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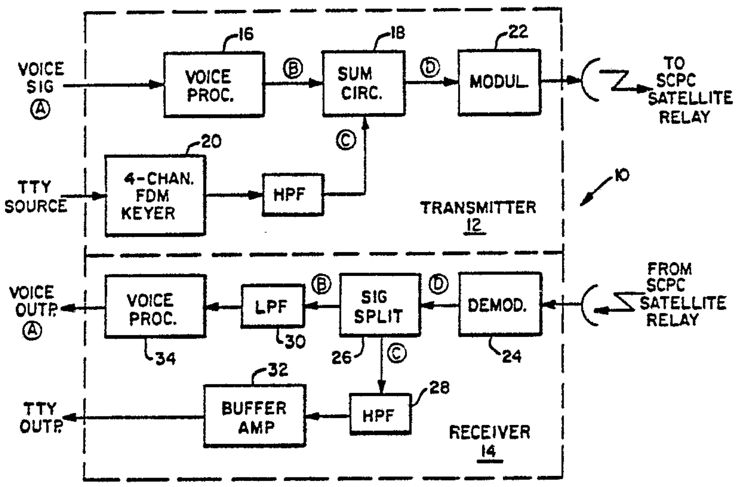
(54) Title: COMMUNICATION SYSTEM FOR PROVIDING NON-INTERFERING MULTIPLE SIGNALS OVER INDIVIDUAL COMMON CARRIER CHANNELS

(57) Abstract

Single-channel-per-carrier communication systems (SCPC) it is frequently desirable to add an auxiliary signal, such as low frequency teletypewriter signals (TTY) to a primary signal being transmitted, such as a voice signal, without interference between the auxiliary and primary signals. To accomplish this addition without interference, means (18) are provided for combining the auxiliary signal with the primary signal only after the primary signal has already been processed for transmission. The auxiliary signal has a frequency different than that of the first signal so that a composite frequency division muliplexed signal (FDM) is formed containing said processed primary signal and the unprocessed auxiliary signal. The composite FDM signal is then modulated with a common carrier and trasmitted over a common communication channel.



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COMMUNICATION SYSTEM FOR PROVIDING NON-INTERFERING MULTIPLE SIGNALS OVER INDIVIDUAL COMMON CARRIER CHANNELS

FIELD OF THE INVENTION

The present invention relates generally to communication systems and, more specifically, to SCPC satellite communication systems for transmitting an auxiliary signal such as a telegraph signal along with a voice signal on a common SCPC system channel.

BACKGROUND OF THE INVENTION

Recently, the development of SCPC equipment has progressed to the point where it has become a practical and cost effective satellite communication system, especially for thin-route telephone communication systems. However, up until now, various attempts to combine auxiliary signals such as telegraph signals (and in particular low frequency TTY signals) with the voice signals for SCPC communication have suffered from certain inefficiencies.

One such prior art attempt has been to use an order wire arrangement. An example of this is the Raven Model 41511-51 order wire system manufactured by the Raven Electronics Corporation. With such a system, a portion of the satellite transponder is reserved solely for the order wire auxiliary signal. Thus, the order wire system does not use a single RF carrier for the auxiliary signal and the voice signal. Accordingly, because extra satellite channels are required, the order wire system is rather inefficient. Thus, it would be more desirable to utilize a multiplex technique so that the voice signals and auxiliary signals could be sent together over a single channel rather than over separate order wire channels.

One approach to utilizing multiplexing for telephone voice signals and auxiliary telegraph signals can be found in U. S. Patent No. 3,610,832 issued to Strobel. Specifically, this patent teaches a time division multiplexing system wherein up to 7 TTY signals can be added to voice signals by a TDM sampling technique. Although this arrangement does serve the function of allowing a common carrier to modulate both the voice and TTY signals, it suffers from the significant disadvantage of high costs in the implementation of the TDM technique.

Accordingly, frequency division multiplexing would appear to offer a less expensive alternative for multiplexing voice and auxiliary signals over a single channel. Such a FDM arrangement is taught in U. S. Patent No. 3,241,066 issued to Ligotky. In this arrangement, a voice signal is combined with telegraph signals and subsequently processed in a voice processor. Specifically, the combined voice and telegraph signals are compressed. Following this compression, the compressed composite signal is modulated by a single carrier and transmitted. After reception, the composite signal is expanded to recover the original voice and telegraph signals.

