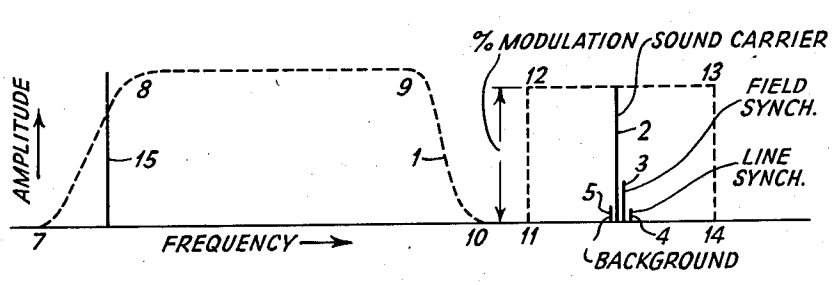
Nov. 10, 1942. A. N. GOLDSMITH 2,301,395

MULTIPLE FREQUENCY MODULATION SYSTEM

Filed Jan. 22, 1941 4 Sheets-Sheet 1

Fig. 1



SIGNAL	MODULATION FREQUENCIES	CARRIER AMPL.**	DEVIATION FACTOR	APPROXIMATE FREQ. BAND
PICTURE	30-4,500,000~	100	—	4,500,000 ~
LINE-SYNCH.	13,230 *~	5	5	140,000 *
FIELD-SYNCH.	60*~ x ½	15	5	140,000*
SOUND	50-12,000~	80	5	140,000*
BACKGROUND-CONTROL	0-20~	5	5	140,000*

*TRANSMISSION OF HARMONICS OPTIONAL

**OR % MODULATION

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Nov. 10, 1942. A. N. GOLDSMITH 2,301,395

