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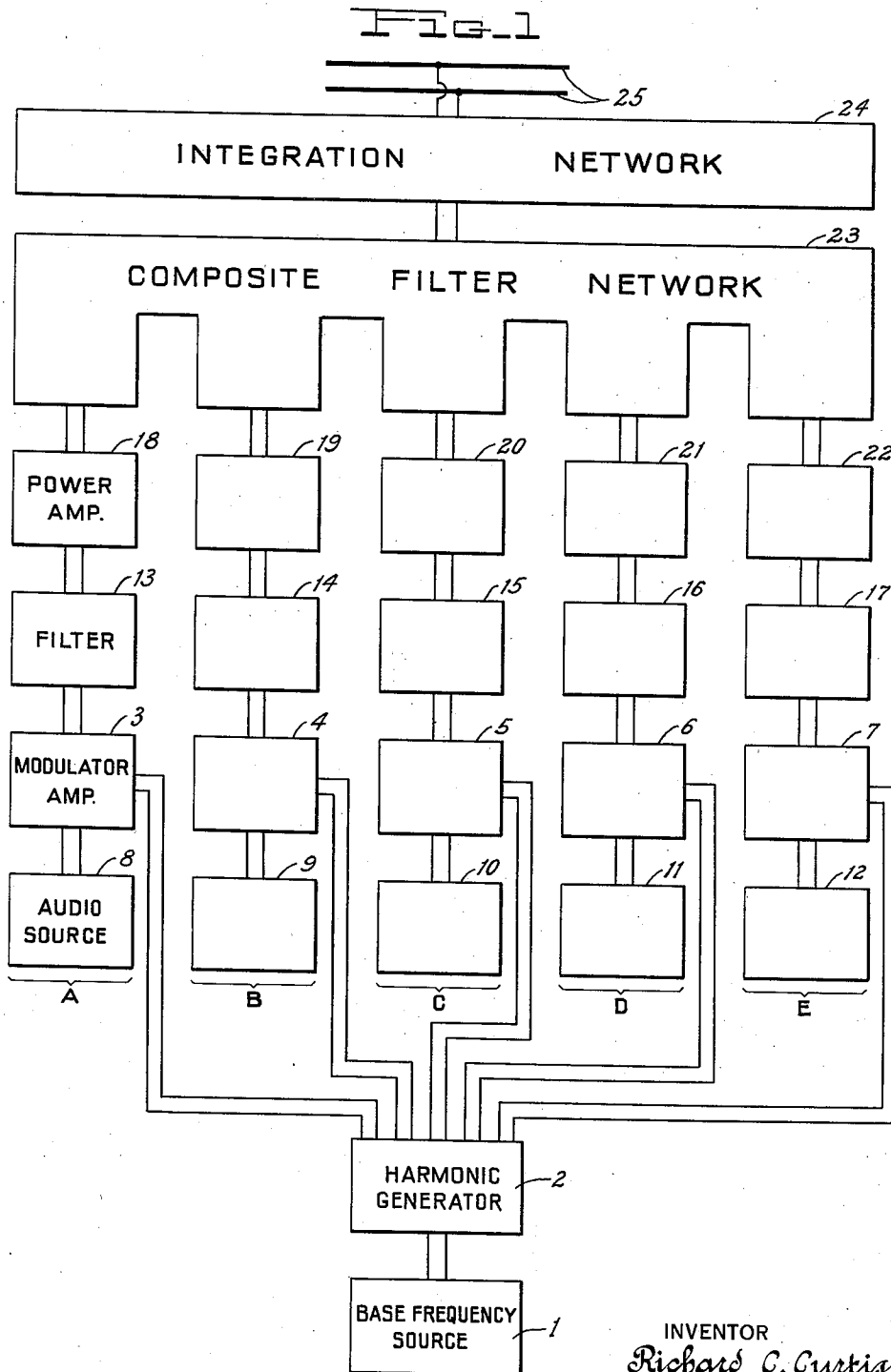
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2,188,499