The advantage of such companding operations (i.e. compression in the transmitter and expansion in the receiver) has long been known for minimizing distortion in communication systems. Basically, companding involves amplifying low signal levels to a greater degree than high signal levels thereby compressing the dynamic range of the output signal. The purpose of this is to place the transmitted signal within a linear range of the channel thereby avoiding or at least significantly minimizing non-linear distortion by the channel. An example of this would be 2/1 Db compression wherein if the input signal has a dynamic range of 2 to 10 Db's, the compressed signal will only have a range of 1 to 5 Db's. Expansion in the receiver then restores the original signal (e.g. in the above example back to 2 to 10 Db's). Such arrangements are commonly used in voice transmission and typically give a significant gain to the voice signal when compared with systems wherein no companding takes place.

Although companding is thus very desirable for processing voice signals for transmission, the inventors have found through their experiments that significant degradation of a composite FDM signal having both voice signals and telegraph signals results if companding is applied to it. In particular, the inventors' experiments show that when strong discrete tone signals such as found in FSK-TTY are companded along with a void signal the strong TTY tone signals capture the operating point of the voice signal. In other words, the normal operating point for the companded voice signal is usually set for a 1000 Hz crossover point. However, the presence of strong individual discrete tones such as those found in FSK-TTY transmission, will have a very marked effect on the compander operating point for the voice signal. This marked effect results in setting the operating point quite differently than it would normally be for the voice signal alone. This creates serious degradation of the test tone to noise ratio (TTNR) of the companded voice band signal. An example of this is shown in the results of the inventors' experiments wherein although a TTY signal was inserted into the voice processor at 10 Db below a 1 kHz tone, they are recovered at only 1 Db below the tone.

The overall result of this capture of the operating point of the voice signal, as far as a user of the system is concerned, is that the telegraph or other auxiliary signals interfere with the voice telephone communication. Since this interference is quite bothersome in the course of normal conversation, most manufacturers have utilized the order wire approach rather than the previously known FDM approach when desiring to add auxiliary signals such as telegraph and TTY to voice in an SCPC system.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide an improved communication system.

Further, it is an object of the present invention to provide an improved SCPC communication system wherein auxiliary signals are added to voice signals on individual channels.

Another object of the present invention is to provide an improved SCPC system wherein a telegraph signal such as TTY is added to a voice signal by frequency division multiplexing the signals onto a common channel.

Yet another object of the present invention is to reduce interference between telegraph and voice signals in an SCPC system wherein such signals are frequency division multiplexed together onto common individual channels.

With these and other objects in view, the present invention contemplates new methods of and apparatus for providing multiple service signals over a common channel. In the transmitter of the communication system a processor is provided for receiving a first signal, such as a voice signal, and performing at least one processing operation on the first signal. Only after the first signal has been processed is an auxiliary signal added to it. The auxiliary signal has a frequency different than that of the first signal so that a composite FDM signal is formed containing the processed first signal and the auxiliary signal. The composite signal is then modulated with a common carrier and transmitted to a receiver. In the receiver, following demodulation, the received signal is split into the first signal and the auxiliary signal. The first signal is then processed in the receiver to restore the original first signal which was provided to the transmitter.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and advantages of the present invention may be more clearly understood by reference to the following detailed description and drawings wherein:

Figure 1 is a block diagram of the transmitter and receiver in accordance with the present invention;

Figures 2A through 2D are waveform diagrams illustrating the waveform at various points in Figure 1; and

Figure 3 shows a modification of the transmitter arrangement in accordance with the present invention.

DETAILED DESCRIPTION

Referring now to the drawings, and in particular to Figure 1, a communication system 10 is shown, in accordance with the present invention, including a transmitter 12 and a receiver 14 for transmitting a composite FDM signal having voice and TTY components over an SCPC communication link. The combination of voice and TTY signals are shown inasmuch as they serve as an excellent illustration of the particular advantages brought about by the present invention. However, other signals could be used, as will be discussed hereinafter.

