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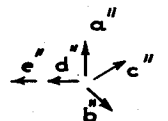
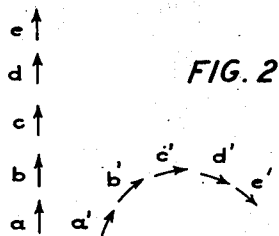
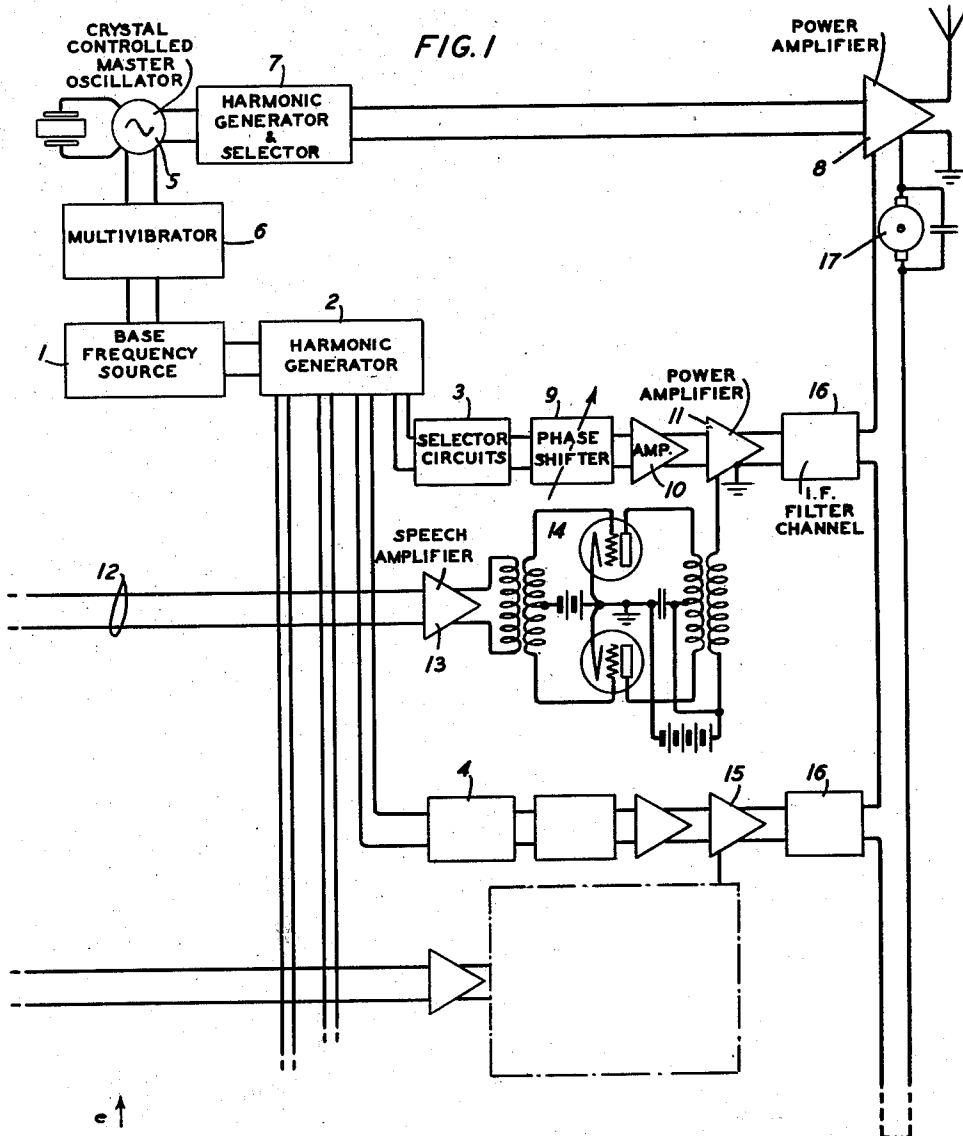
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2,028,212

