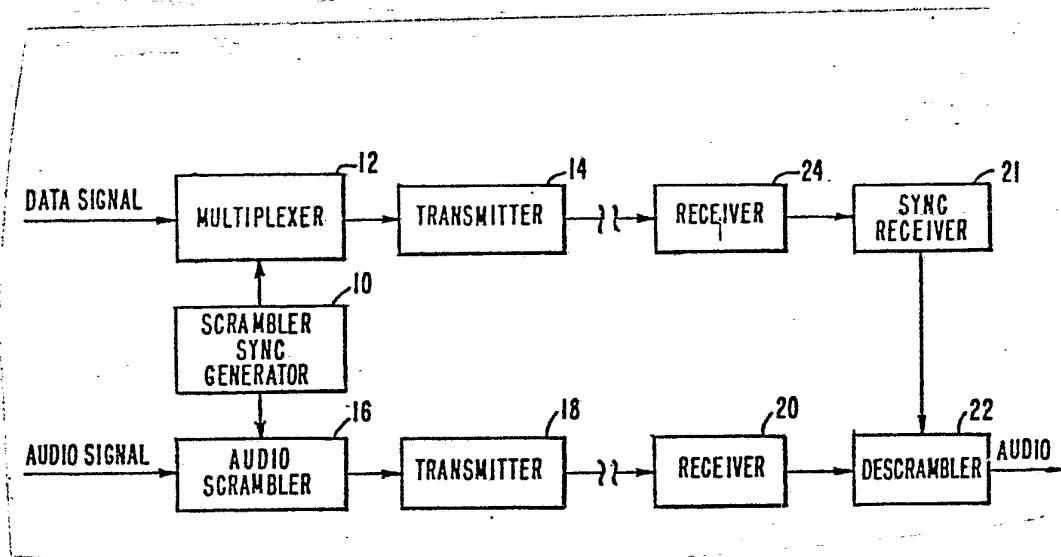




## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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<p>(21) International Application Number: PCT/US83/00408 (22) International Filing Date: 23 March 1983 (23.03.83) (31) Priority Application Number: 366,624 (32) Priority Date: 8 April 1982 (08.04.82) (33) Priority Country: US  (71) Applicant: WESTINGHOUSE ELECTRIC CORPORATION [US/US]; Westinghouse Building, Gateway Center, Pittsburgh, PA 15222 (US). (72) Inventor: THOMAS, Leslie, D. ; 104 Birchwood Road, Baltimore, MD 21228 (US). (74) Agents: RENZ, Charle, F. et al.; Westinghouse Electric Corporation, Research and Development Center, Patent Department, Pittsburgh, PA 15235 (US).</p>		<p>(81) Designated States: BE (European patent), DE (European patent), FR (European patent), GB (European patent), JP, NL (European patent).  Published <i>With international search report.</i></p>

(54) Title: AUDIO SCRAMBLER UTILIZING AN AUXILIARY CHANNEL FOR SYNCHRONIZING THE DE-SCRAMBLER



## (57) Abstract

An exemplary embodiment of the invention utilizing the video channel of a TV signal to transmit synchronizing codes for an audio scrambler (34). Scrambling of the audio is accomplished by digitizing the audio and adding (34) to each sample a pseudo-random digital number. The resulting digital numbers are converted to analog form for transmission. A digital signal specifying the starting point of the pseudo-random number generator is inserted (28) into the video portion of a line of the vertical blanking interval of the TV signal. At the receiving station, the digital number specifying the starting point of the pseudo-random number generator is utilized to set the starting point of a pseudo-random number generator (48) which generates numbers which are utilized to descramble (50) the audio.

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AUDIO SCRAMBLER UTILIZING AN AUXILIARY  
CHANNEL FOR SYNCHRONIZING THE DESCRAMBLER

BACKGROUND OF THE INVENTION

Field of the Invention:

The invention relates generally to audio transmission systems and more specifically to an audio transmission system in which the audio is first converted to a digital signal which is then scrambled and reconverted to an audio signal for transmission with the descrambler at the utilization point being synchronized using data transmitted via an auxiliary channel.