In Figure 1, the original baseband voice signal A (see Figure 2A) is applied to a voice processor 16 for processing into a form which is well suited for transmission over the SCPC communication link. The frequency range for the voice signal is shown as being between 300 Hz and 3400 Hz, although obviously different ranges could be employed. Typically, such a voice processor includes a compressor, as discussed previously. It is also common to use pre-emphasis circuits and echo suppression circuits in such a voice processor to further improve the overall system processing gain. By way of example, for a voice signal between 300 Hz and 3400 Hz, a typical processor might include compression circuits for compressing at 2/1 Db's and pre-emphasis circuits to provide pre-emphasis of approximately 6 Db/octave. In this example, the compression circuit will give approximately an 11 D/b gain while the emphasis circuit will give approximately a 6 D/b gain for an overall 17 D/b system processing gain improvement. Voice processors for these purposes are well known in the art. For example, the Harris voice processor No. 2034 is well suited for such operations.

The processed baseband output of the voice processor may have a form as shown, solely by way of example, as signal B in Figure 2B. This output is applied to one input of a summing circuit 18. Of course, the particular shape of the output wave B will depend on the particular type of processing which the original voice signal A is subjected to in the voice processor 16.

The other input to the summing circuit 18 is a baseband 4-channel FDM-TTY signal C, such as shown in Figure 2C. This composite TTY signal is provided from 4 TTY keyers 20. Each TTY signal comprises a pair of FSK frequencies with one frequency representing a mark and one frequency representing a space, as is conventional. The frequency range in which these 4 FDM-TTY signals are shown, by way of example, is between 3400 Hz and 4600 Hz. Any particular individual frequencies may be used for the discrete FSK frequencies, provided that proper spacing is maintained between each individual frequency to ensure proper distinction in the receiver between a mark and a space signal, and non-interference between one pair of TTY signals and another. An example of sub-carrier frequencies for each FSK pair which is generally suitable for satisfactory separation over an SCPC channel would be f_{01} = 3540 Hz, f_{02} = 3660 Hz, f_{03} = 3780 Hz, and f_{04} = 3900 Hz.

As can be seen by comparing Figures 2B and 2C, the voice signal and the TTY signals lie in different frequency ranges. This is desirable for proper FDM operation, in accordance with the present invention, since the summing circuit 18 can then add these signals together to form a baseband composite FDM signal such as shown in Figure 2D. Typically, some filtering must be applied at some stage to the voice signal prior to the actual addition to eliminate any high frequency components which might interfere with the TTY signals. Of course, the particular frequency ranges shown for the voice and TTY signals are exemplary only, and other suitable ranges could be readily used. Also, either a greater or lesser number of TTY signals could be used.

Looking at Figure 2D, it can be seen that a very important aspect of the present invention is illustrated therein. Specifically, Figure 2D reflects the fact that while the voice signal has been processed in the voice processor to change its waveform from that of the original voice signal A, the TTY signals have not been processed. In particular, the TTY signals have not been subjected to compression along with the voice signals. The significance of this is that it avoids the problem previously mentioned of the capturing of the operating point of the voice signals by the TTY signals if the voice signals were to be compressed with the TTY signals. Applicants found that avoiding such capture by combining the TTY signals with the voice after the voice signal has been processed significantly reduces the interference between the TTY signals and the voice signals. At the same time, the advantages of improved overall processing gain due to the voice processing are still retained.

Following the summation of the voice signals and the TTY signals to form a composite FDM signal D, the composite signal is passed through a modulator 22 where it is modulated in a conventional manner with a common RF carrier for transmission over a common channel of an SCPC satellite relay. This transmission over an SCPC satellite relay link is particularly attractive in light of the recent increased use of such relays for telephone use. However, the present invention could readily be used with other communication link arrangements not utilizing satellite relays (e.g. cable transmission), if desired, and is not in any way limited to satellite usage.

Figure 1 also shows receiver circuitry 14 for use in accordance with the present invention. An SCPC modulated composite signal having voice and TTY components, as described above, is received by the circuit 14 and demodulated, in a conventional manner, in a demodulator 24 to again provide a composite baseband signal having a waveform approximately shown in Figure 2D. Of course, the signal D in the receiver will, in actual practice, differ somewhat from the signal D as transmitted by virtue of attenuation, distortion, noise and interference. But, notwithstanding these factors, the waveform D in the receiver should have the same general shape as that in the transmitter following demodulation, especially if proper voice processing has been used for the particular channel link in question.

