April 1, 1947. D. D. GRIEG 2,418,116

MULTIPLEX SYNCHRONIZING SYSTEM

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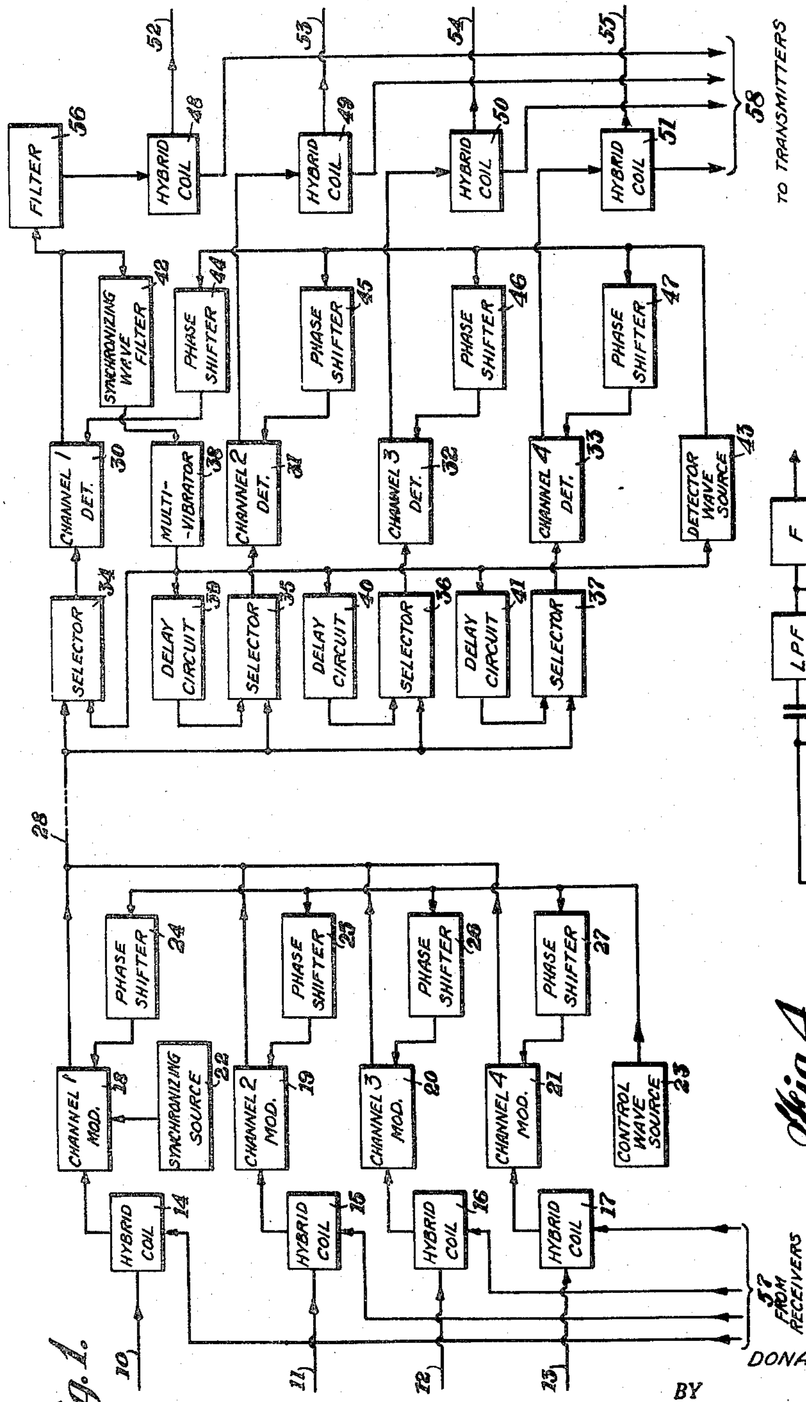

Fig. 1.