Description of the Prior Art:

Many techniques have been utilized in the prior art to scramble speech. These include bandwidth inversion, band splitting, rearrangements of segments of the speech as well as combining the audio with random signals of various types. In general, these systems either offered a relatively low level of security or a low quality signal, or both of these. Many of the low-level security and noise problems were related to the fact that relatively long segments of speech were utilized for purposes of scrambling and the synchronization between the scrambler and descrambler was relatively poor due to the narrow bandwidth of the synchronizing channel. These problems are substantially solved by the disclosed invention by using a broadband auxiliary channel for synchronizing the descrambler.



SUMMARY OF THE INVENTION

The invention comprises a method and apparatus for scrambling an audio signal. Scrambling is accomplished by sampling and digitizing the audio to produce digital numbers to which a random digital code is added. The digital numbers are then reconverted to an audio signal to produce a scrambled analog audio signal. This analog audio signal is then transmitted over a normal audio channel of limited bandwidth, for example, 15 KHZ.

Synchronization at the receiving station for purposes of descrambling is accomplished utilizing a parallel auxiliary channel of high bandwidth such as a TV video channel. In an exemplary system, a digital number specifying the starting point of the random number generator is transmitted during an unused video line of the vertical blanking interval.

Descrambling is accomplished by separating the digital number specifying the starting point of the random number generator from the TV signal and utilizing this number to set the starting point of a random number generator. The audio is sampled to generate a series of digital numbers which are subtracted from the random number to descramble the digitized audio signal. The digital numbers are then converted to analog and filtered to reproduce the original audio signal.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a generalized block diagram of the invention;

Figure 2 is a block illustrating the scrambling technique as applied to a TV signal;

Figure 3 is a diagram illustrating the transmission of the synchronization code during the vertical blanking interval of the TV video signal;

Figure 4 is a block diagram illustrating another embodiment of the invention in which a broad band channel is utilized to synchronize descrambling of an independent audio channel.



DESCRIPTION OF THE INVENTION

Figure 1 is a diagram illustrating a first embodiment of the invention. The basic scrambler digitizes the audio signal and combines the digitized audio signal with digital pseudo-random numbers. Synchronization signals and a digital pseudo-random signal for scrambling the audio signal are provided by a scrambler synchronization generator 10. Synchronizing data from the scrambler synchronization generator 10 is coupled to the input of a multiplexer 12 and combined with a data signal to generate a composite signal comprising the data signal and the synchronizing code. In general, the synchronization code contains relatively high frequency components in order to adequately synchronize descrambling of the audio signal. These high frequency components require the output signal of the multiplexer 12 to have a relatively high bandwidth. The composite output signal of the multiplexer 12, which includes a data signal combined with the synchronization code, is coupled to a transmitter 14 for transmission to a remote location. It is contemplated that the composite signal will be transmitted to a remote location by modulating a radio frequency carrier. Transmission is accomplished by coupling the composite signal to modulate an exemplary transmitter 14.

The pseudo-random digital numbers from the scrambler synch generator 10 are coupled to the input of an audio scrambler 16. The audio scrambler 16 digitizes the audio signal and combines the digitized audio signal with the pseudo-random numbers from the synchronization generator 10 to produce a scrambled digital signal. The scrambled digital audio signal is converted to a scrambled analog audio signal for transmission. Since the synchronizing code is transmitted over an independent broadband channel, the scrambled analog audio signal does not include any information for synchronizing the receiving station descrambler with the scrambler.

A conventional radio frequency analog transmitter 18 receives as an input the scrambled analog audio signal for transmission to the remote location. In most applications it is contemplated that transmission will be accomplished by modulating a radio frequency carrier with the scrambled audio signal. However, other transmission techniques are usable.

At the remote location a radio frequency receiver 20 detects the modulated radio frequency signal, recovers and couples the scrambled analog audio signal to a descrambler 22. A synchronization signal receiver 24 detects the output signal of the high bandwidth transmitter 14 and recovers from this signal the synchronization code which was originally generated by the scrambler and sync generator 10. This synchronization code is coupled to the descrambler 22 and utilized to synchronize a pseudo-random number generator to generate a pseudo-random signal which is utilized by the audio descrambler 22 to reproduce the descrambled audio signal. This system can be assembled using well known circuit techniques and apparatus. Descrambling is the inverse of the scrambling previously described.