RADIO TRANSMITTING SYSTEM

Filed Dec. 22, 1933

3 Sheets-Sheet 1



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2,028,212

RADIO TRANSMITTING SYSTEM

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FIG. 3

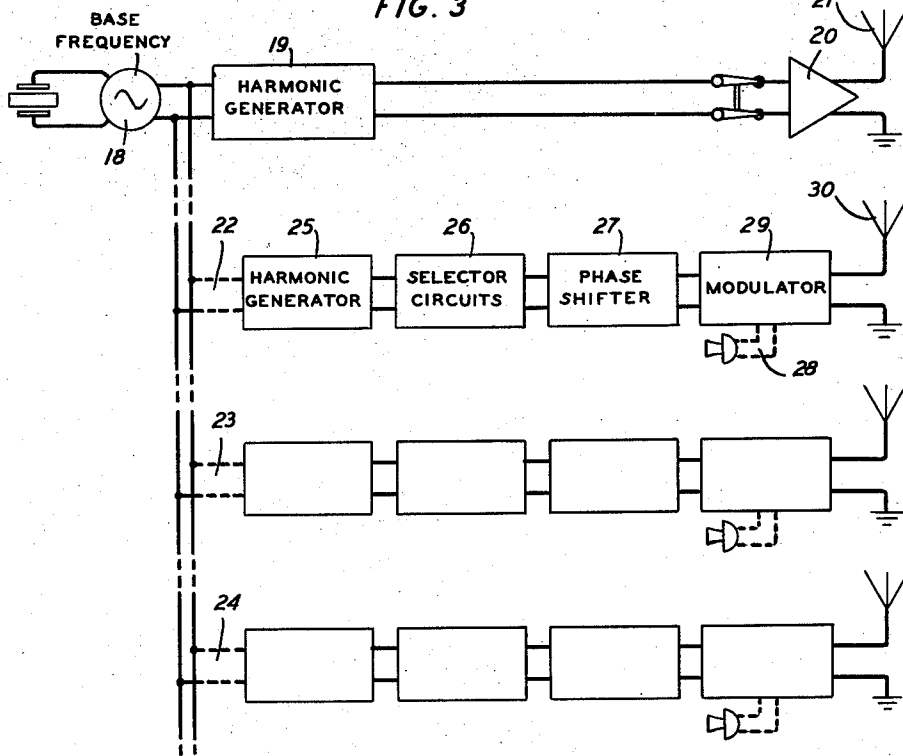
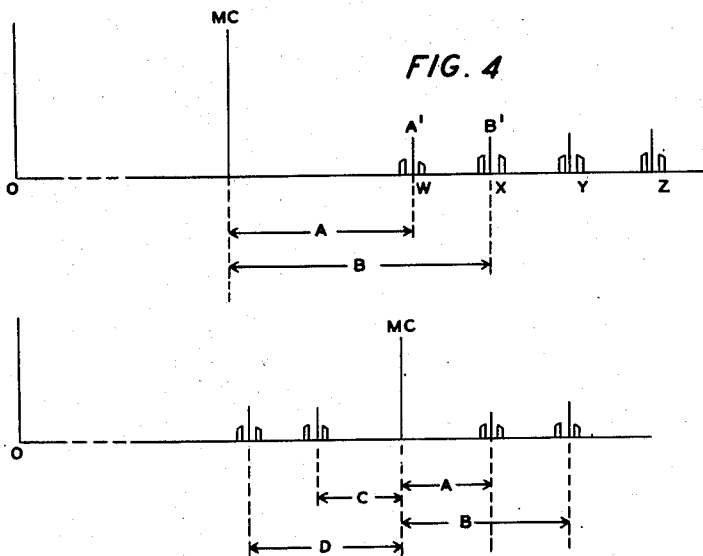