MULTIPLE FREQUENCY MODULATION SYSTEM

Filed Jan. 22, 1941 4 Sheets-Sheet 2

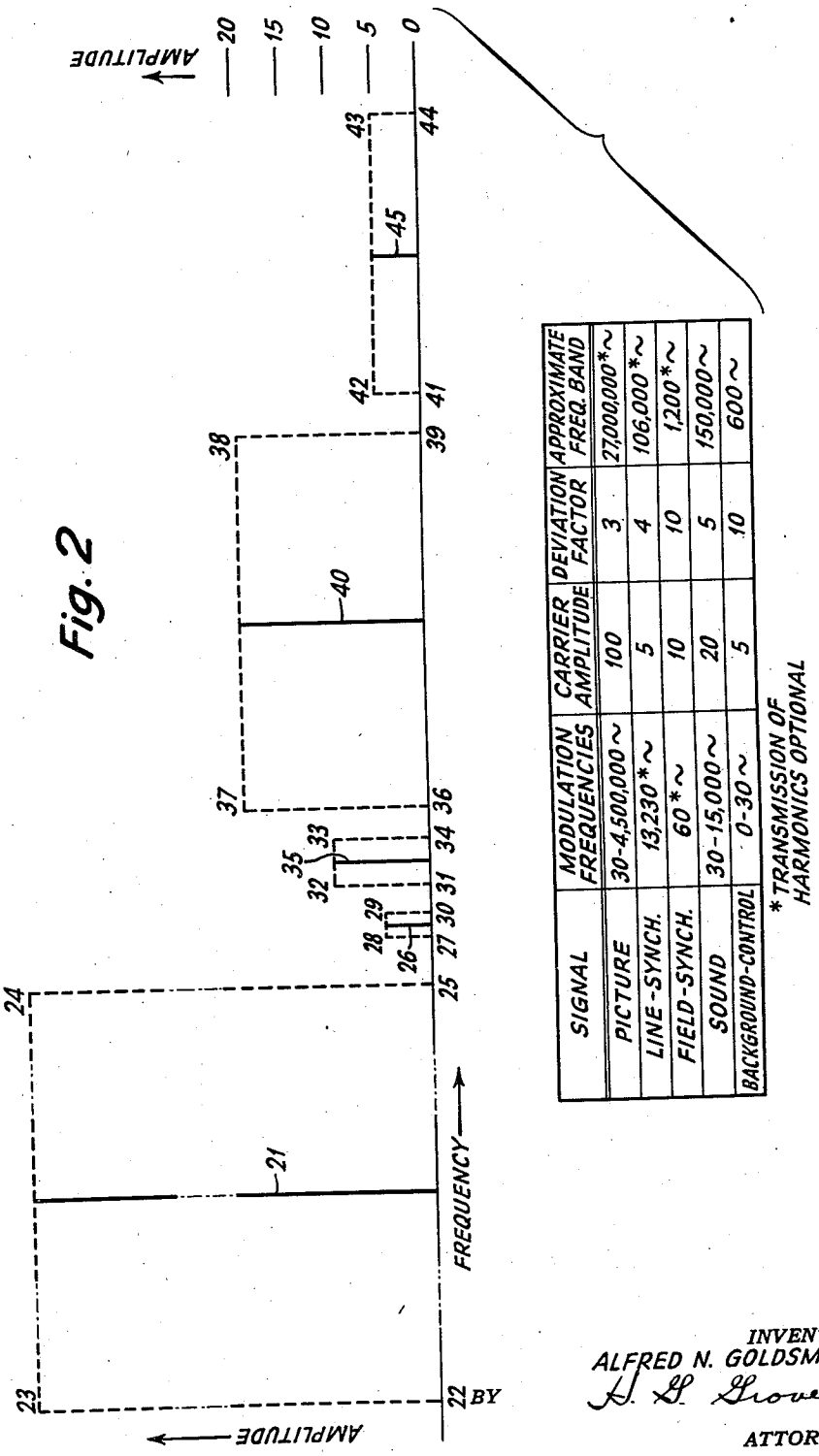


Fig. 2

SIGNAL	MODULATION FREQUENCIES	CARRIER AMPLITUDE	DEVIATION FACTOR	APPROXIMATE FREQ. BAND
PICTURE	30-4,500,000~	100	3	27,000,000*~
LINE-SYNCH.	13,230*~	5	4	106,000*~
FIELD-SYNCH.	60*~	10	10	1,200*~
SOUND	30-15,000~	20	5	150,000~
BACKGROUND-CONTROL	0-30~	5	10	600~

*TRANSMISSION OF HARMONICS OPTIONAL

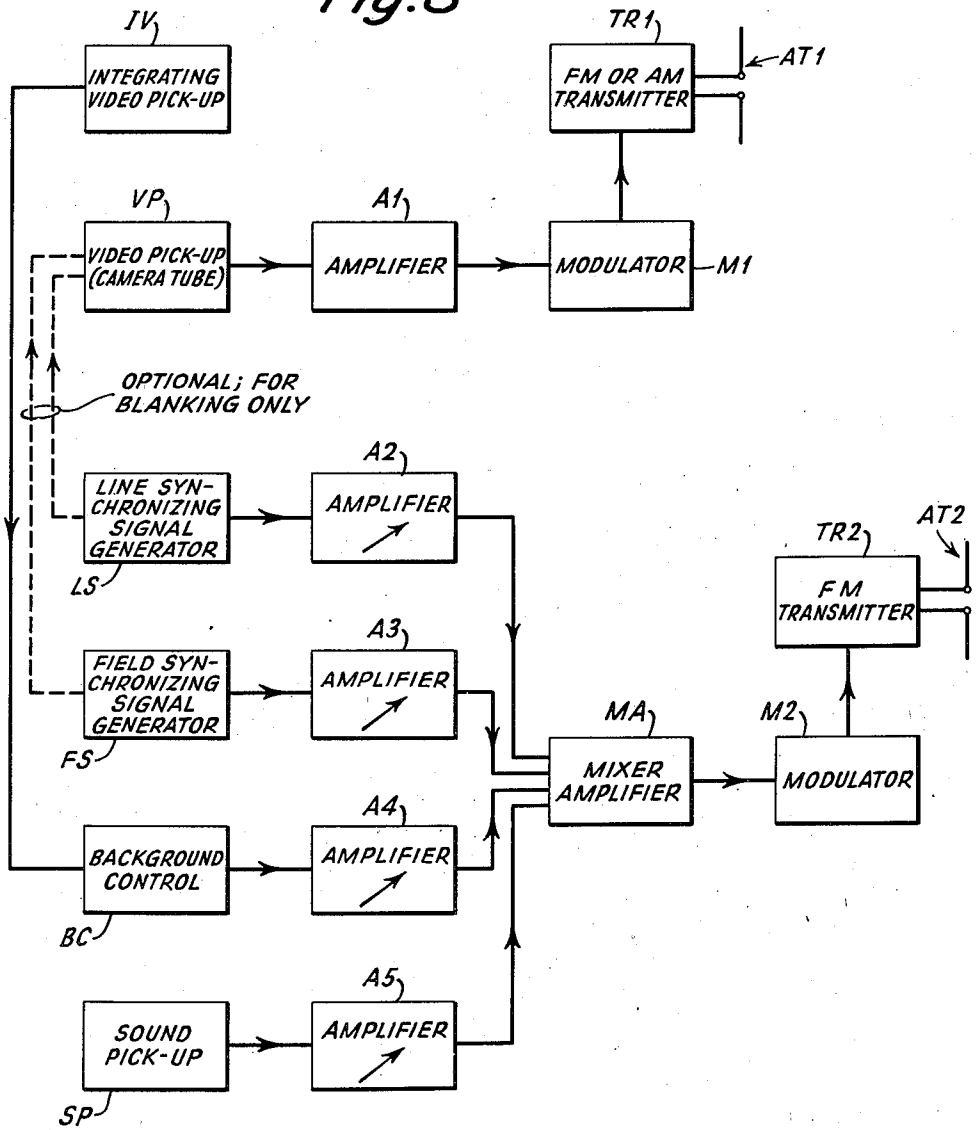
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MULTIPLE FREQUENCY MODULATION SYSTEM