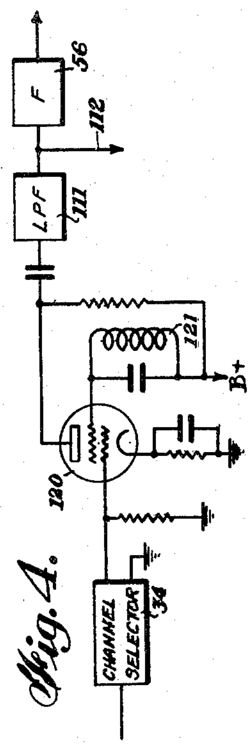

Fig. 4.

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Fig. 2.

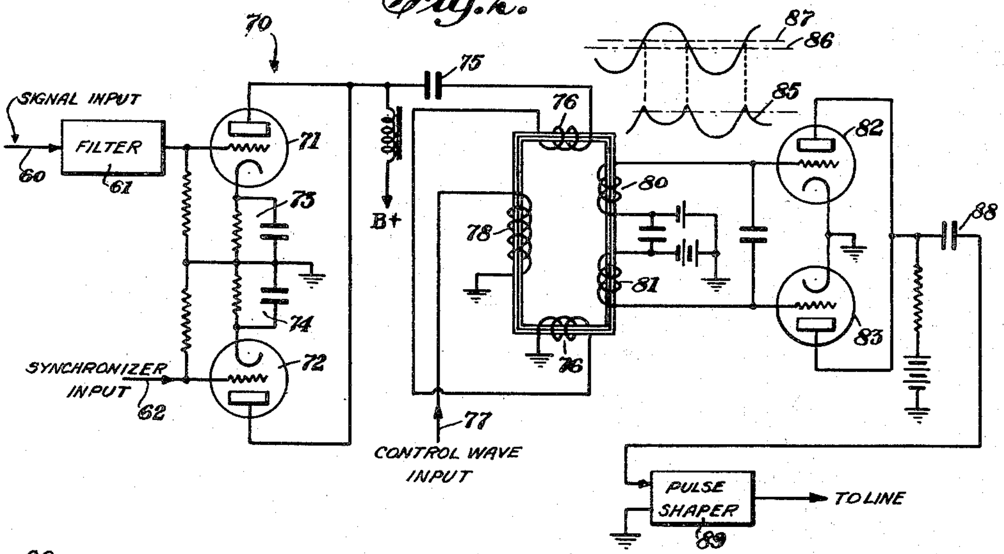


Fig. 3.

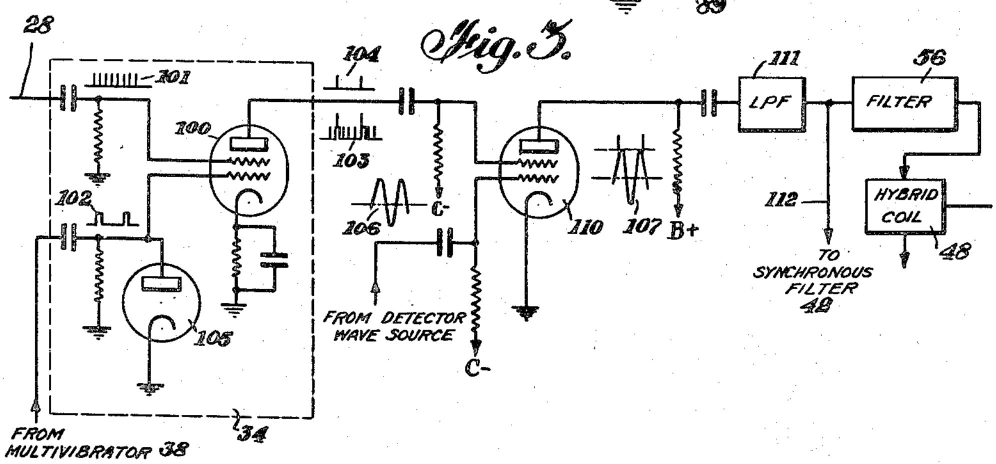
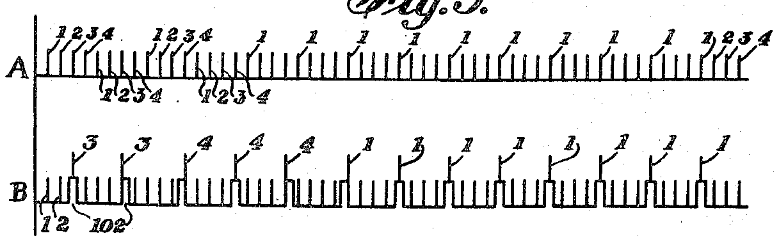


Fig. 5.