FIG. 4



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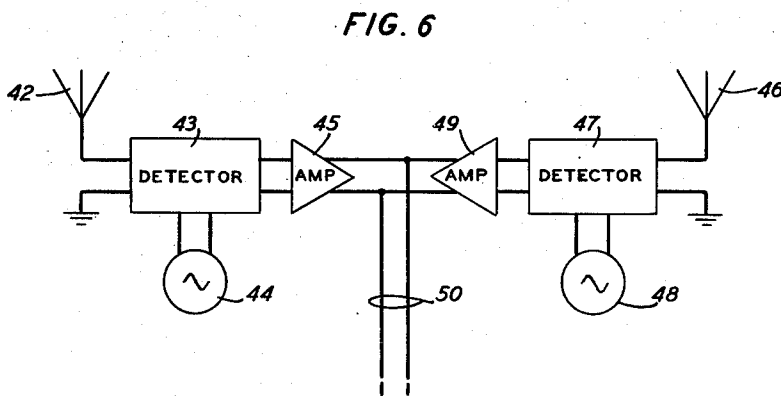
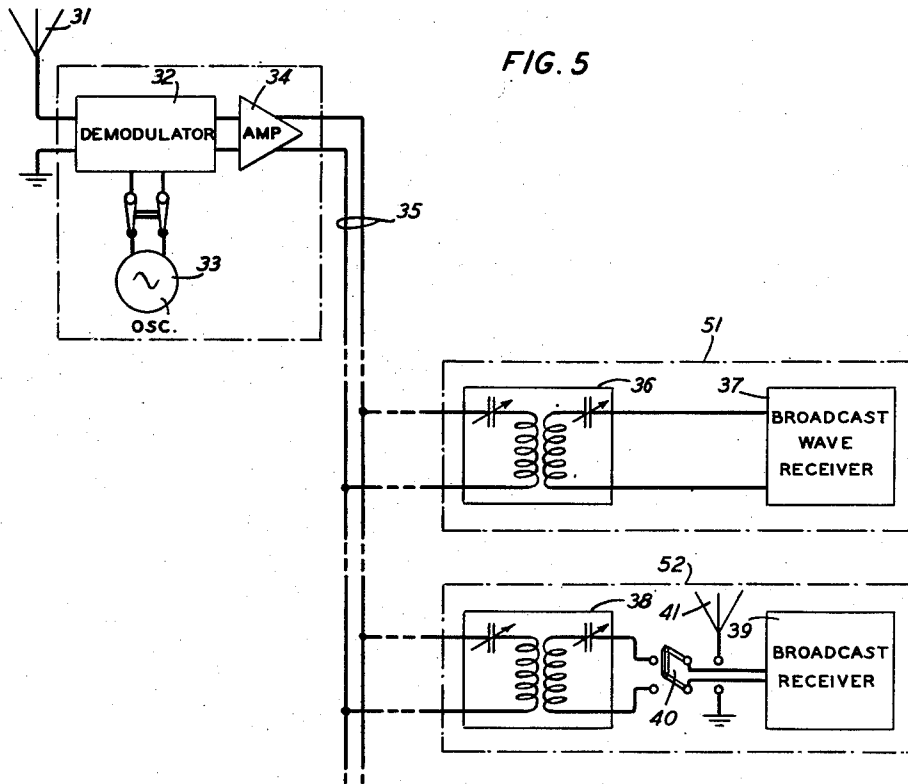
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RADIO TRANSMITTING SYSTEM

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3 Sheets-Sheet 3



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RADIO TRANSMITTING SYSTEM

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9 Claims. (Cl. 250—9)

This invention relates to radio broadcasting systems employing very short waves and, in particular, to efficient transmitting and receiving circuits for such systems.

A feature of the invention is a system in which a plurality of related frequency carrier waves are relatively so phased as to permit the use of a common final amplifier of much lower effective output than the aggregate of the peak outputs of the individual carrier waves.

Another feature of the invention is a receiving system for distributing multiplex short wave broadcast transmitters to broadcast receivers at apartment houses by the use of unmodulated locally generated short wave oscillations which are caused to interact with the received short waves to produce modulated beat frequency waves within the usual broadcast range thus enabling very short wave broadcast programs to be effectively handled by the local broadcast frequency distributing network of the apartment house.

In accordance with the invention, a plurality of carrier waves lying within the present-day broadcasting frequency range are each modulated by a broadcast program or transmission individual thereto. These carrier waves which are preferably produced as harmonics of the same base frequency oscillations so as to control their frequency spacing are given suitable relative phase displacements before being modulated. After modulation they are caused to modulate a common ultrahigh frequency carrier wave, their phase displacements serving to prevent coincidence of their peak outputs whereby the final amplifier may have a much lower power rating than would otherwise be possible.