STAGGERED FREQUENCY SIGNAL DISTRIBUTION

Filed Dec. 21, 1937

3 Sheets-Sheet 1



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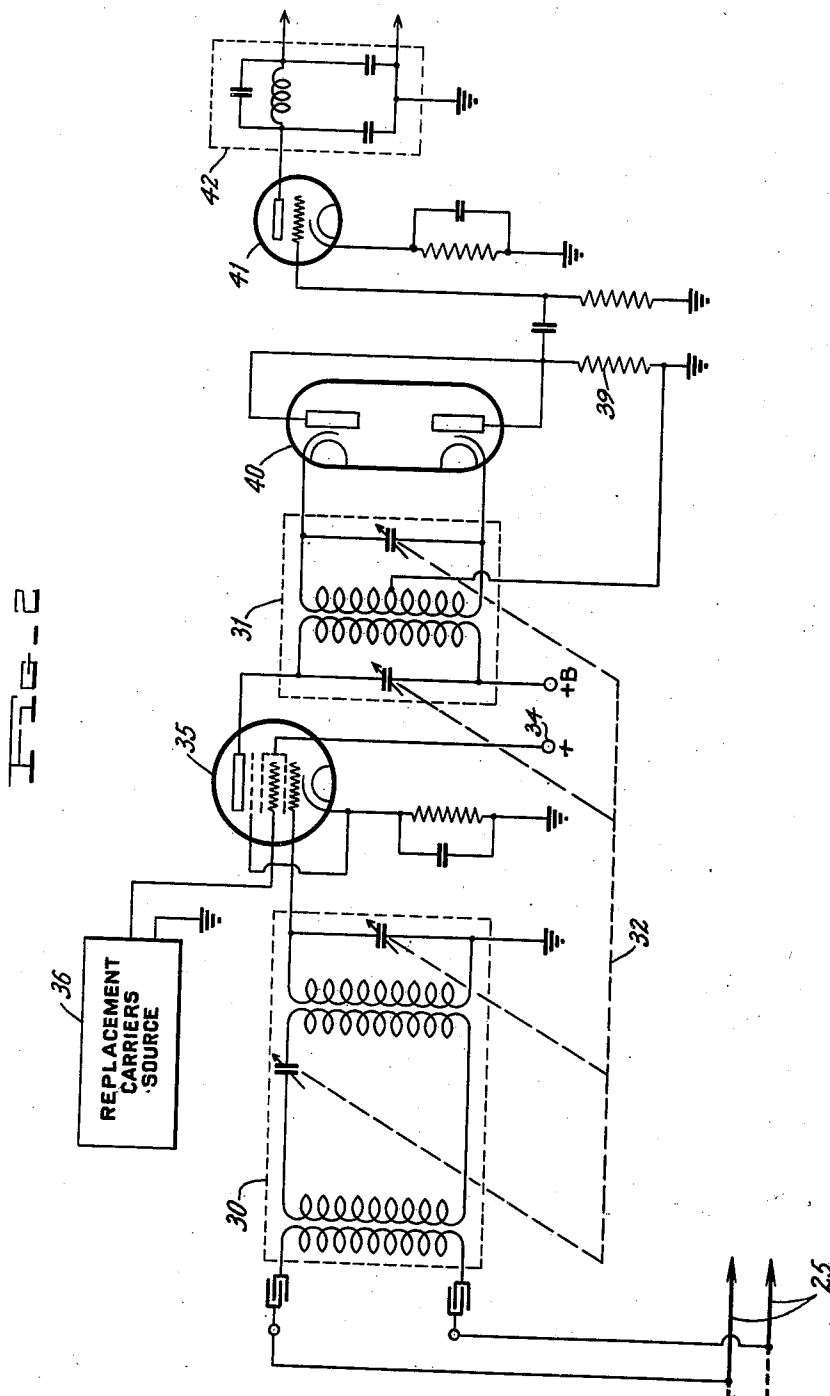
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STAGGERED FREQUENCY SIGNAL DISTRIBUTION

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3 Sheets-Sheet 2



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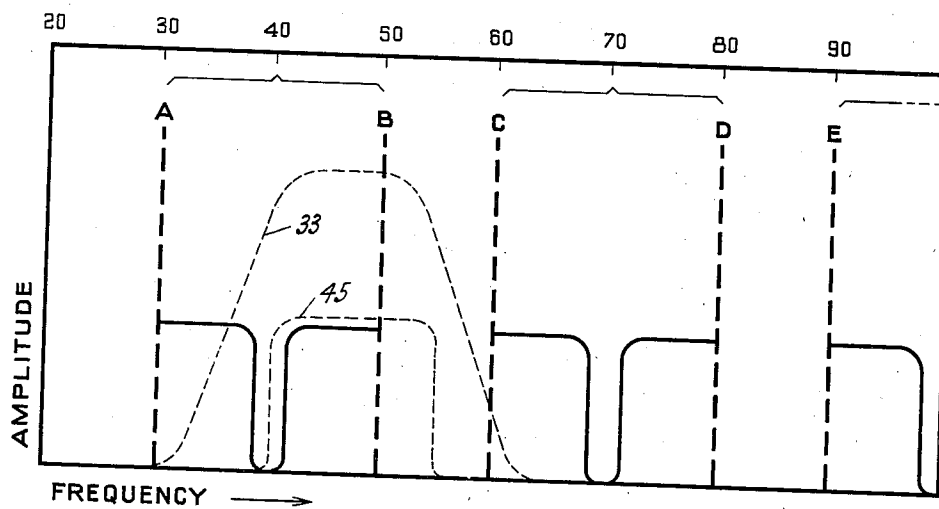
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STAGGERED FREQUENCY SIGNAL DISTRIBUTION