Following demodulation, the baseband signal D is passed through a signal splitter 26 to separate the baseband signal D into a separate baseband voice signal B and a teletype signal C. As can be seen, the voice signal output of the signal splitter 26 still contains the effects of processing which was done in the voice processor 16 of the transmitter.

In order to ensure good isolation of the TTY signal C from the voice signal B, the TTY output of the signal splitter 26 is fed to a highpass filter 28 while the voice output signal is fed to a lowpass filter 30. With these filters, one can attain excellent rejection on the order of 50 Db or better between the voice and TTY signals.

Following the filtering in the highpass filter 28 and rescaling by amplification in a buffer amplifier 32, the TTY signals C are ready for application to a conventional TTY printer (not shown). The voice signal B, however, still is in its processed form (i.e. the form to which it was modified in the voice processor in the transmitter). Therefore, before this signal can be utilized, it must again be converted into the form of original baseband signal A. This conversion is accomplished in a voice processor 34 coupled to the output of the lowpass filter 30. This voice processor 34 performs a reverse operation relative to the transmitting voice processor 16. Thus, the receiver voice processor 34 typically includes an expander to expand the compressed waveform and a de-emphasis circuit to remove the pre-emphasis applied in the transmitter. The output signal A of the voice processor 34 is then in a form suitable for utilization with a telephone or other desired utilization circuit.

Using the system described above, applicants have found essentially no degradation of the test tone to noise ratio (TTNR) by the addition of the TTY signals. For example, using the Harris voice processor mentioned above, it has been found that for an input voice having a TTNR of 55 Db, the recovered voice TTNR is still approximately 55 Db even with the TTY signals added. In a conventional FDM system, such as U. S. Patent No. 3,241,066, however, with the same input voice the recovered voice TTNR is only approximately 35 Db due to interference from the TTY signals.

Also, because the above-described system allows the efficient use of a single RF carrier for multiple communication functions, the space segment RF carrier frequency assignment is conserved. Further, the available EIRP required from the satellite will be conserved.

Although Figure 1 shows the use of a separate summing circuit 18 for combining the voice signal and TTY signals after voice processing, the present invention could combine these signals in an output stage of the voice processor instead, as shown in Figure 3. For example, the usual final amplifier in a conventional voice processor could be modified to receive the TTY input in addition to the processed voice signal. Thus, the final amplifier would act as a summing amplifier 36 to produce the signal D in the same manner as in the Figure 1 arrangement. Note that with this modification, the voice signal still would be processed but the TTY signals will not be even though they are fed to a stage of the voice processor.

The modification of Figure 3 could be taken one step further if the TTY signals were added to the voice signal in the transmitter after the voice signals have been compressed but before other processing steps such as pre-emphasis or echo suppression have taken place. Similarly, the receiver would remove the TTY signals from the voice signals after de-emphasis but before expansion. The reason that this would still yield an improved result is that the greatest degradation of the processed composite signal generally results from companding. However, it is believed that the best results are obtained by adding the TTY signals after the voice has been fully processed, as described with regard to Figures 1 and 3.

Also, although the present invention has been discussed primarily in terms of combining voice signals and TTY signals, it is to be understood that other signal combinations could be utilized which would obtain the basic beneficial results discussed above. Thus, the present invention will yield improved results in any composite FDM signal arrangement wherein a first signal must be subjected to processing which is unnecessary for the auxiliary signal, and where processing the composite signal will increase the interference between the first signal and the auxiliary signal. Further, although voice signals have been generally described above, it should be understood that other audio frequency signals could obviously be used.

It is to be understood that the above-described arrangements are simply illustrative of the application of the principles of this invention. Numerous other arrangements may be readily devised by those skilled in the art which embody the principles of the invention and fall within its spirit and scope.

WE CLAIM:

1. A communication apparatus including a transmitter comprising:

a processor including means for receiving a first signal and means for performing at least one processing operation on said first signal;

means for combining an auxiliary signal with said first signal after the first signal has been processed, wherein said auxiliary signal has a frequency different than that of the first signal so that a composite frequency division multiplex signal is formed containing the processed first signal and the auxiliary signal;

means for modulating said composite signal with a common carrier; and

means for transmitting the composite modulated signal over a common communication channel.

2. A communication apparatus according to claim 1, wherein the first signal is a baseband voice signal and wherein the processor is a voice processor.