The above-described system is most conveniently applied in situations where the data signal to the multiplexer 12 contains some unused time portions which may be utilized to transmit the synchronizing code. Typical examples of such a signal is a standard TV signal in which the unused lines of the vertical blanking interval can be conveniently used to transmit the synchronizing code.

Another embodiment of the invention, as applied to a standard TV signal, is illustrated in Figure 2. In this embodiment the standard TV signal is generated by a conventional color TV camera 26, for example. The composite video signal, including the video and all the normal TV synchronization signals, is coupled to a coding circuit 28 where the random number generator synchronizing code is inserted in the vertical blanking interval of the

video signal. Synchronization signals from the camera 26 are coupled to an analog-to-digital converter 30 to synchronize this circuit such that the audio input signal is sampled at a rate which is synchronized with the TV sync signals including the color burst. Pseudo-random digital numbers are sequentially generated by a random number generator 32. These pseudo random numbers are also synchronized with the TV sync signals, including the color burst. Scrambling of the audio signal is accomplished by coupling the digital output signals from the analog-to-digital converter 30 and the pseudo-random numbers from the pseudo-random number generator 32 to the inputs of a digital adder 34. The output signals of the adder 34 are coupled as in input to a digital-to-analog converter 36 to generate at the output of the analog-to-digital converter 36 the scrambled audio signal. Communication means 38, a standard TV transmitting system for example, receives as an input the scrambled audio and video signals for transmission to a remote location. Coding means may also include conventional apparatus for scrambling the video signal, if desired.

At the remote location both the audio and video signals are coupled to a video audio separation circuit of 40. The video signal, if scrambled, is descrambled using conventional techniques and coupled to a display 42 and to a synchronization separation circuit 44. The display 42 may simply be a conventional TV type display, for example. Sync separation circuit 44 separates the horizontal and vertical synchronizing pulses of the TV signal and the codes used to synchronize the random number generator 32. The horizontal synchronizing pulses, the vertical synchronizing pulses and the color burst signal are coupled to an analog-to-digital converter 46 to synchronize this circuit to sample the scrambled audio signal from the video audio separating circuit 40 at precisely the same rate that the audio signal was sampled at the point of origination. The digital numbers generated by the analog-to-digital con-

verter 46 and the pseudo-random numbers generated by the random number generator 48 are coupled as inputs to an adder 50. The adder 50 performs an inverse operation to the adder 34 to generate at the output of this circuit a digital, but descrambled audio signal. The descrambled audio signal is coupled to the input of a digital-to-analog converter 52 to generate a descrambled audio signal which is filtered by a filter circuit 54 to reproduce the original audio.

10           Figure 3 is a diagram illustrating the prior art technique used for coding the television signal for security purposes and for transmitting the synchronizing codes for the random number generators. This is the same technique used for coding the video signals as more fully  
15 described in U.S. Patent No. \_\_\_\_\_ and may be applied to scramble the video signal in the system illustrated in Figure 2. Each of the lines of the television signal beginning with the trailing edge of the horizontal sync pulse is divided into 910 sample periods which are  
20 synchronized with the color burst. At each sample period the video signal is digitized to generate a digital number which is stored in a memory. During the following line the stored values corresponding to sample counts 0 through  
25 143 are read from the memory and reconverted to analog form to regenerate the synchronizing information of the TV signal. Then the samples ranging from R to 887 are read followed by those corresponding to samples 145 to R+12. This results in portions of the video line being inter-  
30 changed for transmission. As more fully described in the above-referenced patent the value of R is a random number which is determined by a random number generator. This results in the transmitted video signal being scrambled. At the receiver the process is reversed to recreate the original video signal.