Filed Jan. 22, 1941 4 Sheets-Sheet 3

Fig. 3



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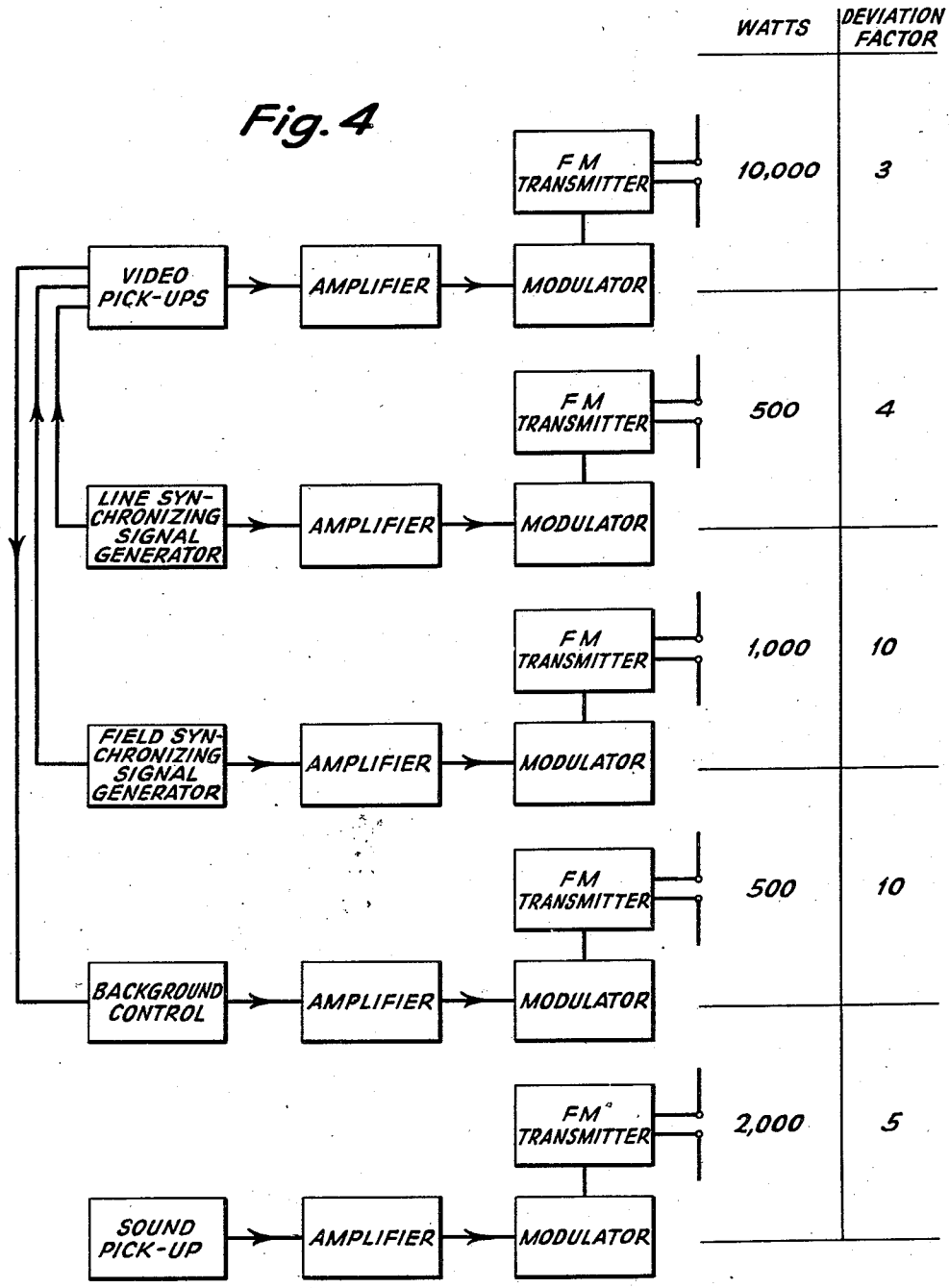
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MULTIPLE FREQUENCY MODULATION SYSTEM

Filed Jan. 22, 1941 4 Sheets-Sheet 4

Fig. 4



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UNITED STATES PATENT OFFICE

2,301,395

MULTIPLE FREQUENCY MODULATION SYSTEM

Alfred N. Goldsmith, New York, N. Y.

Application January 22, 1941, Serial No. 375,438

17 Claims. (Cl. 250—9)

My present invention deals with, and has for one of its objects, the provision of improved methods for multiple transmissions of related signals utilizing frequency modulation in whole or in part for such transmissions, and with the selection of transmission constants for most effective and reliable reception.