The invention may be readily understood from the following description taken in connection with the appended drawings in which

Fig. 1 illustrates schematically the circuit of a multiplex radio broadcast transmitter;

Fig. 2 indicates the initial phase relationships of the intermediate frequency carrier waves;

Fig. 3 illustrates schematically a modification of the circuit of Fig. 1 in which in lieu of successive modulation, a separate unmodulated carrier wave is transmitted;

Fig. 4 is a diagram indicating two different arrangements of the modulating frequencies of the unmodulated and modulated carrier waves of Fig. 3, and

Figs. 5 and 6 illustrate apartment house receiving and distribution systems adapted to receive at will either ordinary broadcast transmissions or the ultrahigh frequency broadcast transmis-

sions from the transmitting circuits of Figs. 1 and 3.

Referring to Fig. 1 a base frequency source 1 produces oscillations of, for example, 10,000 cycles and supplies them to a harmonic generator 2 associated with which are a plurality of harmonic selector circuits 3, 4, etc. each designed to select an individual harmonic of the base frequency wave falling within the ordinary broadcast range. The harmonic generator 2 and the selector circuits 3, 4, etc. may be of well-known types. The base frequency source, although not necessarily so limited, is illustrated as connected to a prime source of ultrahigh frequency waves 5 through a frequency divider or sub-harmonic generator 6 of the multi-vibrator type. Such ultrahigh frequency sources and frequency dividers are well known in the art. The high frequency source 5 which is preferably a vacuum tube oscillator controlled by a piezo electric crystal has an output circuit connected to a harmonic generator and selector 7 which serves to derive and impress ultrahigh frequency waves upon the input circuit of a power amplifier 8. These ultrahigh frequency waves may, for example, be of the order of 30 megacycles or higher.

Each harmonic selector circuit 3, 4 is associated with an individual broadcast channel and since these channels are alike except for the carrier frequencies and the fact that they do not transmit the same program a description of one will suffice for each. Selector circuit 3 selects an appropriate wave within the ordinary broadcast band as, for example, one megacycle and impresses it upon a phase shifting network 9 of well-known type which is variable to permit adjusting the amount of phase shift as may be desired. After undergoing phase shift the oscillations are impressed upon an amplifier 10 and the amplified oscillations are supplied to an intermediate frequency amplifier 11. A program or speech input circuit 12 is associated with amplifiers 13 and 14, the output circuit of the latter of which is inductively connected to the plate circuit of amplifier 11 in accordance with the well-known plate modulator amplifier circuit of U. S. Patent to Heising, No. 1,823,322 issued September 15, 1931, whereby the one megacycle oscillations are modulated by the amplified program currents from circuit 12. In similar fashion the intermediate frequency carrier wave supplied to intermediate amplifier 15 is modulated by the program or other currents of its respectively associated speech or program input circuit.

The modulated intermediate frequency waves

produced in the output circuit of amplifier 11 are transmitted through a band pass filter 16 and impressed, in series with the plate supply emf. derived from source 17, on the plate circuit of power amplifier 8. In like manner each of the other modulated intermediate frequency waves is impressed through its respective band pass filter 16 on the series plate circuit of power amplifier 8. The band pass filters 16 serve to confine the modulated wave bands which they respectively transmit to their appropriate ranges eliminating any harmonics or other components which might fall in the range of and interfere with any of the other intermediate frequency bands. They also exclude bands from other channels from the plate circuits of their respective intermediate frequency power amplifiers, thus preventing undesired intermodulation which might result in cross-talk or interference between two different program channels. Accordingly, oscillations of the extremely high frequency produced by the harmonic generator 7 are simultaneously modulated in the modulating amplifier 8 by all of the modulated intermediate frequency carrier waves. These modulated high frequency oscillations are transmitted in the usual manner to an antenna or a transmission line.