35           Since the above-described scrambling system requires a random number generator at both the point of origination and the point of use, it is necessary to

transmit synchronizing codes permitting the random code generator at the point of use to be synchronized to the similar generator at the point of origination. This synchronization code can be conveniently transmitted during the last line of the vertical blanking interval as illustrated in line 3 of Figure 3. Line 4 indicates a typical synchronizing code which is transmitted during the 17th (last) line of the vertical blanking interval. This technique can be used to transmit the sync codes for the random number generator illustrated in Figure 3. As is obvious from the above description the remainder of the lines of the vertical blanking interval are available for other uses.

Figure 4 illustrates another embodiment of the invention in which an independent audio signal is scrambled and descrambled using synchronizing signals transmitted over an independent high bandwidth channel such as a TV video channel. More specifically, a standard conventional TV signal is generated by a video signal generator 56. The video signal generator 56 also generates the conventional TV synchronizing signals which are coupled to a random number generator 58. The random number generator 58 is in turn coupled to a video combiner 60 to combine the synchronizing code for the random number generator with the TV signal. The TV audio signal in this embodiment is generated by the audio section 62 and in this embodiment is coupled directly to the TV transmitter 64 and transmitted without scrambling. In this exemplary embodiment, the video signal including the random number generator sync code and the unscrambled audio signal are coupled to conventional TV transmitting apparatus 64 for transmitting to a remote location.

An independent audio source 66 which is not associated in any way with the TV signal is generated by an audio source 66. This audio signal and random numbers from the random number generator 58 are coupled to the inputs of an audio scrambler circuit 68 of the type pre-

viously described. The scrambled audio signal of the audio scrambler 68 is transmitted to a remote location by an audio transmitting apparatus 70. At the remote location the television signal is received by a sync receiving  
5 circuit 72 and decoded to recover the synchronizing code and the TV sync pulses to synchronize the descrambling apparatus 74 as described in the previous embodiment. The second input to the descrambler 74 is the scrambled audio signal. The descrambler 74 descrambles the audio signal  
10 using techniques previously described with reference to other embodiments. This embodiment permits an audio scrambler to be synchronized by information transmitted over the non-related high bandwidth signal.

Depending on the specific techniques used above  
15 it may be necessary to phase-equalize the audio signal in order to prevent distortions due to sampling. Additionally, it may be necessary to introduce delays in either the audio transmission path or in the high bandwidth path in order to equalize the transmission delays in the two  
20 transmission paths.

All of the systems described above can be constructed utilizing readily available components and known circuit techniques. Therefore, no detailed schematic diagrams or list of the apparatus necessary has been  
25 included.

## CLAIMS:

1. A method for scrambling an audio signal comprising:
  - a) sampling said audio signal at predetermined time intervals to generate a digital number representative of the amplitude of said audio signal at the sampling time;
  - b) combining each of said digital numbers with a pseudo-random digital number to generate a scrambled digital signal;
  - 10 c) coupling said scrambled digital signal to an analog-to-digital converter to generate at the output of said analog-to-digital converter a scrambled analog audio signal;
  - d) transmitting said scrambled analog audio signal to a remote point via a first channel;
  - 15 e) transmitting synchronizing data to said remote point via a second channel;
  - f) detecting and utilizing said synchronizing data at said remote point to synchronize a pseudo-random number generator to generate a series of pseudo-random numbers;
  - 20 g) detecting said scrambled audio signal at said remote point and sampling said scrambled audio signal to generate digital numbers representative of the amplitude of said scrambled audio signal at the sampling time;
  - 25 h) combining said digital number with said pseudo-random numbers to generate a descrambled digitized audio signal;



i) coupling said descrambled digital audio signal to the input of a digital to analog converter to generate at its output a descrambled analog audio signal.