The invention includes the improved transmission of a multiplicity of related signals which, in general, co-act at the receiving station to form the complete received signal or signals. Further, according to this invention at least one of such multiply-transmitted signals is transmitted by frequency modulation; any or all of the remainder may be transmitted either by frequency modulation or by amplitude modulation. The invention applies equally, with obvious modification, to phase modulation or combinations of amplitude, phase and frequency modulation of any desired types.

As examples of multiple transmissions or groups of signals co-acting, as stated above, to produce the complete received signal, there may be mentioned the following (although any other types of multiple and associated signals fall within the scope of the invention):

(*a*) Telephonic transmission with indicial or auxiliary signals controlling volume expansion or contraction, audio frequency characteristic or the like;

(*b*) Facsimile transmission involving the picture or video signal, and also the indicial or synchronizing signals. These synchronizing signals may be exclusively line-synchronizing signals, or they may include as well page or sheet syncronizing signals;

(*c*) Facsimile and telephony. This multiple transmission is similar to (*b*) above except that there is an added further signal which may be, for example, speech explanatory of the facsimile pictures which are being transmitted, or music suitably accompanying such pictures;

(*d*) Television signals which include the picture or video signals, the line-synchronizing signals, the field-synchronizing signals, and the background-control signals. The last three mentioned signals herein again are the indicial or auxiliary signals;

(*e*) Television and telephony. This well known type of transmission is similar to (*a*) above except that there is an added sound signal related to and forming a part of the combined television-telephone transmission.

In each of the above illustrative transmissions of multiple signals there are various types of signals which should have, for balanced reception, equal reliability and clarity in every part of the reception, and with an equal or balanced contribution by each component signal of the multple signal group to the resulting conjoint reception. To accomplish such "balanced" reception or "balanced contribution" of each of the component signals to the final and conjoint result, each of such components should have transmission parameters adapted to the purpose. It is a feature of this invention that the selection of these parameters for frequency modulation transmissions, alone or in association with amplitude modulated transmission, shall be such as to give balanced contributions from each of the signals. The underlying reason for this is that, in a multiple reception, it is not desirable that some of the included signals shall be highly reliable while others shall be relatively unreliable in certain portions of the service area.

To be more specific, the selection of the parameters for a given signal forming one of the multiple group of associated signals is determined by considering the following characteristics of the surrounding individual signal:

(*a*) The extent or importance of its contribution to the conjoint signal. Some signals must be substantially perfectly received for satisfactory operation while others will give tolerable reception despite considerable leeway in the quality of the reception thereof.

(*b*) Sensitiveness of the received signal of a particular type to natural or man-made disturbances of reception thereof.

(*c*) Susceptibility of each type of signal to minor variations or errors in the receiving equipment constants, or changes in such constants during the use of the receiver (e. g., because of heating of the component parts of the receiver and consequent changes in their electrical constants or electrical changes resulting from variations in the voltage of the power supply).

(*d*) The inherent width of the frequency band corresponding to the modulation of the corresponding signal. For example, for a video signal the band is extremely wide, whereas for a background control signal the band is very narrow.

(*e*) The power of the transmitter for that particular signal, which corresponds in general to the corresponding carrier amplitude, the percentage of modulation, or both. In all of the following it is assumed that 100% modulation is used unless otherwise stated.

It has heretofore been customary to select the operating parameters for each of the component

signals of a multiple transmission in such fashion that the signal-to-noise ratio at the receiver was as nearly as possible the same for each of the component signals. This has been based on the assumption that the signal-to-noise ratio determines absolutely the desired utility of the signal. In the present invention it has, however, been postulated and explained that the overall reliability factor of each component signal, as herein described, is the correct criterion of the utility of that signal. Therefore, since the ideal multiple-signal circuit should have equal utility for each of the received component signals, it follows that the overall reliability factor of each of the component signals should be the same and that the circuit parameters for each of the component signals should be correspondingly chosen according to that criterion. Further, it should be noted that since the signal-to-noise ratio for each component signal is only one of the factors controlling the overall reliability factor for that signal (and sometimes by no means the most important one under practical working conditions), the operating results obtained by adopting the overall reliability factor as the criterion for selection of the component-signal circuit parameters are not only different from those which would result from considering only the signal-to-noise ratio as the criterion, but are also markedly superior in utility thereto.

From the preceding, it will be seen that among the objects of this invention is the production of maximum reliability of reception not of a single signal, but of a multiple associated group of signals arranged to co-act.

Another object of the invention is the appropriate selection of parameters for each of the individual signals of a multiple transmission to produce balanced reception whereby each of the component signals contributes an "equal" or "balanced" portion to the reception.

In this invention the parameters which are selected for the control of signal reliability and contribution are the individual carrier amplitudes and the individual deviation factors of those particular signals transmitted by frequency modulation. It is not necessary herein to discuss frequency modulation methods in detail since these are well known in the art.