In Fig. 2, certain phase relationships of the unmodulated carrier waves are illustrated. Assuming that the various intermediate carrier frequency waves originated as harmonics of the same fundamental frequency wave, it will be apparent that at a particular instant the maximum of the fundamental wave will coincide with the maxima of each of the harmonics. At that instant, therefore, the phase relations of the various harmonics selected as intermediate frequency carrier waves may be represented by the vectors of the diagram at the left of Fig. 2. The power which the aligned vectors represent at that instant is proportional to the square of their vector sum or twenty-five times the power which would be represented by each vector alone. The power capacity of the amplifiers which this condition would make necessary is very high. It is accordingly highly desirable that the condition represented by the left-hand diagram of Fig. 2 never occur and that the possibility of any condition approximating it be precluded, if possible.

Consider the conditions at a later time assuming that the vectors a , b , c , d , and e represent respectively the 10th, 11th, 12th, 13th, and 14th harmonics of the base frequency. The expression 11th harmonic is used here as connoting the harmonic whose frequency is eleven times that of the base frequency. When a has shifted from its starting position through any given number of cycles to the position a' as indicated in the second diagram of Fig. 2, b will have shifted to a position b' in which the angle of vector b' is such that the total angle through which the vector has swept will be related to that traversed by vector a by the ratio of 11 to 10. Similarly, vectors c , d , and e will have advanced to positions c' , d' , and e' determined in the same fashion. The total angle of advance of each vector will be directly proportional to its frequency. It will, therefore, be appreciated that in a system of waves of frequencies harmonically related to the same base frequency wave the condition for periodic phase coincidence of all of the wave maxima is that at any instant their individual relative phase angles are such with respect to an arbitrary initial point that each is proportional to the frequency of its respective wave. Since, for harmonically related

waves these two conditions of periodic phase coincidence and proportionality of phase to frequency are inseparable it follows that periodic phase coincidence may be avoided by imparting to the harmonically related waves arbitrary initial phases related in some random manner departing widely from that of proportionality to frequency.

Stated somewhat differently the relationship between phase of vectors and their frequencies is such that if this left-hand diagram represents what occurs at one instant, the middle diagram represents what will occur at some later instant and there will be found at all times an orderly arrangement of phase of vectors with respect to their frequency. To prevent the situation portrayed by the left-hand diagram from ever occurring, we must set up as an initial condition a disorderly relation of phase angle with respect to frequency which is what is shown in the third diagram of Fig. 2. Once a disorderly arrangement is set up, the phase agreement of all the vectors as illustrated in the left-hand diagram will never occur. From another viewpoint, a random phase arrangement of the various vectors is what is desired.

Referring again to Fig. 2, the third diagram shows one arbitrary phasing of the components in accordance with the present invention. Assume that the vectors a , b , c , d , and e as generated were in phase coincidence at their maxima as indicated in the first diagram. Suppose that the 10th harmonic vector a be utilized in its position of a'' as generated. The 11th harmonic b may be advanced 135° to b'' . The 12th harmonic c may be advanced 45° to c'' . The 13th and 14th harmonics may both be advanced 270° or what is the same thing retarded 90° . It will be apparent that this arbitrary phasing so departs from frequency proportionality that the condition essential to maximum amplitude coincidence is avoided. Moreover, it will be apparent that the sum of the vectors a'' , b'' , c'' , d'' , and e'' is very much less than the sum of their individual magnitudes and, in fact, much less than the sum of two aligned vectors such as d'' and e'' . Assuming a base frequency of 10,000 cycles the phase relationship of vectors a'' , b'' , c'' , d'' , and e'' indicated in the third diagram will recur periodically ten thousand times each second, but will not impose an inordinate load upon the common amplifier.

The relative phasing between carrier waves when these carrier waves are produced in a harmonic series is important in carrier current systems if the unmodulated carrier wave is transmitted together with the sideband or sidebands. This same type of disorderly or random phasing is desirable if several carrier wave channels are provided over a wire line as would be the case if the several channels in Fig. 1 delivered their power through filters 16, 16 etc., to a carrier transmission line rather than to amplifier 8.

The technique of imparting desired phase shifts to single frequency waves and the circuits employed for that purpose are so well known in the art as to require no description.