2. A method for scrambling an audio signal comprising:

5 a) sampling said audio signal at predetermined time intervals to generate a digital number representative of the amplitude of said audio signal at the sampling time;

10 b) combining each of said digital numbers with a pseudo-random digital number to generate a scrambled digital signal;

15 c) coupling said scrambled digital signal to an analog-to-digital converter to produce a scrambled audio signal;

d) transmitting said scrambled audio signal to a remote location via a first channel;

e) generating a pulsed digital code specifying the starting point of said pseudo-random digital code;

20 f) transmitting said pulsed digital code to said remote location via a second channel;

g) detecting said pulsed digital code at said remote location;

25 h) sampling said scrambled audio signal at said remote location to generate a series of digital numbers;

i) combining said series of digital number with said pseudo-random number to generate a descrambled digital audio signal;

30 j) converting said descrambled digital audio signal to an analog signal.

3. A method for scrambling an audio signal in accordance with claim 2 wherein said second channel is the video channel of a color TV system and further including the step of inserting said pulsed digital code in the video portion of a selected line of the vertical blanking interval.

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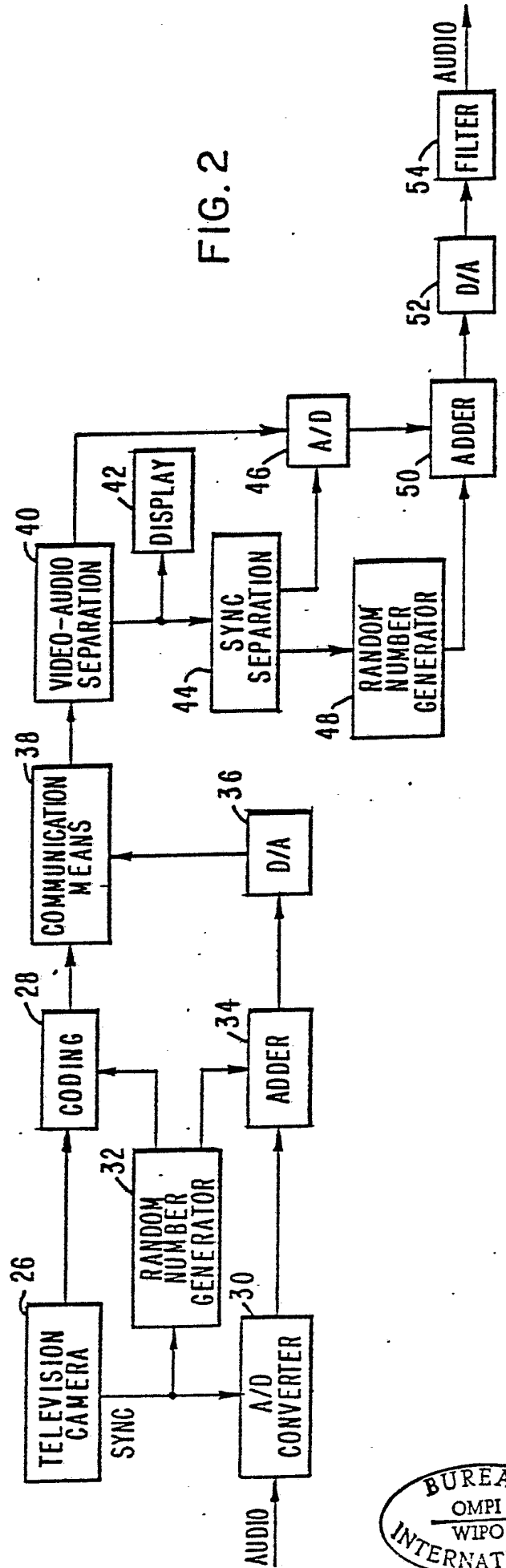
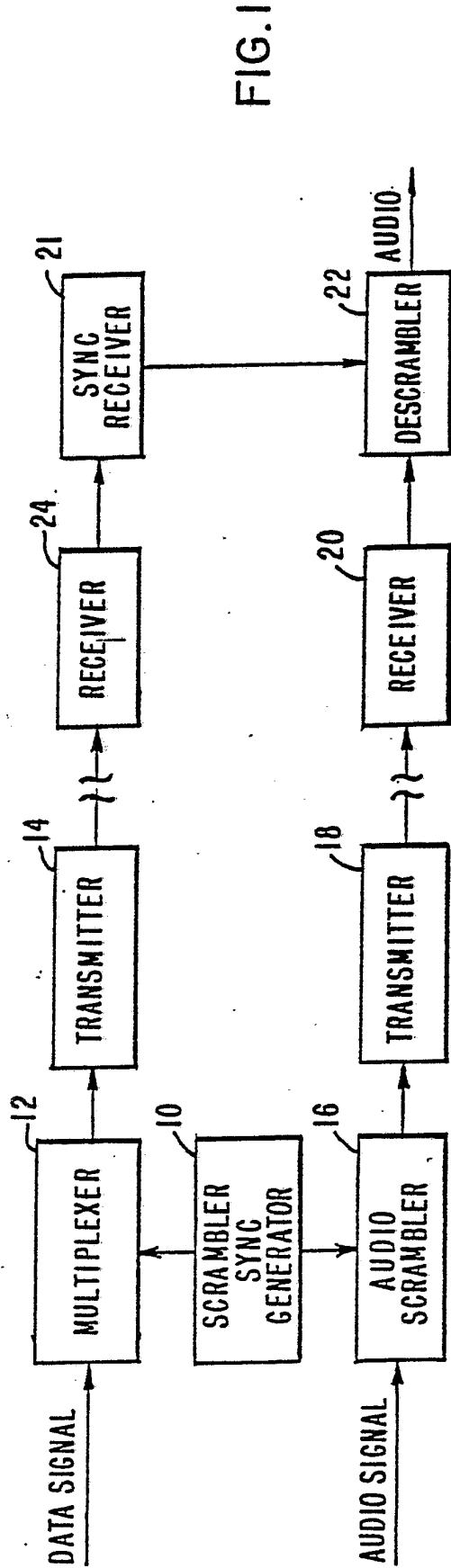
4. A method for scrambling an audio signal in accordance with claim 3 wherein the sampling rate of said audio signal is phase locked with the color burst of the TV signal.