To illustrate the invention more fully, there have been selected two possible methods of producing such multiple signal transmissions with balanced reception of each of the signals. The two cases herein discussed are on somewhat different bases and are:

(A) A system for multiple transmission wherein all signals must have frequency bands capable of accommodation within a specified and limited channel band width. As an example of this, the present invention has been applied to a television-telephone transmission restricted to the present 6-megacycle channels. This is set forth in Figure 1 and table 1.

(B) Systems for multiple transmission wherein there is no particular limitation to available channel width for accommodation of the required frequency bands, but wherein extreme reliability and balance of reception, as defined above, is a controlling factor. As an example of such a system, there may be selected, as illustrated in Figure 2 and table 2, a television-telephone channel in the micro-wave region occupying a channel or band width of about 30 megacycles and intended for utmost reliability of reception, either by the public or in the individual stations of a radio television relay network.

Another example of this second type of system (B) would be a micro-wave television-telephone transmission, with the pictures in full color. To anticipate slightly, it is obvious that any special indicial signals required to control color in such a transmission must have extreme reliability in order to insure precision in the color rendition. Thus, the necessity for accurate background control in black and white television transmissions is far less than the need for accurate background control in color television. Accordingly, the indicial signals related to color rendition in such a multiple transmission must have high reliability and therefore should be given either greater carrier amplitudes, higher deviation factors for frequency modulation transmission, or both. More specifically, if a tricolor additive television transmission is involved, the reliability of each of the three component color transmissions (blue, green and red, respectively) should be related to the delineatory capabilities of the corresponding color. Thus, the blue transmission controls (blue having the maximum delineatory capabilities) should be of the highest reliability, while the green transmission contributory signals (the green transmission having intermediate delineatory capabilities) may have slightly lower reliability, and the least acceptable reliability is required for the red component contributory signals (which have the least delineatory capabilities). This illustration is given to indicate the method whereby any multiple transmission is analyzed and each portion of such transmission is then given a suitable parameter, including particularly deviation factor and carrier amplitude for frequency modulation transmission, consistent with and required for its reliable reception.

As already indicated, particular examples of systems (A) and (B) above are shown on the accompanying drawings, system A being outlined in Figure 1 and table 1, and system B in in Figure 2 and table 2. Figs. 3 and 4 show schematic diagrams of apparatus employed. Each of these is, as stated, a television-telephone transmission since this affords readily a practical group of multiply transmitted component signals. In table 1 are listed under the column "signal" the five component signals. In the next column are given the ranges of modulation frequencies required for the corresponding purpose or signal. This column requires some additional explanation. While the line-synchronizing signal is derived from and has an inherent frequency of 13,230 cycles per second (in the case of the illustratively selected 441-line 60-field per second television transmission), it may or may not be necessary to transmit the harmonics of the line-synchronizing frequency of 13,230 cycles per second in order to secure the brief impulsive wave shape which is ultimately desired. Of course, alternatively an actual saw-tooth deflection wave of that frequency may be transmitted, or a pure alternating current of that frequency may be transmitted and caused to trigger an impulse generator at the receiver which controls the saw-tooth horizontal or line deflection generator. There are numerous possible variations herein, none of which affect the general basis of this invention. The field-synchronizing frequency is 60 cycles per second and similar remarks apply to the inclusion or non-inclusion of the harmonics of the 60 cycles in the modulation of the transmission. As a matter of fact, in the

example shown in table 1, all the signals except the picture signal or frequency modulated transmissions are on a single carrier and with the same illustrative deviation factor of five, but with different percentages of modulation. The picture signal itself is shown as amplitude modulated in Figure 1 and occupies the band 7, 8, 9, 10, located asymmetrically relative to the carrier frequency 15, the system being the well known vestigial side-band amplitude modulated transmission. In Figure 1, 2 represents the sound carrier percentage of modulation, 3 represents the field-synchronizing signal percentage of modulation, and 4 and 5 the line synchronizing and background control percentages of modulation. These are all relative values and should not add to more than 100% at any given time. However, in the example shown it is assumed that all four of these signals will not reach 100% modulation simultaneously and that therefore there is slight leeway available.

In the third column of table 1 are, in fact, given the corresponding carrier amplitudes (for the picture signal) or percentage of the modulation (for the other four signals).

In the fourth column of table 1 are listed the deviation factors, which are identical for the last four signals. There is, of course, no deviation factor for the amplitude modulated picture signal. The approximate frequency band required for each of the signals is as shown in the fifth column of table 1.

In Figure 1, 11, 12, 13 14 show schematically the frequency band occupied by the sound signal and the video or picture indicial signals as indicated in table 1. It will be noted that the picture indicial signals which must have a high degree of reliability to give proper line interlacing, and faithful picture reproduction, are associated with the sound carrier and transmitted by frequency modulation. This constitutes an improvement in reception results.