3. A communication apparatus according to claim 2, wherein the auxiliary signal is a baseband telegraph signal.

4. A communication apparatus according to claim 1, wherein the communicaton channel is a radio frequency link and the common carrier is a common radio frequency carrier.

5. A communication apparatus according to claim 3 or 7, wherein the voice processor includes means for compressing the voice signal.

6. A communication apparatus according to claim 3 or 7, wherein the voice processor includes means for pre-emphasizing the voice signal.

7. A single-channel-per-carrier communication apparatus including a transmitter comprising:

a voice processor including means for receiving a baseband voice signal and means for compressing said baseband voice signal for transmission over an individual channel;

means for combining a baseband auxiliary signal to such baseband voice signal after the voice signal has been compressed such that the auxiliary signal is not compressed by the voice processor, wherein the auxiliary signal has a different frequency than that of the voice signal so that a composite frequency division multiplex baseband signal is formed having the baseband voice signal and the baseband auxiliary signal;

means for modulating the composite baseband signal with a common RF carrier to form a composite frequency division multiplex RF signal; and

means for transmitting the modulated composite frequency division multiplex RF signal over the individual channel.

8. A communication apparatus according to claim 7, wherein the auxiliary signal is a baseband telegraph signal.

9. A communication apparatus according to claim 3, 8, 16, or 22, wherein the baseband telegraph signal is a composite frequency division multiplex telegraph signal containing multiple individual telegraph signals.

10. A communication apparatus according to claim 9, wherein the baseband composite telegraph signal has four individual telegraph signals.

11. A communication apparatus according to claim 10, wherein the four individual telegraph signals are within a frequency range between 3400 Hz and 4600 Hz.

12. A communication apparatus according to claim 11, wherein the baseband voice signal has a frequency range between 300 Hz and 3400 Hz.

13. A communication apparatus according to claim 2 or 7, wherein the voice processor includes echo suppression means.

14. A communication apparatus including a receiver comprising:

means for receiving a composite signal which is frequency division multiplexed on a common communication channel and modulated with a common carrier, wherein the composite signal includes a processed first signal which has been processed in a transmitter from an original first signal and an auxiliary signal having a different frequency than the processed first signal and which has not been processed in said transmitter processor;

a receiver processor including means for processing a received first signal to restore it to the original first signal; and

means coupled between the receiving means and the receiver processor for separating the auxiliary signal from the first signal prior to the application of the first signal to the receiver processor.

15. A communication apparatus according to claim 14, wherein the first signal is a voice signal and the transmitting and receiving pro-

cessors are voice processors.

16. A communication apparatus according to claim 15, wherein the auxiliary signal is a telegraph signal.

17. A communication apparatus according to claim 16, wherein the receiver includes means coupled to the input of the separating means for demodulating the received voice and telegraph signals to baseband levels.

18. A communication apparatus according to claim 14, wherein the communication channel is an RF link and the common carrier is a common RF carrier.

19. A communication apparatus according to claim 15, wherein the processed voice signal has been compressed and the voice processor includes means for expanding this compressed signal.

20. A communication apparatus according to claim 15, wherein the processed voice signal has been pre-emphasized and the voice processor includes means for de-emphasis of this signal.

21. A single-channel-per-carrier communication apparatus including a receiver comprising:

means for receiving a composite RF signal which has been frequency division multiplexed on a common channel with a common RF carrier wherein the composite signal includes a compressed voice signal and an uncompressed auxiliary signal;

means for expanding the compressed voice signal; and

means coupled between the receiving means and the expander for separating the auxiliary signal from the voice signal prior to application of the voice signal to the expander.

22. A communication apparatus according to claim 21, wherein the auxiliary signal is a telegraph signal.

23. A communication apparatus according to claim 16 or 22, wherein the telegraph signal has a higher frequency than the voice signal and wherein the receiver further comprises a highpass filter coupled to the telegraph output of the signal separator and a lowpass filter coupled to the voice output of the signal separator.

24. A communication apparatus including a transmitter comprising:

a compressor for compressing an audio signal for transmission over a communication channel;

means for combining an auxiliary signal with the voice signal after the audio signal has been compressed, wherein the auxiliary signal has a frequency different than the audio signal so that a composite frequency division multiplex signal is formed having the compressed audio signal and the uncompressed auxiliary signal; and

means for transmitting the composite frequency division multiplex signal over a common communication channel.