5 5. A method for scrambling an audio signal in accordance with claim 4 further including the step of phase equalizing said scrambled analog audio signal at the point of utilization.

10 6. A method for scrambling an audio signal in accordance with claim 5 further including the introduction of time delays to equalize the transmission time of said first and second channels.

15 7. A method for scrambling an audio signal in accordance with claim 6 wherein said delay is introduced in said second channel.





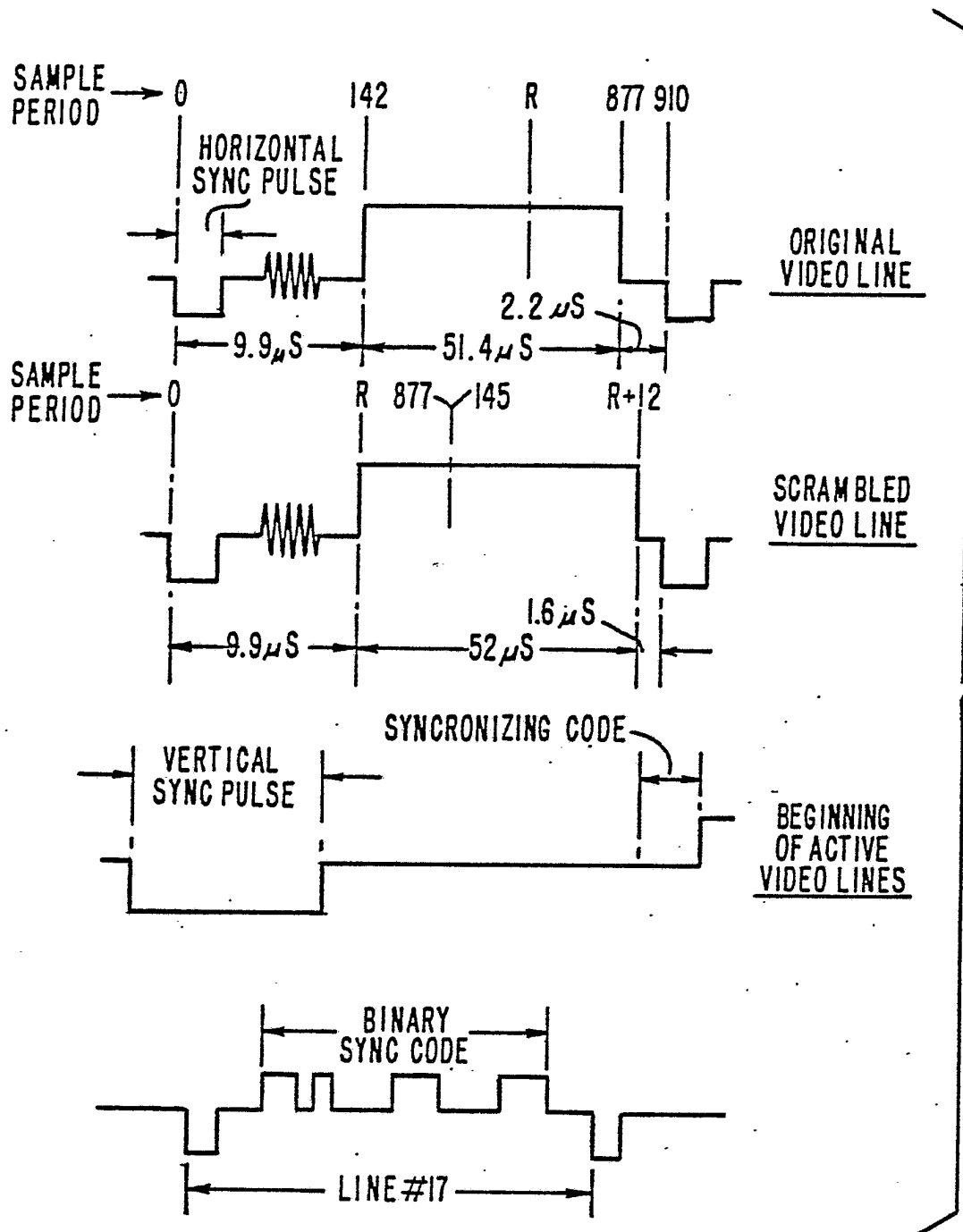


FIG.3

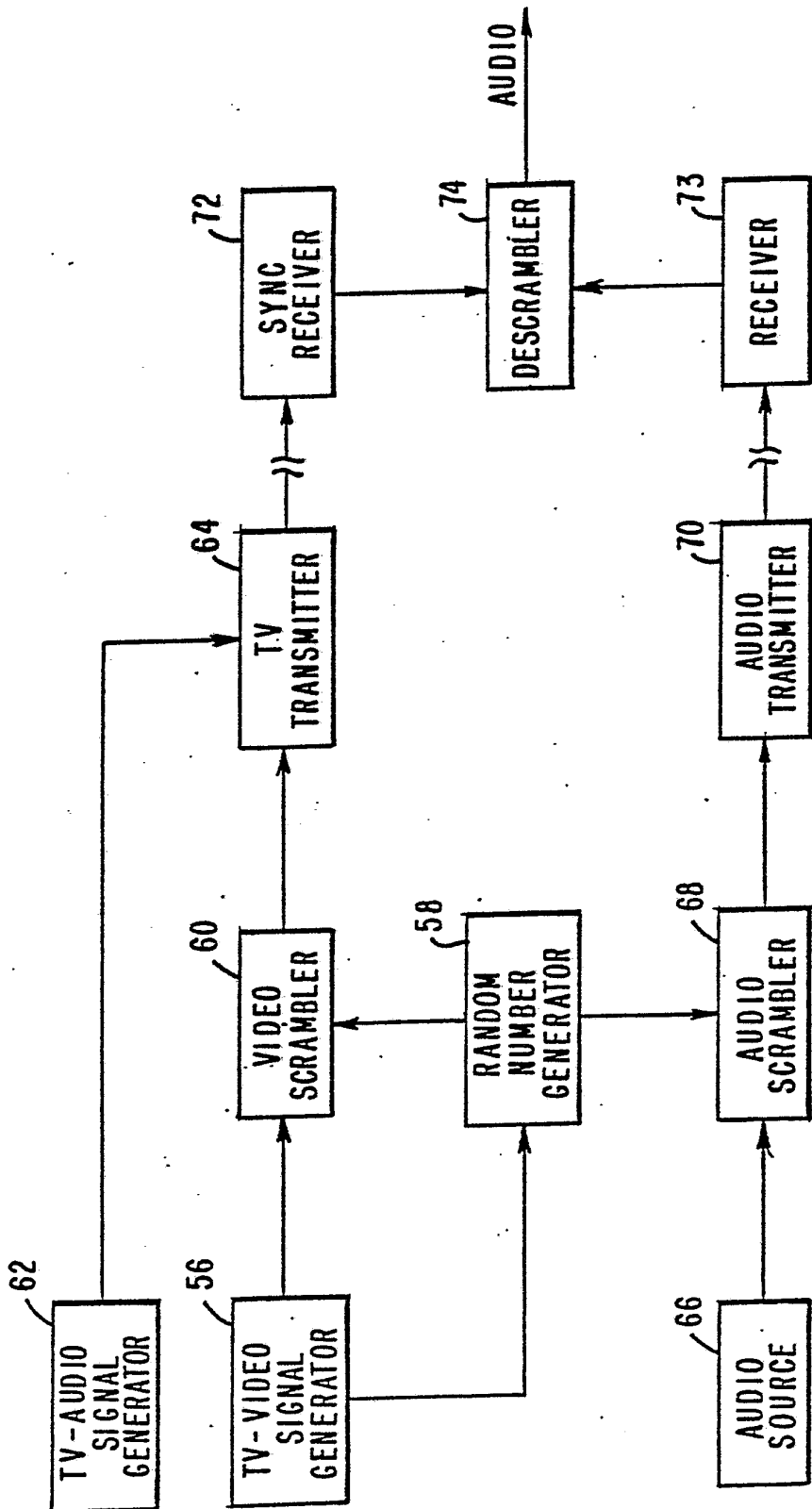
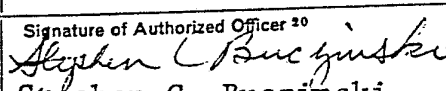


FIG. 4



# INTERNATIONAL SEARCH REPORT

International Application No PCT/US83/00408

<b>I. CLASSIFICATION OF SUBJECT MATTER</b> (if several classification symbols apply, indicate all) <sup>3</sup>		
According to International Patent Classification (IPC) or to both National Classification and IPC INT. CL. 3 H 04 N 7/16; H 04 M 1/70, 3/16 U.S. CL. 358/121; 179/1.5R, 1.5S		
<b>II. FIELDS SEARCHED</b>		
Minimum Documentation Searched <sup>4</sup>		
Classification System	Classification Symbols	
U.S.	358/121 179/1.5R, 1.5S	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched <sup>5</sup>		