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MULTIPLEX SYNCHRONIZING SYSTEM

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20 Claims. (Cl. 179—15)

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This invention relates to synchronizing systems particularly adapted to synchronize multiplex pulse system channels to assure proper alignment thereof.

Multiplex communication systems have been proposed in which each channel comprises a train of spaced impulses. The pulses of each channel are spaced apart a predetermined distance and the pulses of each train are interleaved in such spaces so that a plurality of separate messages may be carried simultaneously on a common medium. In such systems the receivers are adapted to select a single channel, and some means must be provided to assure a proper alignment of each channel with its associated receiver. This may be done by a visual or aural monitoring circuit. Such monitoring, however, requires that an operator manipulate some control to effect the alignment.

It is an object of my invention to provide a synchronizing system and method for a multiplex pulse transmission system, which will assure proper automatic alignment of the pulse channels with a receiving system.

It is a further object of my invention to provide a receiver for receiving suitably modulated pulses, and effecting a proper alignment of a plurality of pulse channels in response to the modulation of the received pulses.

According to a feature of my invention, I provide, at the transmitting terminal of a multiplex pulse communication system, a synchronizing source which is used to modulate the pulses of one channel. At the receiving end is provided a selecting oscillator circuit operating at a frequency or cadence slightly lower than the cadence frequency of the pulses of a channel. The output wave from the selecting oscillator circuit serves to successively select pulses of the respective channels at successively different receivers. Thus, in normal operation, the selection progressively applies successively different channels to each receiver. In the output of one receiver circuit is provided a filter tuned to select the demodulated synchronizing signal and apply it to the selecting oscillator circuit to synchronize this oscillator to the normal pulse cadence frequency. Thus in effect this one receiver circuit successively tests the incoming channels to find the one having therein the synchronizing signal. Accordingly, when the progressive application of channels reaches the point where the modulated pulse series is applied to this one receiver, the oscillator is brought into synchronism and the successive application to different receivers is halted. The channels and receivers are so arranged that when the progression is halted the channels are each properly aligned with their associated receiver.

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The synchronizing system is adapted to line up any multiplex pulse system regardless of its purpose. It is contemplated for use more particularly, however, in communication systems wherein the pulses are modulated with different signals. These signals may be applied as amplitude modulation of the pulses, or some form of time modulation such as cadence frequency modulation, or time displacement modulation, or as pulse width modulation as desired. When "cadence frequency modulation" of pulses is employed the synchronizing signal must, of course, be chosen outside of the frequency band of the signals transmitted over the other channels or at least the frequency of the synchronizing signal must be excluded from the intelligence signals transmitted over the channels.

A better understanding of my invention and the objects and features thereof may be had from the particular description of an embodiment thereof made with reference to the accompanying drawing, in which:

Fig. 1 is a schematic block circuit diagram of a multiplex transmission system in accordance with my invention;

Fig. 2 is a circuit diagram of a time displacement modulator which may be used in the circuit of Fig. 1;

Fig. 3 is a circuit diagram of a selector and channel detector which may be used in the circuit of Fig. 1;

Fig. 4 is a modified form of channel detector for use in a circuit such as shown in Fig. 1; and

Fig. 5 is a pulse diagram illustrating the operation of a synchronizer in accordance with my invention.

In Fig. 1 is illustrated diagrammatically a multiplex channel system to which the principles of my invention have been applied. Incoming signals over lines 10, 11, 12 and 13 are applied over hybrid coils 14, 15, 16 and 17 to the respective channel modulators 18, 19, 20 and 21, respectively. In addition, energy from a synchronizing source 22 is applied to channel modulator 18. A control wave source 23 produces a switching control wave to sequentially energize channel modulators 18 to 21, respectively, over individual phase shifter units 24, 25, 26 and 27. Each of the channel modulators 18 to 21, inclusive, produces a series of pulses which are modulated to carry the desired message incoming over their respective lines 10, 11, 12 and 13. This modulation may be amplitude modulation, or some form of time modulation such as cadence frequency modulation, time displacement modulation or width modulation of the pulses. Through the operation of the control waves and the phase shifters, the pulses from the respective channels are applied to line 28 in such order that the pulses of the separate channels are interleaved one with another.

