. In order to reduce parasitic noises it may be well to insert a resistance in series in one of the connections connecting the high tension winding of the power transformer to one of the plates of the rectifier valve (or to the set of two plates when two valves are employed in parallel), in order to compensate the difference of resistance of the two high tension half windings, which might be a cause of transmission of 50 period current in the feed circuit of the amplifier-detector system.

Moreover, an improvement of the filtering of the power voltages is also obtained by arranging the magnetic axes of the cores of the different self inductances of filtering belonging to

different filter sections, perpendicular to each other so as to avoid couplings by magnetic induction.

It is clear that the arrangements described are not limited in their application to the transmission of signals over electric cables, but on the contrary they have a general application and in particular various arrangements described may be used either alone or in combination with other devices.

What is claimed is:

1. A modulating device comprising a thermionic tube having a plurality of electrodes including an anode, a source of signal waves applied to one electrode of said tube, a source of ultra-high frequency carrier waves applied to a second electrode of said tube and an output circuit coupled to said anode whereby output waves including carrier and sideband components are produced in the output circuit of said tube by electron discharge flow and whereby also further carrier components are transmitted into the output circuit by virtue of interelectrode capacity, and means for compensating for the passage of currents at the frequency of said carrier waves to the output circuit of said tube by virtue of interelectrode capacity whereby the resultant current in said output circuit includes sideband components and carrier components produced by electron discharge flow but is free from carrier components transmitted by virtue of interelectrode capacity.

2. A modulating device comprising a thermionic tube having a cathode, and anode and two or more grid electrodes, a source of signal waves applied to one grid, a source of ultra-high frequency carrier waves applied to another grid and an output circuit coupled to said anode whereby output waves including carrier and sideband components are produced in the output circuit of said tube by electron discharge flow and whereby also further carrier components are transmitted into the output circuit by virtue of interelectrode capacity, and means for compensating for the passage of currents at the frequency of said carrier waves to the output circuit of said tube by virtue of interelectrode capacity whereby the resultant current in said output circuit includes sideband components and carrier components produced by electron discharge flow but is free from carrier components transmitted by virtue of interelectrode capacity.

3. A modulating device comprising a thermionic tube having a cathode, an anode, a control grid, a screening grid and a suppressor grid, a source of signal waves applied to said control grid, a source of ultra-high frequency carrier waves applied to said suppressor grid and an output circuit coupled to said anode whereby output waves including carrier and side band components are produced in the output circuit of said tube by electron discharge flow and whereby also further carrier components are transmitted into the output circuit by virtue of interelectrode capacity, and means for compensating for the passage of currents at the frequency of said carrier waves to the output circuit of said tube due to the interelectrode capacity between said suppressor grid and said anode whereby the resultant current in said output circuit includes sideband components and carrier components produced by electron discharge flow but is free from carrier components transmitted by virtue of interelectrode capacity.

4. A modulating device comprising a thermionic tube having a plurality of electrodes including an anode, a source of signal waves applied to one electrode of said tube, a source of ultra-high frequency carrier waves applied to a second electrode of said tube and an output circuit coupled to said anode whereby output waves including carrier and sideband components are produced in the output circuit of said tube by electron discharge flow and whereby also further carrier components are transmitted into the output circuit by virtue of interelectrode capacity, and means for applying to the output circuit of said tube said further carrier components equal in amplitude and opposite in phase to currents passing to said output circuit due to interelectrode capacity between the electrode to which the carrier wave is applied and the output electrode of said tube whereby the resultant current in said output circuit includes sideband components and carrier components produced by electron discharge flow but is free from carrier components transmitted by virtue of interelectrode capacity.

5. A modulating device comprising a thermionic tube having a plurality of electrodes including an anode, a source of signal waves applied to an electrode of said tube, a source of ultra-high frequency carrier waves applied to another electrode of said tube and an output circuit coupled to said anode whereby output waves including carrier and sideband components are produced in the output circuit of said tube by electron discharge flow and whereby also further carrier components are transmitted into the output circuit by virtue of interelectrode capacity, and a balancing condenser for applying to the output circuit of said tube currents equal in amplitude and opposite in phase to currents passing to said output circuit due to interelectrode capacity between the electrode to which the carrier wave is applied and the output electrode of said tube whereby the resultant current in said output circuit includes sideband components and carrier components produced by electron discharge flow but is free from carrier components transmitted by virtue of interelectrode capacity.