25. A communication apparatus including a receiver comprising:

means for receiving a composite frequency division multiplex signal having a compressed audio signal and an uncompressed auxiliary signal having a frequency different than that of the compressed audio signal;

means for expanding the compressed audio signal; and

means for separating the uncompressed audio signal from the auxiliary signal before applying the compressed audio signal to the expander.

26. A communication apparatus including a transmitter and receiver, said apparatus comprising:

compander means for compressing an audio signal in the transmitter and for expanding said audio signal in the receiver;

means in the transmitter for combining an auxiliary signal to the compressed audio signal after said compression of the audio signal, wherein the auxiliary signal has a frequency range different than that of the audio signal to form a composite frequency division multiplex signal containing the compressed audio signal and the uncompressed auxiliary signal;

means for transmitting the composite frequency division multiplex signal over a common communication channel to the receiver; and

means in the receiver for separating the auxiliary signal from said compressed audio signal prior to expansion of said voice signal.

27. A communication apparatus according to claim 24, 25, or 26, wherein the auxiliary signal is a telegraph signal.

28. A method for transmitting communication signals comprising:

receiving a first signal and performing at least one processing operation on said first signal;

combining an auxiliary signal with said first signal after the first signal has been processed, wherein said auxiliary signal has a frequency different than that of the first signal so that a composite frequency division multiplex signal is formed containing the processed first signal and the auxiliary signal;

modulating said composite signal with a common carrier; and

transmitting the composite modulated signal over a common communication channel.

29. A method according to claim 28, wherein the first signal is a baseband voice signal and wherein the processing operation comprises voice processing.

30. A method according to claim 29, wherein the auxiliary signal is a baseband telegraph signal.

31. A method according to claim 30, wherein said voice processing includes compressing the voice signal.

32. A method according to claim 30, wherein said voice processing includes pre-emphasizing the voice signal.

33. A method for receiving communication signals comprising:

receiving a composite signal which is frequency division multiplexed on a common communication channel and modulated with a common carrier, wherein the composite signal includes a processed first signal which has been processed in a transmitter from an original first signal and an auxiliary signal having a different frequency than the processed first signal and which has not been processed in said transmitter processor;

separating the auxiliary signal from the first signal; and

processing the received first signal after it has been separated from the auxiliary signal to restore the first signal to the original first signal.

34. A method according to claim 33, wherein the first signal is a voice signal.

35. A method according to claim 34, wherein the auxiliary signal is a telegraph signal.

36. A method according to claim 34, wherein the received processed voice signal has been compressed and the processing step includes expanding this compressed signal.

37. A method according to claim 34, wherein the received processed voice signal has been pre-emphasized and the processing step includes de-emphasizing of this pre-emphasized signal.

38. A method of transmitting communication signals comprising:

compressing an audio signal for transmission over a communication channel;

combining an auxiliary signal with the audio signal after the audio signal has been compressed, wherein the auxiliary signal has a frequency different than the audio signal so that a composite frequency division multiplex signal is formed having the compressed audio signal and the uncompressed auxiliary signal; and

transmitting the composite frequency division multiplex signal over a common communication channel.

39. A method for receiving communication signals comprising:

receiving a composite frequency division multiplexed signal having a compressed audio signal and an uncompressed auxiliary signal having a frequency different than that of the compressed audio signal;

separating the uncompressed audio signal from the auxiliary signal; and, subsequently,

expanding the compressed audio signal;

40. A method for transmitting and receiving communication signals utilizing a transmitter and receiver, comprising:

compressing an audio signal in the transmitter;

combining an auxiliary signal to the compressed audio signal after said compression of the audio signal, wherein the auxiliary signal has a frequency range different than that of the audio signal to form a composite frequency division multiplex signal containing the compressed audio signal and the uncompressed auxiliary signal;