These pulses are then transmitted to the remote end of line 28 where they are applied to channel detectors 30, 31, 32 and 33 over individual channel selectors 34, 35, 36 and 37. At the receiving station is provided a channel selector wave generator 38 which is preferably a multivibrator producing square wave impulses at a cadence frequency slightly lower than the cadence frequency of the pulses of a channel. These square wave pulses are applied to selector 34 and over delay circuits 39, 40 and 41 to selectors 35, 36 and 37 so that incoming channels are selectively applied to the channel detectors 30, 31, 32 and 33, respectively.

Since the cadence frequency of the multivibrator pulses is slightly lower than the cadence of the pulses of the incoming channels, the channels will be progressively applied to different channel detectors. This progression will continue until such time as channel 1 is applied to the corresponding detector 30 for channel 1. At this time, in the output of channel 1, will be present the synchronizing voltage from source 22. This synchronizing voltage is picked off in synchronizing wave filter 42 and applied to multivibrator 38 to synchronize its operation to the average pulse cadence frequency. As a consequence, the incoming pulse channels will then be applied to the proper detector circuits without further progression and all the channels will be properly aligned. To operate the channel detectors a wave source 43 may be provided synchronized with the output of multivibrator 38 to produce a demodulating wave. This demodulating wave may be applied to channel detectors 30 to 33, respectively, over separate phase shifters 44, 45, 46, and 47. The detected outputs of the separate channels may then be applied over hybrid coils 48, 49, 50 and 51 to the corresponding audio frequency output lines 52, 53, 54 and 55.

Since energy from synchronizing source 22 is continuously applied to channel 1, a filter 56 is provided in the output of channel 1 to prevent application of this synchronizing source to the audio frequency line 52.

At the transmitting end of the line, receiver circuits may be coupled to the hybrid coils 14, 15, 16 and 17 by means of lines 57, and at the receiver transmitters may be coupled to hybrid coils 48, 49, 50 and 51 through lines 58.

Furthermore, at the receiver end of the line, individual demodulation control for the detectors 30, 31 and 32 may be provided, if desired, in which case demodulating wave source 43 and phase shifters 44, 45, 46 and 47 may be eliminated.

While only four channels have been illustrated for the purpose of simplifying the showing, it is clear that a much larger number of channels may be multiplexed in accordance with my system. The only limitation on the number of channels applicable to the line depends on the width of the pulses used, the cadence frequency necessary to carry the message and the amount of time displacement or width variation which may occur in the modulation circuits.

In Fig. 2 is illustrated a channel modulator suitable for use in the system, as illustrated in Fig. 1. In this arrangement the signal input may be applied over a line 60 and a filter 61 serving to eliminate the signal frequency corresponding to the frequency of the synchronizing source to a mixing circuit indicated generally at 70 simultaneously with synchronizing signals incoming over line 62. Mixer 70 comprises two vacuum tubes 71 and 72 suitably biased, for example, by cathode resistor bias means 73 and 74. The output circuit of these two tubes is connected in parallel and the combined waves are applied over a coupling condenser 75 to the input or modulating coils 76 of a time modulation circuit. The control wave from a source such as 23 is applied over line 77 to coil 78 of the modulator. This control wave, modulated with the other input waves, is applied over separate transformer connections 80, 81 to the grids of a pair of rectifier tubes 82, 83. These tubes, as shown, are similarly biased so that in the absence of modulating input the rectified wave will be uniform providing equally spaced peaks or cusps. The modulating voltages serve to alter the effective bias of the rectifiers between the limits shown at 86 and 87 and thus vary the positions of the peaks of wave 85 between limits on opposite sides of the unmodulated position, (e. g., as at curve 85) depending upon the modulation. These output peaks are then applied over a coupling condenser 88 to pulse shaper 89 which serve to narrow the pulses and produce the desired shape for transmission of the communication line. A more complete understanding of this type of time modulating transmitter arrangement may be obtained from a reference to copending application, Serial No. 455,897, filed August 24, 1942. It should be further understood that in the other channels where the synchronizing input is not required, this portion of the circuit may be eliminated. Likewise, filters 61 may not be necessary in all cases but are provided as a precautionary measure since without these filters anyone familiar with the operation of the synchronizing circuit at the receiver might apply a tone frequency to the line equal to the synchronizing frequency which would serve to improperly align the receiving channels.