<b>III. DOCUMENTS CONSIDERED TO BE RELEVANT</b> <sup>14</sup>		
Category <sup>6</sup>	Citation of Document, <sup>16</sup> with indication, where appropriate, of the relevant passages <sup>17</sup>	Relevant to Claim No. <sup>18</sup>
Y	US, A, 4,295,223 (Shutterly) 13 October 1981	1-7
Y	US, A, 3,746,799 (Gentges) 17 July 1973	1-7
Y	US, A, 4,221,931 (Seiler) 9 September 1980	1-7
A	US, A, 4,215,366 (Davidson) 29 July 1980	
A	US, A, 4,086,435 (Graupe Et Al) 25 April 1978	
A	US, A, 4,318,125 (Shutterly) 2 March 1982	
<p><b>* Special categories of cited documents: <sup>15</sup></b></p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"T" later document published 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</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"&amp;" document member of the same patent family</p>		
<b>IV. CERTIFICATION</b>		
Date of the Actual Completion of the International Search <sup>3</sup>	Date of Mailing of this International Search Report <sup>3</sup>	
08 July 1983	<b>15 JUL 1983</b>	
International Searching Authority <sup>1</sup>	Signature of Authorized Officer <sup>20</sup>	
ISA/US	 Stephen C. Buczinski	