It is only necessary to point out finally that, in order to avoid overlapping modulation frequencies, the field frequency is not sent, but rather a field synchronizing signal of sixty times one-half or 30 cycles per second. This can be utilized at the receiver in various simple ways to produce the desired 60-cycle field frequency. Thus, a frequency doubler can be employed at the receiver or, alternatively, the 30-cycle signal can be subjected to whole wave rectification, thus making available sixty half-waves per second each of which may be used for field synchronizing purposes.

Figure 2 and table 2, forming part thereof, illustrate an example of system B referred to above. The table is self-explanatory in the light of the previous explanation of table 1. It will be noted from Figure 2 and table 2 that the method differs from Figure 1 and table 1 in that: (*a*) the picture transmission is accomplished by frequency modulation for increased reliability, (*b*) the last four signals (picture-indicial and sound signals) are each sent on their own carrier, and (*c*) each of the five signals has a selected carrier amplitude and deviation factor which is illustratively chosen to yield an approximation to "balanced" reception of the conjoint signal.

It will be noted that the exact values for the quantities in columns 3 and 4 of table 2 of Figure 2 will vary with the factors stated hereinbefore. Among other things, also, the optimum overall reliability factor will vary with the type of service as, for example, non-directional broadcasting or point-to-point directional communication.

This overall reliablity factor for accomplishing balanced reception or balanced contribution of each of the component signals to the final and conjoint result may be expressed inversely in terms of the number of failures of the circuit to function in one hour, or ten hours, or one hundred hours, or any other thoughtfully selected period. Illustratively, suppose that some form of control signal were being transmitted and that its effect normally was a perfectly definite one. Clearly, according to the preceding criterion, a circuit and its terminal equipment which gave, say, twenty failures to operate in one hundred hours would have half the "overall reliability factor" of a circuit which gave only ten failures to operate in one hundred hours of operation.

Alternatively, the overall reliability factor might be defined in terms of the ratio of the time during which the circuit was operated (for a long period of operation which would give a fair sample of all normal or even special conditions that might be encountered) to the time during which the circuit failed or was inoperative. Thus, if in one thousand hours of operation the circuit were inoperative three minutes in the aggregate, the reliability factor might be taken as one thousand times sixty divided by three, or twenty thousand. It is not necessary here to select any particular one of a number of rational and useful definitions for the overall reliability factor. The illustrative and alternative definitions given above sufficiently indicate the meaning and purpose of the term. All that is required in the choice of the operating constants of systems covered by this invention would be that the reliability factor of each of the individual signals is substantially the same. That is, there should be no more interruptions of service or functioning in a given period of time of any one of the signals listed in tables 1 and 2, forming part of Figures 1 and 2; or alternatively the ratio of operative time for any one of these signals to inoperative time of the same signal, over a long and typical period of time, should be the same for each and every one of the signals.

Reverting again to Figure 2 and table 2 forming part thereof, it is to be noted that the video carrier is swung between the frequency limits 22 and 25 so that the picture signal may be represented by the rectangle 22, 23, 24, 25. At the receiver the band pass characteristic should be chosen so as to pass not only the band of frequencies 22—25 for the picture, but preferably should be made wider; for example, by twice the highest video modulating frequency in order to take care of the side bands just outside of the frequency range through which the carrier is swung. Thus, the frequency range 22—25 of Figure 2 may not represent the exact channel employed, but merely the limits through which the video carrier frequency is swung.

Numerals 26, 35, 40 and 45 of Figure 2 represent additional carriers which are frequency modulated in accordance with the indicial signals. As illustrated, the amplitudes of these auxiliary carriers and their frequency deviations are adjusted in accordance with the principles of this invention. As indicated, the background carrier 26 is swung through a range of frequencies from 27 to 30; sound carrier 40 is given the relative amplitude shown and is swung over a range of frequencies from 36 to 39; the field synchronizing impulses are impressed on the carrier 35 which is swung in frequency over the range 31 to 34;

and the line synchronizing impulses are impressed on still another carrier **45** occupying the band of frequencies from 41 to 44. Typical relative amplitudes and frequency deviations for the system depicted in Figure 2 are outlined in greater detail in table 2 and are shown schematically (not to scale) in the drawing of Figure 2.

That is, since Figure 2 is schematic and not to scale, the relative proportions of the various rectangles are only indicative of, or roughly approximate of, the frequency and amplitude domains occupied by each of the component signals. It should be noted that **27—30** is the background control signal, and occupies about $10\times2\times30$ or 600 cycles, and has an amplitude of 5. **31—34** represents the field synchronizing signal also, and has a band width of $10\times2\times60$ or 1200 cycles (neglecting harmonics), and an amplitude of 10. **36—39** is the sound signal, and has a width of $5\times2\times15{,}000$ or 150,000 cycles, and an amplitude of 20. **41—44** represents the line synchronizing signals, and has a width of $4\times2\times13{,}230$ or about 106,000 cycles, and an amplitude of 5.