In the circuit of Fig. 3, the base frequency oscillator 18, preferably a piezo electric controlled electron discharge device, is associated with the harmonic generator 19 and power amplifier 20 from which ultrahigh frequency oscillations are supplied to antenna or transmission line 21 to be radiated in unmodulated form. The same base frequency oscillator 18 supplies base frequency

oscillations over a number of lines 22, 23, 24, etc. to remote broadcasting stations each comprising a harmonic producer 25, a selector 26, a phase shifter 27, a speech input circuit 28, a modulator 29, and antenna 30. In this circuit each transmitting channel or station modulates ultrahigh frequency waves by speech frequency currents rather than by modulated intermediate frequency waves as in the system of Fig. 1. Unmodulated ultrahigh frequency waves radiated from antenna 21 and the different frequency modulated waves radiated by the antennae 30 of the various stations are preferably separated by not more than the usual broadcasting carrier frequency. Moreover, oscillations from antenna 21 are of relatively very high power. Consequently, at any receiving station, the first demodulator will receive a large amplitude unmodulated frequency wave from antenna 21 and a plurality of differently modulated carrier waves of much smaller amplitude and for the waves received from each broadcasting station will yield an ordinary broadcast frequency modulated wave as a result of the interactions which occur between the unmodulated and modulated received waves. If, for example, the unmodulated wave received from antenna 21 is 30 megacycles and the modulated carrier wave received from the first antenna 30 is of 31 megacycles, the first demodulator will produce a correspondingly modulated difference frequency wave of one megacycle.

Inasmuch as the various intermediate frequency waves resulting from the detection of the principal carrier wave of Fig. 1 are so phased as to avoid coincidence of their maxima there will be less tendency for the intermediate frequency amplifier of the receiver to become overloaded and to cause intermodulation with resultant cross-talk. The same fact is true with respect to the ultrashort wave amplifiers used in receiving systems cooperating with the ultrashort wave transmitting antennae 30 of Fig. 3 if two or more of the radio transmitting channels are located at the same point. To meet that condition phase shifters 27 may be provided, these phase shifters being constructed and adjusted in similar fashion to so relate the phases of the various carriers that phase coincidence of their maxima does not occur.

Fig. 4 shows diagrams of two arrangements of carrier frequencies which may be used in the system of Fig. 3. In the first diagram the abscissa of the first vertical line at MC indicates the frequency of the main unmodulated carrier wave transmitted from the antenna 21 and the abscissae of W, X, Y, Z, etc. those of the modulated carrier waves A', B' from the other stations with their associated program side bands. The modulated intermediate frequency waves resulting after the first demodulation are represented by the lengths A, B, etc. The second diagram illustrates conditions when the main carrier is positioned in frequency intermediate the modulated carrier waves thus permitting spacing between the modulated waves to be larger while at the same time enabling the desired intermediate frequencies to be obtained.

A schematic diagram of a receiver suitable for use in conjunction with the transmitting system of Fig. 1 is illustrated in Fig. 5, in which a receiving antenna 31 is connected to a detector 32 with which is associated a local ultrashort wave oscillator 33. This apparatus may be placed on the roof of an apartment house to convert the very short wave program transmissions to the or-

dinary broadcast range by the well-known principle of interaction employed in superheterodyne circuits and to amplify them by means of amplifier 34 before impressing them upon the apartment house distributing network comprising the shielded distributing leads 35. In one apartment 51 a variable selecting device 36 is shown associated with the broadcast receiver 37 which may be of ordinary type. In another apartment 52 a similar variable selector 38 and broadcast receiver 39 are provided but an intermediate switch 40 is included in the circuit to permit the receiver 39 to be switched from the distribution system 35 to an ordinary broadcast frequency antenna 41, at will. This system economizes with respect to the special detecting and amplifying equipment required for the extremely high frequency program waves and, also, avoids the difficulty of distributing ultrahigh frequency waves over the apartment house distributing system. The same system may be used for receiving from the transmitters of Fig. 3 by disconnecting the local oscillator 33 or by disconnecting amplifier 20 and antenna 21 at the transmitter.