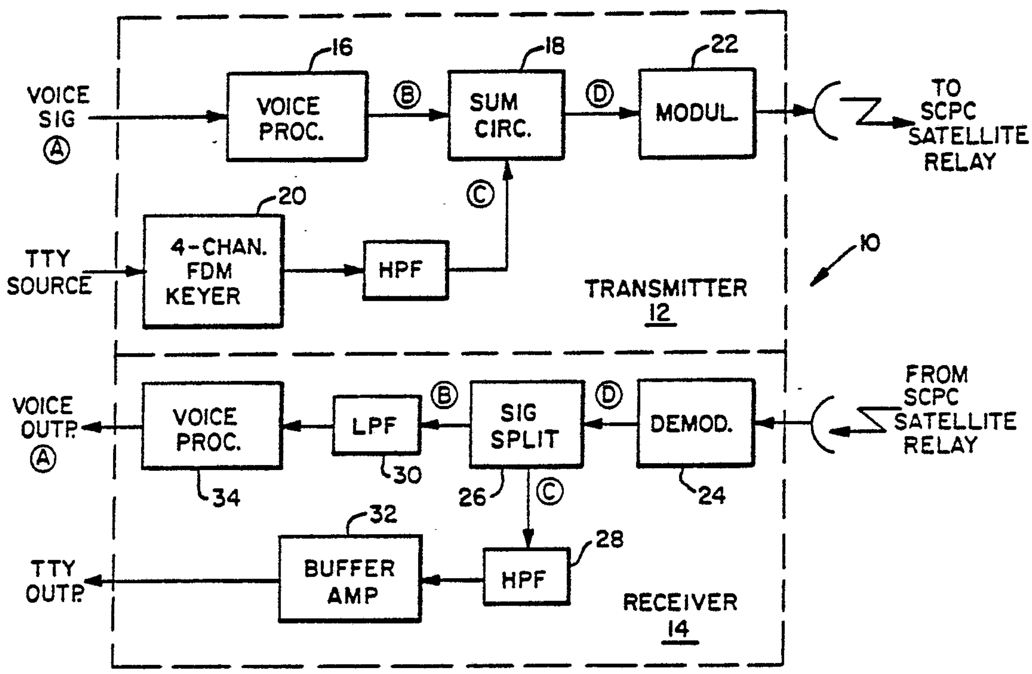
transmitting the composite frequency division multiplex signal over a common communication channel to the receiver; and

separating the auxiliary signal from said compressed audio signal, and, subsequently,

expanding the audio signal.

41. A method according to claim 38, 39, or 40, wherein the auxiliary signal is a telegraph signal.

FIG. 1.



SUBSTITUTE SHEET

FIG. 2A.

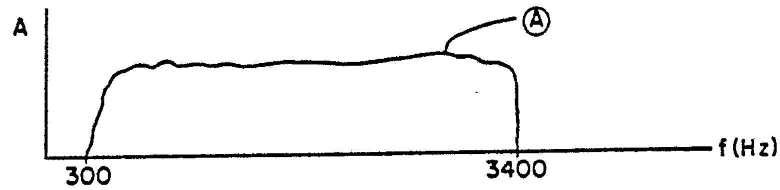


FIG. 2B.

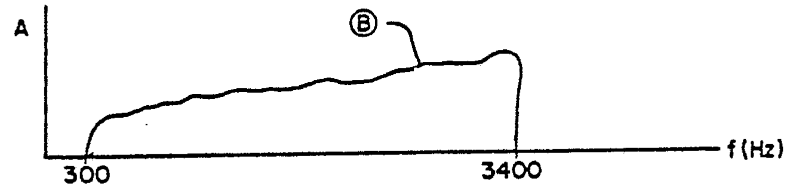


FIG. 2C.

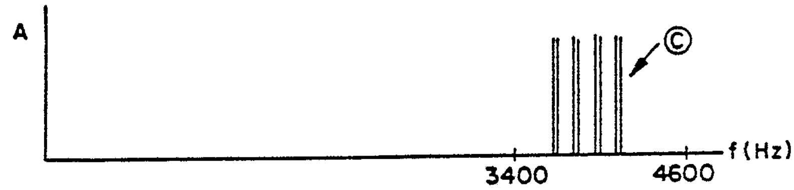


FIG. 2D.