Figure 3 is a schematic diagram of transmitting apparatus operating in accordance with Figure 1 and table 1. The transmitter TR1, which sends out the video signal, may be either of the frequency or amplitude modulated type. It is noted that in Figure 1 and table 1, an amplitude modulated transmitter is specified, but the type of modulation is optional and does not affect the validity of the method described herein. The integrating video pick-up IV comprises a photocell arrangement used to measure the average brightness of the scene which is to be transmitted so that an appropriate background control system, expressive of this average brightness, may be transmitted. In Figure 3, therefore, the integrating video pick-up IV is shown connected to the background control BC.

The outputs, respectively, of the line synchronizing signal generator LS, the field synchronizing signal generator FS, the background control BC, and the sound pick-up SP (essentially a microphone) are connected to adjustable amplifiers A2, A3, A4, A5 whereby the gain of the waves fed to the mixer amplifier MA is controlled. In this way, the respective frequency deviations of the waves fed to and radiated by the antenna AT2 from the frequency modulation transmitter TR2, controlled by modulator M2, are also controlled. That is, as illustrated, the outputs of amplifiers A2, A3, A4 and A5 are passed into the mixer amplifier MA which in turn controls the modulator M2 of the frequency modulation transmitter TR2. Amplifier A1 and modulator M1 are provided, as illustrated, for the video pick-up apparatus VP.

An entirely feasible alternative method would be to have the outputs of the four amplifiers A2, A3, A4 and A5 separately modulate different small frequency modulation transmitters and the outputs of each of the four frequency modulation transmitters would then be combined with or without amplification and fed into a single antenna system. This would enable different deviation factors to be used for the four signals to be transmitted, each on their own carrier.

At the receiver, which is not shown in the drawings, there would be a conventional frequency modulation receiver which would produce in its output the four signals including the sound signal, and associated therewith. The separation of these four signals, once they were demodulated, could be accomplished either by normal band-pass filter technique, or by the usual method of heterodyning followed by intermediate frequency selection.

Each of the transmissions shown in the attached Figure 4, which corresponds in general only to Figure 2 and table 2, may or may not have the same overall reliability factor. The factors are such that improved overall reliability follows as compared to prior art systems. It will be observed that Figure 4 is somewhat similar to Figure 2, but instead of using carrier amplitudes in the ratios given in table 2, I have used carrier power in the same ratios. It will also be noticed in the example illustrated in Figure 4 that I have used high power and low deviation factor for the video or picture transmission to minimize channel width. I have used low power and a medium deviation factor for the line synchronizing signal which is not too critical and does not require ideal conditions for a high overall reliability factor. I have used higher power, and exceptionally large deviation factor, for the field synchronizing signal inasmuch as precision of line interlacing in the resulting picture requires nearly ideal conditions to give a high overall reliability factor for line interlacing. The background control signal is on low power, and has been given a high deviation factor to take care of sudden changes in motion picture or film transmission. The sound channel has been given medium power and a higher deviation factor than the picture signal in order to get substantially the same overall reliability factor as the other component signals.

It is to be clearly understood that composite systems wherein amplitude modulation is combined with either frequency modulation or phase modulation fall within the scope of this invention.

Also, the criterion for transmission or non-transmission of the harmonics of the line-synchronizing signal depends on the nature of the receiving circuit and its operation; that is, whether the said circuit is responsive to the line-synchronizing signal in such fashion that an accurately timed response can be secured in such circuit from an incoming synchronizing signal having a given abruptness of rise at its leading edge (that is, at the inception of such signal). If the circuit will respond accurately in timing to a synchronizing signal having a fairly gradual rate of its rise at its inception, it will not be necessary to transmit the harmonic frequencies of the synchronizing signal—otherwise it may be necessary so to do.

Having thus described my invention, what I claim is:

1. In a signaling system in which a multiplicity of related signals coact at a receiving point of the system in order to form the complete signal or completed signals transmitted from a transmitting point of the system, a plurality of electrical circuits at the transmitting end of the system for generating the series of related component signals, and electrical wave means to transmit each of the related component signals, the circuits and electrical wave means for each component being arranged to have parameters related to those for the other signal components, so as to produce substantially identical reliability factors for each of the component signals.

2. The system of claim 1, characterized by the fact that means are provided for transmitting one or more of the signal components by frequency modulation.

3. A transmitting system for transmitting a

multiplicity of related signals, which related signals are all necessary and must coact in order to form the complete signal, comprising a plurality of modulation circuits, one for each of the component or related signals, each of said modulation circuits having parameters related to those of the other modulation circuits to produce a substantially identical reliability factor for each of the component signals, and means for transmitting the output of each of said modulation circuits.