Fig. 6 illustrates an alternative system in which the ultrahigh frequency waves extend over a greater range than ordinary broadcast programs. To meet this situation, the range of the high frequency programs is arbitrarily divided into two lesser ranges, each of which is handled by an individual ultrahigh frequency converting unit. One unit comprises an antenna 42, detector 43, oscillator 44, an amplifier 45. The other unit comprises an antenna 46, detector 47, oscillator 48, and amplifier 49. Except for the frequencies involved each of these units resembles the units 31, 32, 33, 34 of Fig. 5. Each unit supplies broadcast program waves converted to the ordinary broadcast range to the distribution system 50 which corresponds in every respect to the distribution system 35 of Fig. 5.

What is claimed is:

1. A multiplex system for transmitting signals comprising a plurality of channels, a power amplifier common thereto and means for applying to each of said channels signals of a frequency individual to the respective channel and in such phase relationship as to cause their aggregate magnitude to remain at all times much less than the sum of their individual peak magnitudes.

2. A communication system comprising a plurality of channels, a source of carrier waves for each channel of a carrier frequency individual to the channel with which the respective source is associated, means for modulating said waves, a common amplifier connected to all of said channels to simultaneously amplify all of said modulated carrier waves, and means for maintaining an arbitrary relationship between the peak magnitudes of said carrier waves such that the sum of said peak magnitudes remains at all times considerably in excess of the aggregate of the waves applied to said amplifier.

3. In combination, a source of base frequency waves, a harmonic generator associated with said source to produce a plurality of harmonic frequency carrier waves therefrom, a plurality of channels associated with said harmonic generator and each including means for selecting an individual harmonic frequency carrier wave, and means for modifying said carrier waves in accordance with signals and for impressing them upon a common medium, said means including a power amplifier, at least one of said channels including phase shifting means for shifting the phase of

its carrier wave with respect to that produced by the harmonic generator.

4. A successive modulation system comprising an ultrashort carrier wave source, means for modulating waves produced by said source by a plurality of lower frequency carrier waves which are each of a carrier frequency different from that of any of the other lower frequency carrier waves, means for insuring that the aggregate magnitude of said lower frequency carrier waves remains at all times much less than the sum of their peak magnitudes, and means for modulating each of said lower frequency carrier waves by a signal individual thereto.

5. In a chain system of broadcasting transmitters, a control station and a plurality of widely separated radio broadcast transmitters associated with said control station, said control station comprising a base frequency oscillator, including a piezo electric crystal to control the oscillator frequency, a harmonic generator associated with said base frequency oscillator to produce an unmodulated carrier wave, means for radiating said unmodulated carrier wave, transmitting channels individual to said broadcast transmitting stations and extending to said control station, means for impressing upon each of said transmitting channels oscillations from said base frequency oscillator, each of said broadcast transmitting stations comprising a harmonic generator, a carrier wave selector, a phase shifting device and a modulator whereby a harmonic carrier wave may be produced from incoming base frequency oscillations and may be selected, properly phased and modulated.

6. A communication system comprising means for modulating each of a plurality of carrier waves of different harmonic frequencies of a com-

mon fundamental by signals individual thereto, means for transmitting the energy of said carrier waves over a common medium, and means for restricting the aggregate energy of said waves at all times to a magnitude much less than the sum of their peak magnitudes without at any time restricting their individual magnitudes.

7. A transmitting system comprising means for modulating each of a plurality of carrier waves of different harmonic frequencies of a common fundamental by signals individual thereto, means for transmitting the energy of said carrier waves over a common medium, and means for shifting the phase of the carrier waves with respect to each other to restrict the aggregate energy of said waves to a magnitude much less than the sum of their peak magnitudes without at any time restricting or diminishing their individual magnitudes.

8. A communication system comprising means for modulating each of a plurality of carrier waves of different harmonic frequencies of a common fundamental by signals individual thereto, means for transmitting the energy of said carrier waves over a common medium, and means for random phasing of the carrier waves so that the maximum value of all the carrier waves will never occur at the same instant.

9. The method of transmitting a plurality of individual carrier waves of different harmonic frequencies of a common fundamental over a common medium which comprises the step of arranging the carrier waves in random phase so that the sum of their peak magnitudes is greatly diminished without changing their individual magnitudes.

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