In Fig. 3 is illustrated a circuit diagram of a selector and channel indicator arrangement which may be used in the system of Fig. 1 in conjunction with a transmitter arrangement, such as shown in Fig. 2. In this arrangement, selector 34 is shown to comprise a mixing tube 100. This tube preferably is of the double grid type in which the two grids are so arranged that the signals incoming on the separate grids tend to combine to increase the output of the tube circuit. The pulses 101 incoming over the line are applied to one of the grids and the selector waves 102 from multivibrator 38 are applied to the other grid. Tube 100 is biased beyond cutoff so that, in the absence of both signals being present at the same time, no output is obtained from the tube. Selector pulses 102 applied to their grid of tube 100 serve to partly remove the bias so that the tube is just below cut-off. When signal pulses 101 are applied while pulses 102 are present in the tube the combined pulses will appear as shown in the curve 103.

Because of the bias on tube 100, this tube serves as a clipper at the same time as it serves as a mixer and output pulses 104 are obtained therefrom. A rectifier 105 is coupled across the input of selector waves 102 so that these waves will always reach a predetermined constant maximum voltage level at the tube. It will thus be seen that the selector 34 serves to select only one train of pulses corresponding to a single channel.

In the demodulator circuit an alternating current wave 106 is applied simultaneously with the pulse train 104 to a mixing tube 110. The frequency of wave 106 is a harmonic of the control wave frequency, preferably, an even harmonic thereof. In tube 110 then will be produced the combined wave form 107. It is evident that the pulses 104 will be raised to different levels above the clipping voltage of tube 110, depending on their time position relative to detector wave 107. As a consequence, in the output of tube 110 will be present a plurality of pulses having an envelope frequency corresponding to the modulations of pulses 101. This output signal is then applied over a low-pass filter 111, which serves to remove the pulse cadence frequency, to line 112 leading to the synchronizing filter 42 and to filter 56 and hybrid coil 48. This same type of detector arrangement may be provided for each of the channels shown in Fig. 1. The control wave for the detector is shifted in phase properly to align it with the pulses of each of the selected channels.

In Fig. 4 is illustrated a modified form of receiver circuit eliminating the necessity of a separate control wave source, as is used in connection with the circuit of Fig. 3. In this arrangement, the selected pulses from channel selector 34 are applied to the detector tube 120. These pulses serve to excite a tuned tank circuit 121 at the average cadence frequency of the applied pulses. Thus, a detecting wave is generated directly in circuit 121 which combines with the incoming pulses to provide output pulses having a variable amplitude envelope in a manner similar in operation to the combining circuit described in connection with Fig. 3. This receiver circuit is of the type described more fully in my copending application Serial No. 459,959, filed September 28, 1942. The output pulses from 120 may be applied over low-pass filter 111 to filter 56 and to line 112 leading to the synchronizing filter arrangement.

In order more fully to explain the operation of the channel synchronizing system, reference may be had to Fig. 5. Curve A of this figure illustrates the pulse responding channels 1 to 4, inclusive. In curve B is shown the combination of pulses from the multivibrator selector arrangement and the incoming channel pulses. As illustrated in the curves, the channels first arrive at the receiving end in such position that channel 3 is initially selected. However, because the cadence frequency of the square wave pulses for multivibrator 38 is somewhat lower than the cadence frequency of the channel pulses, the selection progresses from channel 3 to channel 4 and from channel 4 to channel 1. Once channel 1 is selected, the synchronizing wave is able to effect control of the multivibrator circuit 38 and pull it into step so that channel 1 continues to be selected at this point. The other selector waves, because of the delay circuits are also then properly timed to select a single channel and apply it to the respective channel indicators.