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3 Sheets-Sheet 3

FIG. 3



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UNITED STATES PATENT OFFICE

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STAGGERED FREQUENCY SIGNAL
DISTRIBUTION

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Wired Radio, Inc., New York, N. Y., a corpora-
tion of Delaware

Application December 21, 1937, Serial No. 180,971

5 Claims. (Cl. 179—15)

This invention pertains in general to signal-
ing systems and specifically relates to an ar-
rangement for simultaneously transmitting and
selectively receiving plural signals.

5 The principal object of the invention consists
in providing a transmission system for generat-
ing a plurality of carrier frequencies for com-
bining with different modulation frequencies to
produce plural modulated high frequency chan-
10 nels of special frequency inter-relationships for
transmission purposes.

A further object comprises providing a sys-
tem and method of transmission and reception
in which a plurality of programs of special fre-
15 quency relationships are transmitted to a receiv-
ing point, the frequency characteristics of the
transmitted frequencies and the receiving cir-
cuits cooperating to produce the efficient selec-
tive reproduction of a particular transmitted
20 program channel.

These and other objects will be apparent from
the following, reference being had to the accom-
panying drawings in which like reference num-
erals designate corresponding parts, and in
25 which:

Fig. 1 is a schematic representation of one
embodiment of a transmission system in accord-
ance with the invention;

30 Fig. 2 is a diagrammatic representation of the
reception circuit employed in one embodiment of
the invention; and

Fig. 3 is a graphical representation of inter-
related frequency characteristics in accordance
with the operation of the system of the inven-
35 tion.

The invention contemplates the production
of a plurality of modulated high frequency chan-
nels, the carrier frequencies and side band fre-
quencies of which are staggered along the fre-
40 quency spectrum in a special relationship. In
accordance with the invention, the frequency
separation between any given carrier and the
side band components of adjacent carriers is
essentially greater than the audio frequency cut-
45 off of the associated receiver detector-output.
Accordingly, the receiver is designed to perform
a selection operation among the various trans-
mitted channels to reproduce a particular selected
program. The system may incorporate fixed car-
50 rier transmission or may utilize suppressed-
carrier transmission, such different modes of op-
eration being possible through appropriate
changes in the circuits, but still carrying out
the purpose and scope of the invention.

The transmission system

Referring to the drawings in detail, the trans-
mitter in the present embodiment of the inven-
tion comprises a base frequency supply source 1,
which may be a crystal controlled electronic oscil-
lator or the like for supplying a standard base
frequency, such as 10 kilocycles. The output
of the base frequency source 1 is directed to a
harmonic generator 2 which generates harmonics
of the base frequency. In the present embodi-
10 ment, these harmonics are delivered to modula-
tor-amplifiers 3—7, as frequencies of 30, 50, 60,
80, and 90 kilocycles, respectively.

Sources of modulation frequencies 8—12 pro-
15 vide various modulation frequencies to the modu-
lators 3—7, individual to program channels A—E.
The modulators 3—7 combine the respective car-
rier frequencies and modulation frequencies to
produce modulated high frequency energy in-
cluding side bands of frequencies for the chan-
20 nels A—E. Filters 13—17 restrict the output of
the modulators 3—7 so as to form amplitude-
frequency characteristics as represented in Fig.
3. It will be seen that the program channel
carriers A, B, C, D and E, respectively, derived
25 from the modulators 3—7, are spaced in a spe-
cial arrangement along the frequency spectrum.
The carrier frequencies A and B are paired, and
the carrier frequencies C and D are paired, and
so on; the carrier frequency E forming the lower
30 component of an uncompleted pair of carrier fre-
quencies. The filters 13—17 operate to substan-
tially eliminate all of the side band frequen-
cies except those along the frequency spectrum be-
tween each pair of carrier frequencies. It will
35 be noted that, as a result, a staggered frequency
relation arises. Substantially no modulation side
band frequencies exist between the carrier fre-
quencies B—C or D—E.