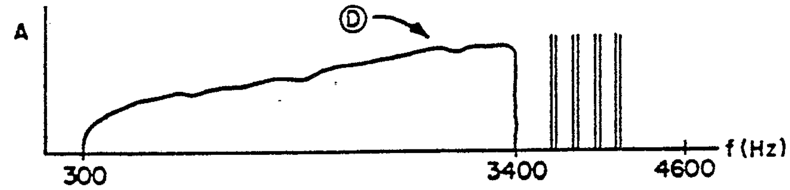
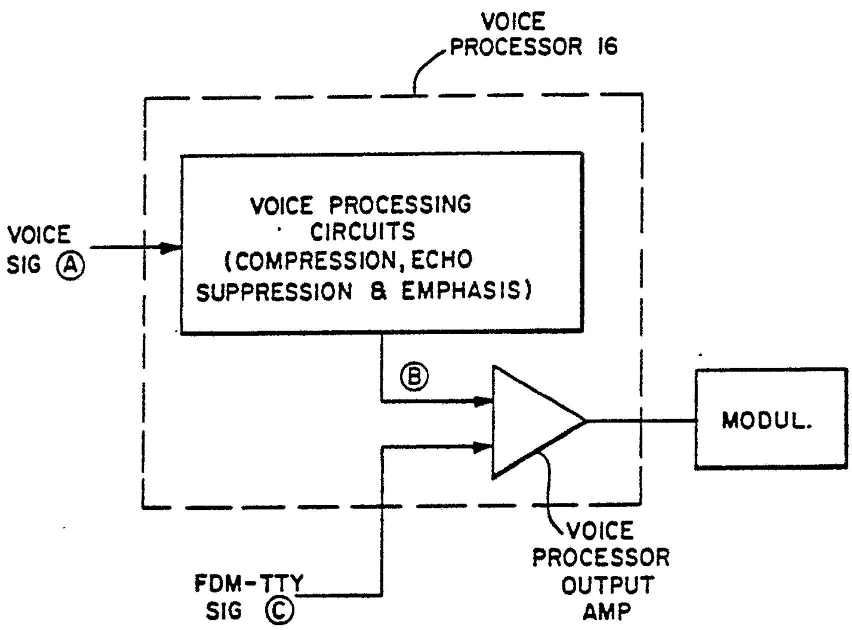


FIG. 3.


VOICE
PROCESSOR 16
VOICE PROCESSING
CIRCUITS
(COMPRESSION, ECHO
SUPPRESSION & EMPHASIS)
VOICE
SIG Ⓐ
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MODUL.
FDM-TTY
SIG Ⓒ
VOICE
PROCESSOR
OUTPUT
AMP

INTERNATIONAL SEARCH REPORT

International Application No PCT/US81/00868

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int. Cl.[3] H04J/ 1/02; H04J 1/08
U.S. Cl. 370/7, 76

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
U.S.	370/7, 76, 69, 118 179/15.55R

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
A	US, A, 2,677,726, Published 4 May 1954, Entz et al.	1-41
X	US, A, 4,005,277, Published 25 January 1977, Araseki et al	13
A,P	US, A, 4,252,995, Published 24 February 1981, Schmidt et al.	1-41
X	US, A, 3,133,993, Published 19 May 1964, Devries.	6,20,32,37
A	US, A, 3,718,767, Published 27 February 1973, Ellis	1-41
A	US, A, 2,795,650, Published 11 June 1957, Levine.	1-41
A	US, A, 3,922,493, Published 25 Novermer 1975, Brenig et al.	1-41
X	US, A, 3,241,066, Published 15 March 1966, Ligotky.	3,8,9-12,16, 17, 22, 23, 27, 30, 31, 35, 36, 41

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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but on or after the priority date claimed
"T" later document published on or after the international filing date or priority date and not in conflict with the application, but cited to understand the principle or theory underlying the invention
"X" document of particular relevance

IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
27 August 1981	09 SEP 1981
International Searching Authority [1]	**Signature of Authorized Officer [20]**
ISA/US	Douglas W. Olms

Form PCT/ISA/210 (second sheet) (October 1977)

International Application No. PCT/US81/00868

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

A	US, A, 3,610,832, Published 05 October 1970, Strobel.	1-41
A	US, A, 3,757,225, Published 04 September 1973, Ulicki.	1-41
X	GB, A, 734,590, Published 03 August 1955.	1-41

V.☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE [10]

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1.☐ Claim numbers ...., because they relate to subject matter [12] not required to be searched by this Authority, namely:

2.☐ Claim numbers ...., because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out [13], specifically:

VI.☐ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING [11]

This International Searching Authority found multiple inventions in this international application as follows:

1.☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.

2.☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3.☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.

☐ No protest accompanied the payment of additional search fees.