6. A modulating device comprising a thermionic tube having a cathode, a control grid and a second grid, a source of signal waves applied to said control grid, a source of ultra-high frequency carrier waves applied said second grid and an output circuit coupled to said anode whereby output waves including carrier and sideband components are produced in the output circuit of said tube by electron discharge flow and whereby also further carrier components are transmitted into the output circuit by virtue of interelectrode capacity, a balancing condenser comprising a movable armature and two stationary armatures, said movable armature being connected to said output circuit and said fixed plates being respectively so coupled to said source of carrier waves as to derive potentials in opposite phase at the frequency of the carrier waves whereby the resultant current in said output circuit includes sideband components and carrier components produced by electron discharge flow but is free from carrier components transmitted by virtue of interelectrode capacity.

7. A modulating device as claimed in claim 6 further comprising a transformer having primary and secondary windings over which said modulating waves are applied to said second grid, and wherein said fixed armatures are connected one to an end of the primary winding and the

other to the corresponding end of the secondary winding of said transformer.

8. A modulating device as claimed in claim 6, further comprising a transformer having primary and secondary windings over which said modulating waves are applied to said second grid, and wherein said fixed armatures are connected respectively to each end of the secondary winding of said transformer and the midpoint of said secondary winding is connected to earth over a condenser.

9. A modulating device comprising a thermionic tube having a plurality of electrodes including an anode, a source of signal waves applied to one electrode thereof, a source of ultra-high frequency carrier waves applied to a second electrode thereof, and an exterior connection between said second electrode and said anode comprising a condenser in series with an anti-resonant circuit the elements of which are so chosen that it behaves at the carrier frequency as a positive reactance equal in absolute value to that of the interelectrode capacity between said second electrode and said anode.

10. The method of transmitting a given wide band of signal frequencies, which comprises changing the frequency of said band to form a second band wholly above the upper limit of said given band, changing the frequency of said second band to form a third band non-inverted with respect to said given band and lying partly within the frequency range of said given band, transmitting said third band to a remote point and deriving therefrom a band of frequencies equal to said given wide band of signal frequencies.

11. The method of transmitting a given wide band of signal frequencies which comprises producing a first oscillation of higher frequency than the upper limit of the given band, modulating said oscillation with said given band to produce a first carrier equal in frequency to said first oscillation and a lower side band wholly above the upper limit of the given band, producing a second oscillation whose frequency exceeds the frequency of the first oscillation by a predetermined number of cycles per second which is substantially less than the upper frequency limit of the given band, modulating said second oscillation with said first carrier and lower side band to produce a second carrier whose frequency is equal to said predetermined number of cycles per second and an upper side band lying above said second carrier, transmitting said second carrier and upper side band to a remote point, and deriving from said second carrier and upper side band a wide band of frequencies equal to said given wide band of signal frequencies.

12. The method of transmitting a given band of signal frequencies which comprises producing an oscillation, modulating said oscillation with said given band to produce a carrier and two side bands, suppressing that part of one of said side bands which lies remote from the carrier, changing the frequency of the unsuppressed part of said one side band and of the carrier and of the whole of the other side band to produce a new carrier whose frequency is lower than the upper limit of the given band and a new complete side band lying above and a new partial side band lying below said new carrier, transmitting said new carrier and new side bands to a remote point, and deriving from said new partial and complete side bands and said new carrier a useful band of signal frequencies equal to said given band, whereby the lower part of said useful band includes energy derived from both side bands and the upper part of said useful band includes only energy derived from one of said side bands.

13. A system for transmitting a given wide band of signal frequencies which comprises a source of high frequency oscillations, electronic discharge modulation means for deriving from said given wide band and said oscillations by electron discharge flow a set of modulation products including two wide side bands and a carrier wave of the same frequency as said oscillations, said modulation means having inherent capacity which passes a harmful amount of said oscillations directly into said set of modulation products to form an undesired component having the same frequency as but a different phase from said carrier wave, means for neutralizing said undesired component, means for transmitting said carrier wave and one of said side bands to said remote point, and demodulation means for deriving from said transmitted carrier and side band a set of demodulation products which include a wide band of frequencies equal to said given wide band of signal frequencies.

14. The method of transmitting to a remote receiving station a given wide band of signal frequencies which comprises shifting said band to such a position in the frequency spectrum that the lower limit of the shifted band lies intermediate the upper and lower limits of the given band, while maintaining the various frequencies of the shifted band in the same order as the corresponding frequencies of the given band, transmitting said shifted band to said remote receiving station, thereafter raising said band to a higher position in the frequency spectrum at said station, amplifying said band while at said higher position in the frequency spectrum, and finally at said same station shifting said band to the same position in the frequency spectrum as said given band.

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