Mention has heretofore been made of the car-
40 rier frequencies, although in the present em-
bodiment of the invention, the carrier frequen-
cies A—E are eliminated or suppressed, so that
high frequency energy in the form of side-band
frequencies with carrier suppressed is transmitted
45 over the medium 25. However, fixed carriers
may be utilized with corresponding modifications
of the system, as before pointed out. A form of
suppressed carrier system is disclosed in Edmund
A. Laport, United States Patent No. 2,089,561, 50
issued August 10, 1937.

The outputs of filters 13—17 are directed
through power amplifiers 18—22 and thence
through a composite filter 23 and an integra-
55 tion network 24 to a transmission medium 25.

The transmission medium 25 may be of various forms, as, for example, in wired radio broadcasting, it may be a power transmission network.

The composite filter network 23, and the integration network 24, cooperate to produce the conjoint and integrated distribution of the various frequencies over the transmission medium. The detailed construction and operation of such circuits is disclosed in a copending application of Henry R. Butler, Serial No. 161,389, filed August 28, 1937.

The reception system

In accordance with the invention, a special form of receiver is employed having frequency characteristics cooperating with the special arrangement of staggered frequency transmission so as to make possible an efficient reproduction of selected programs with a minimum of interference, and without requiring critical adjustment in the receiver.

Referring to Fig. 2, a primary selection circuit is divided into two parts 30 and 31. The selection circuit 30 has its input connected through capacitive couplings with the transmission medium 25 for deriving therefrom the carrier frequency energy depicted in Fig. 3. The circuits 30-31 comprise an inductively coupled filter with adjustable capacitors which are interconnected by a common mechanical operating element 32 for broadly selecting frequencies along the frequency spectrum depicted in Fig. 3. The circuits 30-31 are essentially broadly tuned and have a transmission curve represented by the curve 33 in Fig. 3, this curve being shiftable along the frequency spectrum in accordance with the manipulation of the element 32.

A multi-electrode tube 35 is interposed between the circuits 30 and 31. The tube 35 may be of various types suitable for the purpose, although a type 6L7 has been satisfactorily employed in the present embodiment of the invention. The primary control electrode of this tube is connected with the output of circuit 30, and the secondary control electrode of the tube is connected with a replacement carriers source 36. The replacement carriers source 36 generates carrier frequencies respectively equal, within two to ten cycles, to the carrier frequencies A-E in Fig. 3, which are suppressed in transmission. The number of cycles per second that such replacement carriers may vary from the carriers which they replace depends upon the quality and type of program being received, for instance, about two cycles for high quality music or ten cycles for speech. The tube 35 thus operates to superpose a replacement carrier frequency on each of the incoming side bands from circuit 30, with the band of frequencies selected by the circuit 30 predominating over the others.

The screen electrode of tube 35 is connected with a suitable source of positive voltage 34 and the suppressor electrode thereof is connected with the cathode. The anode of tube 35 is connected with the input of the circuit 31. The output of circuit 31 is connected with a full wave diode detector tube 40. The detector tube 40 is substantially a linear detector, a tube of type 6H6 having been used successfully. The plural anodes of the tube 40 are connected in an output circuit comprising resistance 39 and coupled with tube 41, which is an audio frequency amplifier tube. The output of the tube 41 is then connected through a circuit 42 to the reproducing or utilization load.

It should be noted that the output resistance 39 of detector tube 40 is not by-passed with a condenser. The current through resistance 39 therefore follows the instantaneous values of current from circuit 31 except that, due to the rectifying action of tube 40, the current in resistance 39 is always in the same direction. The audio frequency potential thereby developed across resistance 39 is the average of the rectified carrier frequency impulses and not the peak value corresponding to the envelope thereof such as obtained when a by-pass condenser is employed. For the purpose of this specification, a substantially linear detector tube, such as 40, having a substantially non-reactive output circuit, such as 39, is called an average-type linear detector.

The circuit 42 limits the audio frequency output of the tube 41, and, in general, provides a cut-off limitation for the output of detector tube 40. The frequency range below the cut-off frequency of the circuit 42 should be made less than the effective frequency range of separation in the staggered frequency arrangement of transmission. Assume, in Fig. 3, that the side band of carrier B at 50 kilocycles had been selected by the circuits 30 and 31, as represented by curve 33. The circuit 42 would then have an audio frequency response with respect to the detected audio frequencies substantially as indicated by curve 45 in Fig. 3. It will be seen that this curve is limited to substantially 10 kilocycles of the audio frequency spectrum, it being understood that the use of the curve 45 in Fig. 3 is for the purpose of showing the relative cut-off of the side band frequencies after conversion to audio frequencies, as such cut-off would be related to the high frequencies.