4. In a radio system wherein a group of component signals are transmitted so that by coaction and combination of said component signals the whole transmitted signal is reconstructed, a transmitting system comprising means for transmitting one of the component signals by frequency modulation over one channel, and means for transmitting the other components of the signal by independent modulations over other channels, the parameters of the modulation circuits being inter-related to produce a substantially identical overall reliability factor for each of the component signals.

5. In a sound-picture system employing a pair of high frequency channels, means for producing a carrier wave in each channel, means for amplitude modulating one of said carriers with the picture signal, and means for frequency modulating the other carrier with the picture-accompanying sound signal, the parameters of the modulation circuits being inter-related to produce substantially identical overall reliability factors for the sound and picture channels.

6. A transmitting system for transmitting a multiplicity of related signals, which related signals are adapted to coact in order to form the complete signal, a plurality of modulation circuits including at least one frequency modulation circuit and an amplitude modulation circuit, one for each of the component signals, each of said modulation circuits having parameters related to those of the other modulation circuits to produce a substantially identical reliability factor for each of the component signals, and means for transmitting the output of each of said modulation circuits.

7. In a signaling system a first high frequency generator, a second high frequency generator operating at a different frequency, means for modulating oscillations from the first generator with a picture signal with one type of modulation, and means for modulating oscillations from the second generator with a second signal to accompany the picture signal but with another type of modulation, and means for simultaneously transmitting both modulated oscillations, the parameters of the circuits being related to produce the same overall reliability factors for both circuits.

8. In the signaling system of claim 1, a receiver suitable for signals transmitted therein, said receiver being characterized by the provision of a filter for each of the component signals transmitted, and means for translating the filtered signals in such co-relationship as to re-establish the whole transmitted signal.

9. The transmitting system of claim 3 in combination with a receiver suitable for receiving signals transmitted thereby, said receiver being characterized by the provision of a filter for each of the component signals transmitted, and means for transmitting the filtered signals in such co-relationship as to reestablish the whole transmitted signal.

10. In a radio system wherein a group of component signals are transmitted so that by coaction and combination of said component signals the whole transmitted signal is reconstructed, a transmitting system comprising means for transmitting one of the component signals by frequency modulation over one channel, and means for transmitting the other components of the signal by independent modulations of the same type over other channels, the parameters of the modulation circuits being interrelated to produce a substantially identical overall reliability factor for each of the component signals.

11. In a radio system wherein a group of component signals are transmitted so that by coaction and combination of said component signals the whole transmitted signal is reconstructed, a transmitting system comprising means for transmitting one of the component signals by frequency modulation over one channel, and means for transmitting the other components of the signal by independent modulations of different types over other channels, the parameters of the modulation circuits being interrelated to produce a substantially identical overall reliability factor for each of the component signals.

12. In a radio system wherein a group of component signals are transmitted so that by coaction and combination of said component signals the whole transmitted signal is reconstructed, a transmitting system comprising means for transmitting one of the component signals by angular velocity modulation over one channel, and means for transmitting the other components of the signal by independent modulations over other channels, the parameters of the modulation circuits being inter-related to produce a substantially identical overall reliability factor for each of the component signals.

13. In a system wherein a plurality of related radio signals are to be transmitted for coaction at a remote receiving point, the method of operation which comprises determining the permissible total time of failure of each of the related signals over a protracted period of time, and adjusting the values of carrier amplitude and percentage modulation for each of the related signals which will give for all related signals substantially the same proportion of total time of failure of operation to the time during which the signal component was under observation.

14. In an angular velocity system wherein a plurality of related radio signals are to be transmitted for coaction at a remote receiving point, the method of operation which comprises determining the permissible total time of failure of each of the related signals over a protracted period of time, and adjusting one or more of the values of carrier amplitude, percentage modulation and deviation factor for each of the related signals which will give for all the signals substantially the same proportion of total time of failure of operation to the time during which the particular signal component was under observation.

15. In a signaling system according to claim 1, including frequency selective circuits at the receiving point for the discrimination of the component signals.

16. In a system wherein a plurality of related radio signals are to be transmitted for coaction at a remote receiving point, the method of operation which comprises determining the permissible total time of failure of each of the related signals over a protracted period of time,

and adjusting the values of carrier amplitude and percentage modulation for each of the related signals which will give for all related signals substantially the same proportion of total time of failure of operation to the time during which the signal component was under observation, and wherein the total value of all percentages of modulation of the related signals does not exceed 100% at any given time.

17. In a multiplex signaling system wherein the component signals are of diverse character and not primarily dependent on the signal-to-static ratio thereof in each case for the determination of the overall reliability of operation of the corresponding component signal, a plurality of electrical circuits at the transmitting end of the system for generating the component signals, and electrical wave means to transmit each of the component signals, the circuits and electrical wave means for each component being arranged to have parameters related to those for the other signal components, so as to produce substantially identical reliability factors for each of the component signals.

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