For purposes of illustration, the cadence frequency is shown to progress by half of the pulse interval of the combined pulse trains, it should be clearly understood that in normal operation this progression would be much slower. Hence, upon reaching channel 1, a sufficient number of pulses will be detected during the period of transversal of the selector pulse to convey the synchronizing frequency to the multivibrator. It should further be understood that while the progression is relatively slow, the cadence frequencies for each channel are above normal audio frequencies, for example, in the range of 12 kilocycles or the like. Accordingly several hundred pulses may be selected from each channel without consuming an appreciable amount of time in bringing the circuit into proper synchronism.

While in the principal example given the selector system is shown used to align a plurality of multiplex channels it is clear that the principles of my invention may be applied for the purpose of causing selective operation of any one receiver to pick out a desired channel. For this purpose individual selector wave generators may be used with each receiver circuit as shown in connection with channel one. Individual selector wave generators, with synchronizing wave filters may be provided to pull the selectors into step with a channel to which the particular synchronizing frequency has been applied. Thus any channel may be selected by simply modulating it with the proper synchronizing wave.

This principle may also be used for selectively dropping or intercepting at an intermediate point in the line any desired channel or channels.

With a description of a specific embodiment and modifications thereof as given herein, it is clear that one skilled in the art may develop many other circuits and arrangements to accomplish the result in accordance with my invention. The specific example is intended merely as an illustration and not as a limitation on the scope of my invention, as set forth in the objects of the invention and the accompanying claims.

What is claimed is:

1. In a communication system having a first terminal means for transmitting a plurality of trains of pulses of a given average cadence each train representing a channel of communication, means for timing said separate trains of pulses in a given time displacement so that the pulses of successive trains are interleaved with respect to one another, and means for imparting to the pulses of one of said channels a modulation of a predetermined frequency; a second terminal having receiver means for said one channel, selector means for selecting a single channel for application to said receiver means, a selector wave generator operating at a cadence lower than said given average cadence, to supply a selector wave to said selector means, whereby it will serve to select progressively different channels for said receiver means, filter means coupled to the output of said receiver means for selecting said modulation of said predetermined frequency, and means for applying said selected modulations to said selector wave generator to synchronize its operation with said given average cadence, whereby said one channel will be continuously applied to said receiver means.

2. A multiplex system comprising a first terminal including, means for transmitting a plurality of trains of pulses of a given average cadence each train representing a channel of communication, means for timing said separate trains of pulses in a given time displacement so that the pulses of successive trains are interleaved with respect to one another, and means for imparting to the pulses of one of said channels a

modulation of a predetermined frequency; and a second terminal including individual receiver means for said trains of pulses, separate selector means each for selecting a single channel for application to corresponding receiver means, a selector wave generator operating at a cadence lower than said given average cadence to supply a selector wave to each selector means, whereby it will serve to select progressively different channels for respective ones of said receiver means, filter means coupled to the output of the receiver means for said one channel for selecting said modulation of said predetermined frequency, and means for applying said selected modulations to said selector wave generator to synchronize its operation with said given average cadence, whereby said channels will be continuously applied to their corresponding receiver means.

3. A multiplex system according to claim 2, further comprising means for signal modulating the pulses in each of said trains, means for translating the signal output from each of said receiver means, and means in the output of said one receiver between said translating means and said filter means for eliminating said selected modulations from said translator device.

4. A multiplex system according to claim 2, further comprising a plurality of sources of signals, a plurality of pulse generators, means for coupling said sources to said pulse generators to signal modulate said pulses, filter means in said coupling means to block signal frequencies of said predetermined frequency present at said signal sources from signal modulating said pulses.

5. In a multiplex system in which separate channels represented by separate trains of pulses of a given average cadence frequency, interleaved in time with respect to one another are transmitted to a receiver circuit in which the separate channels are selected and segregated and applied to separate receivers, the method of selecting said channels for proper aligned reception, which comprises modulating one of said channels with a synchronizing signal, selecting said channels in rotation with a selecting period longer than the period of said cadence frequency, whereby progressively different channels will be selected, detecting said selected channels, filtering out said synchronized signal at one of said receivers, and controlling said selecting period in response to said filtered synchronizing signal to make it correspond to said average cadence frequency, whereby upon selection of said one channel at said one receiver, said progressive selection of channels is halted.