In the operation of the system, the frequency separation between any given carrier frequency of Fig. 3 and the side band components of the adjacent carriers is greater than the cut-off limitation of the detector output as determined by the circuit 42. The tube 35 functions to amplify in addition to replacing the carriers on the side band frequencies selected by circuit 30, such superposed and amplified frequencies being delivered then to circuit 31. The circuit 31 operates to further eliminate frequencies except those within the broad curve 33.

The detector tube 40, functioning as a substantially linear detector, receives the output of tube 35 with one carrier and its side band made more predominant by selection in circuit 31, and performs a combining operation by difference or beat detection to reproduce only the frequencies which result from the predominant carrier beating with all other frequencies within the selectivity curve 33. It is characteristic of a linear detector that it reproduces in its plate circuit only the beat frequencies due to the predominant carrier in its input circuit, and that beats between the frequencies of adjacent side bands which may be present in said input circuit do not appear in said plate circuit. In contrast to such characteristic of a linear detector, an exponential detector would reproduce the beats of adjacent side bands with each other, which would appear as unintelligible audio-frequency interference in the output. Thus, as will be noted from Fig. 3, the side band frequencies representing high audio frequencies associated with relatively weak carrier A and those associated with the predominant carrier B, respectively, are so closely adjacent each other that

their frequency differences are in the audio range. However, the beats between said side band frequencies will not appear in the output of linear detector tube 40, Fig. 2, whereas such beats would appear if an exponential detector were used. Nevertheless, the beats of the side band frequencies associated with carrier A against the strong carrier B itself, will appear in the output of tube 40 and will be amplified by tube 41, but they will be cut-off by circuit 42 because all such beats are higher than ten kilocycles per second. The same applies to beating of carrier B with the relatively weak carrier C and the portion of its side band within the selectivity curve 33.

It will be understood that the system is not necessarily limited to suppressed carrier and that fixed carrier and variable carrier modes of operation may be employed if desired. Further, various changes can be made. For example, the source 36, in the suppressed carrier mode of operation, instead of supplying all of the replacement carriers to the tube 35, can be operated to supply a selected replacement carrier to be combined with the selected side band frequencies corresponding to the program to be reproduced.

These and other variations are obvious to those skilled in the art, but such variations are clearly within the intended scope and teaching of the invention. Therefore no limitation of the invention is intended except as set forth in the claims which follow:

What is claimed as new and original to be secured by Letters Patent of the United States is:

1. A receiver for a group of frequencies comprising side bands the carrier frequencies of which are spaced along the frequency spectrum so that adjacent side bands do not overlap and so that no two carrier frequencies are spaced apart less than the width of one side band, said receiver comprising a broadly tuned selector circuit adapted to make a selected carrier predominate over the other frequencies, but not completely excluding other carriers or their side bands, a linear detector connected to said selector circuit and having a load circuit of substantially zero reactance, whereby the only beat frequencies detected are those due to the selected carrier beating against all other frequencies within the range of said selector circuit, and a circuit for limiting the detected beat frequencies in the receiver output to a range substantially corresponding in width to the selected side band.

2. A receiver as defined in claim 1, having an

audio frequency amplifier between said linear detector and said output limiting circuit, and resistance coupling between said amplifier and said detector.

3. A receiver for a group of suppressed carrier single side bands which are spaced along the frequency spectrum so that adjacent side bands do not overlap and so that no two of their carrier frequencies are less than a side band apart, said receiver comprising a broadly tuned selector circuit adapted to make a selected side band predominate over the others, means connected to said circuit for superposing replacement carriers on the respective side bands, a second broadly tuned selector circuit following said means and adapted to make the selected side band and its replaced carrier more predominant but not completely excluding other side bands or their carriers, a linear detector connected to the second selector circuit, and an audio frequency circuit limiting the output of said detector to a frequency range no wider than one said side band.

4. A receiver comprising broadly tuned selection circuits and a substantially linear average type detector, the breadth of tuning of said circuits being sufficient to include with the selected carrier a carrier and side band portion of an adjacent channel but being adapted to make predominant the selected carrier and its side band, whereby the only beat frequencies detected are those due to the selected carrier beating against all other frequencies within the range of said selection circuits, and means for limiting the detected beat frequencies to a range substantially corresponding in width to the side band of the selected carrier.

5. A receiver for suppressed carrier single side bands comprising a first selection circuit for frequencies in the vicinity of a desired one of said side bands, means for superposing a replacement carrier thereon, a second selection circuit for the desired side band and its superposed replacement carrier, a linear average type detector and an audio frequency limitation circuit for the output thereof, said detector operating to detect only the beat frequencies due to the selected carrier beating against all other frequencies within the range of said selection circuits and said limitation circuit operating to eliminate all detected frequencies except those within the desired side band.

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