6. A multiplex system comprising a first terminal, means for transmitting a plurality of trains of pulses of a given average cadence each train representing a channel of communication, means for timing said separate trains of pulses in a given time displacement so that the pulses of successive trains are interleaved with respect to one another to produce a resultant train having a given average spacing between adjacent pulses, means for modulating the pulses of the different trains with intelligence signals, means for imparting to the pulses of one of said channels a modulation of a predetermined frequency, a second terminal for receiving said trains of pulses for detecting the modulations thereon, separate selector means each for selecting a single channel, a selector wave generator operating at a cadence lower than said given average cadence, whereby it will serve to select progressively different channels for respective ones of said selectors, said selector wave generator serving to produce substantially rectangular pulses having a width less than said given average spacing to supply a selector wave to each selector, filter means coupled to the output of the selector for said one channel for selecting said modulation of said predetermined frequency, and means for applying said selected modulation to said selector wave generator to synchronize its operation with said given average cadence, whereby said channels will be continuously applied to their corresponding selectors.

7. A multiplex system according to claim 6, further comprising means for signal modulating the pulses in each of said trains, means at said second terminal for detecting signal output from each of said selectors, and further filter means in the output of the detecting means for said one channel for removing the modulation corresponding in frequency to said predetermined frequency from said detected signal output prior to application to further translator means.

8. A multiplex system according to claim 6, further comprising a plurality of sources of signals, a plurality of pulse generators corresponding in number to said plurality of trains, means for coupling said sources to said pulse generators to signal modulate said pulses, and filter means in said coupling means to block from said signals, frequencies of said predetermined frequency before modulation.

9. A multiplex system according to claim 6, further comprising a plurality of sources of signals, a plurality of pulse generators corresponding in number to said plurality of trains, means for coupling said sources to said pulse generators to signal modulate said pulses, filter means in said coupling means to block from said signals, frequencies of said predetermined frequency before modulation, means for detecting the signal output from each of said selectors, and means in the output of the detecting means for said one channel for removing the modulations corresponding in frequency to said predetermined frequency from said detected signal output at a point beyond said filter first named.

10. In a communication system in which a plurality of separate channels represented by separate trains of pulses of a given average cadence frequency, interleaved in time with respect to one another are transmitted to a receiver circuit in which the separate channels are selected and segregated and applied to separate receivers, the method of selecting one of said channels for reception at a given receiving station which comprises modulating one of said channels with a synchronizing signal, selecting said channels at said receiving station in rotation with a selecting period longer than said cadence frequency, whereby progressively different channels will be selected, detecting said selected channels, filtering out said synchronized signal at said receiver station, and controlling said selecting period in response to said filtered synchronizing signal to make it correspond to said average cadence frequency, whereby upon selection of said one channel at said receiver station, said progressive selection of channels is halted.

11. In a multiplex transmission system, a terminal having means for producing a plurality of trains of pulses interleaved together in a given sequence, the different trains representing different channels, means to effect intelligence modu-

lation of the pulses of respective channels, means to modulate the pulses of one channel carrying signal intelligence modulation with a given distinct signal for synchronizing control, a second terminal having means for receiving and synchronizing said respective channelled trains of pulses, comprising means for testing in succession said trains of pulses including a device responsive to the energy of said distinctive signal and means under control of said device in the presence of said distinctive signal in a tested train to discontinue the succession of testing.

12. A multiplex transmission system according to claim 11, wherein the testing means appertains to a particular receiver channel, and the receiving and synchronizing means comprises means for continuously producing relative rotation of the incoming and receiving channels when they are not in synchronism.

13. A multiplex transmitting system according to claim 11 having means associated with each of the channels except said one channel for removing energy corresponding to that of said distinct signal from such channels, thereby rendering said one channel distinctive for use as a synchronizing channel.

14. In a receiver system for reception of a given one of a plurality of trains of pulses interleaved together in time, the pulses of said one of the trains being modulated with a signal distinct from the modulation of the other of said trains; means for selecting the trains of pulses in succession including a device responsive to the energy of the distinctive signal, means to detect the signals of each train of pulses as they are selected, and means under control of said responsive device acting in the presence of energy of the distinctive signal in the detected signals to discontinue the succession of the selecting operation of said selecting means.

15. In a receiver system for reception of the signal intelligence modulation of a given train of pulses interleaved in time spaced relation with other trains of pulses, said given train being modulated with a synchronizing signal distinct from said signal intelligence modulation; means for selecting the trains of pulses in succession including filter means, means to detect the signals of each train of pulses as they are selected, said filter means passing only the energy of said synchronizing signal, means to apply said synchronizing signal energy to said selecting means to discontinue the succession of the selecting operation thereof, and a second filter means to pass the signal intelligence of said given channel and to block said synchronizing signal energy.

16. In a receiver system for multiplex reception of a plurality of trains of pulses interleaved together in time, one of said trains of pulses being modulated with a synchronizing signal distinct from a signal energy of the other trains; separate receiving channels for each of a predetermined number of said trains of pulses, means for selecting the trains of pulses in succession, means to detect the signals of each train of pulses as they are selected, filter means associated with one of said receiver channels for passing only the energy of said synchronizing signal, means to apply said synchronizing signal energy to said selecting means to discontinue the succession of the selecting operation thereof, and means controlled by said selecting means for rendering the separate receiving channels receptive to pulses of said trains in accordance with the interleaved timing of said predetermined number of trains of pulses.

17. In a communication system, means for producing a plurality of trains of pulses interleaved together in a given sequence, the different trains representing different channels, separate means for modulating a characteristic of the pulses of each of at least certain of said channels according to signal intelligence for such channel, means to modulate the pulses of one of said channels with a given signal frequency as distinguished from the varying frequencies of the intelligence signals of the other channels, thereby rendering said one channel distinctive for synchronizing purposes, a receiver, means to transmit the interleaved trains of pulses to said receiver, means for selecting the trains of pulses in succession including a device responsive to the energy of the distinctive signal, means to detect the signals of each train of pulses as they are selected, and means under control of said responsive device acting in the presence of energy of said distinctive signal in the detected signals to discontinue the succession of the selecting operation of said selecting means.

18. In a multiplex communication system, means for producing a plurality of trains of pulses interleaved together in a given sequence, the different trains representing different channels, separate means for modulating a characteristic of the pulses of each of at least certain of said channels according to signal intelligence for such channel, means to modulate the pulses of one of said channels with a signal frequency outside the frequency band of the intelligence signals of the other channels, thereby rendering said one channel distinctive for use as a synchronizing channel, a receiving terminal, means to transmit the interleaved trains of pulses to said receiving terminal, said terminal having a plurality of receiving channels corresponding to at least certain of said trains of pulses, means for selecting the trains of pulses in rotation, means to detect the signals of each train of pulses as they are selected, filter means associated with one of said receiver channels for passing only the energy of said synchronizing channel, means to apply said synchronizing energy to said selecting means to discontinue the rotation selecting operation thereof, and means controlled by said selecting means for rendering each receiving channel receptive to pulses of said trains in accordance with the interleaved timing of said certain trains of pulses.

19. In a receiver system for reception of a train of pulses having a given average cadence, the pulses being modulated with synchronizing signals, a normally blocked selector circuit, means for producing deblocking pulses at a cadence lower than said average cadence to deblock said selector circuit whereby said selector circuit is caused to scan in time, means to demodulate the signals of the pulses selected by said selector circuit, and means responsive to the presence of energy of said synchronizing signals in the demodulated signals to cause said deblocking pulse producing means to produce the deblocking pulses at said average cadence.

20. In a receiver system for reception of a train of pulses having a given average cadence, the pulses being modulated with synchronizing signals; the method comprising selecting increments of received energy at a lower cadence than said average cadence to scan in time until said increments coincide substantially with the pulses

of said train, demodulating the increments of signal energy, segregating the synchronizing signal energy, and controlling by means of the synchronizing signal energy the increment selecting operation to correspond with said average cadence.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,048,081	Riggs	July 21, 1936
2,105,016	Smith	Jan. 11, 1938
2,092,442	Colwell	Sept. 7, 1937

FOREIGN PATENTS

Number	Country	Date
555,993	British	Sept. 15, 1943