

Oct. 7, 1947.

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2,428,366

PULSE MULTIPLEX SYSTEM

Filed Feb. 8, 1945

3 Sheets-Sheet 1

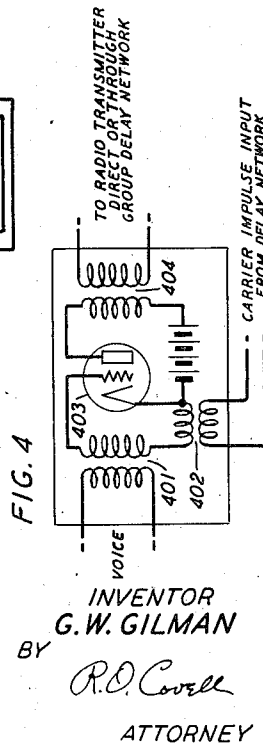
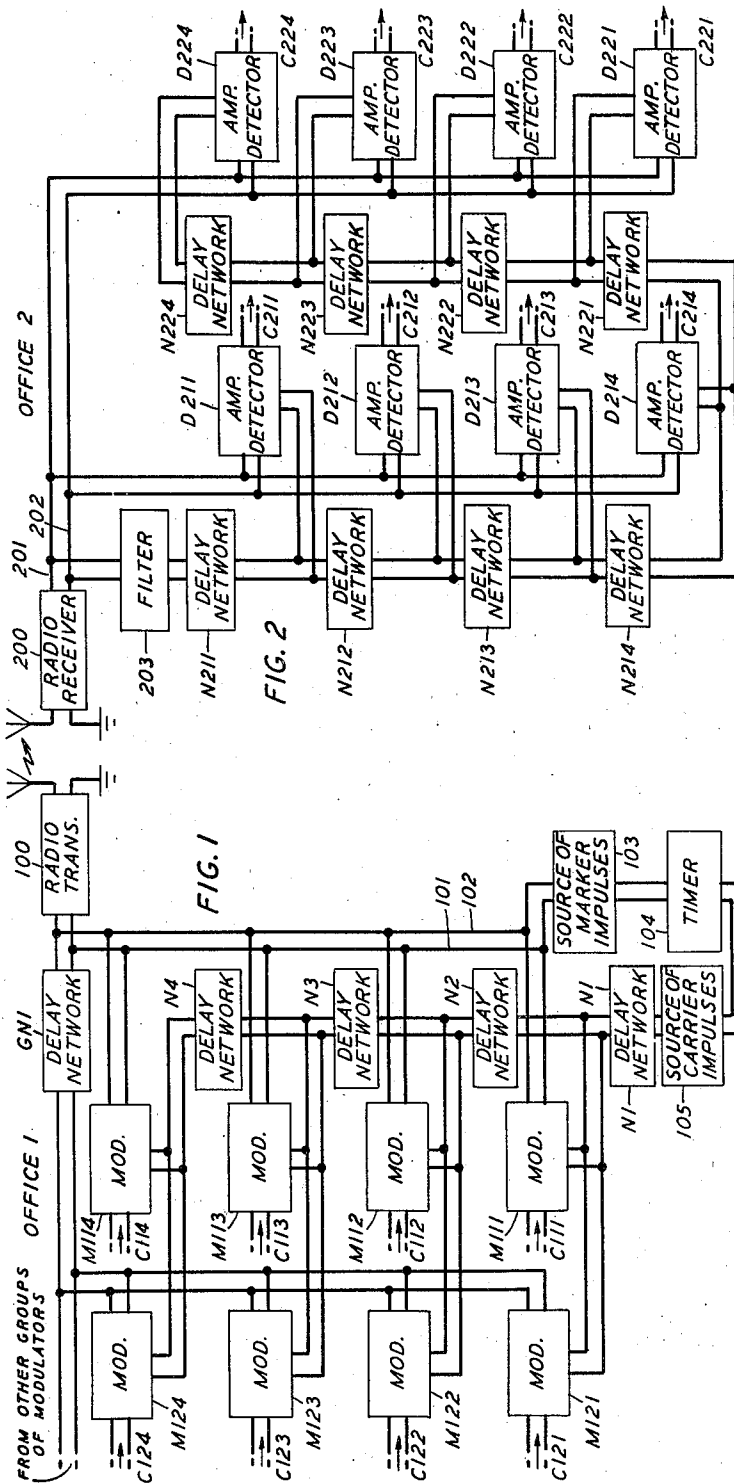


FIG. 4

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FIG. 6

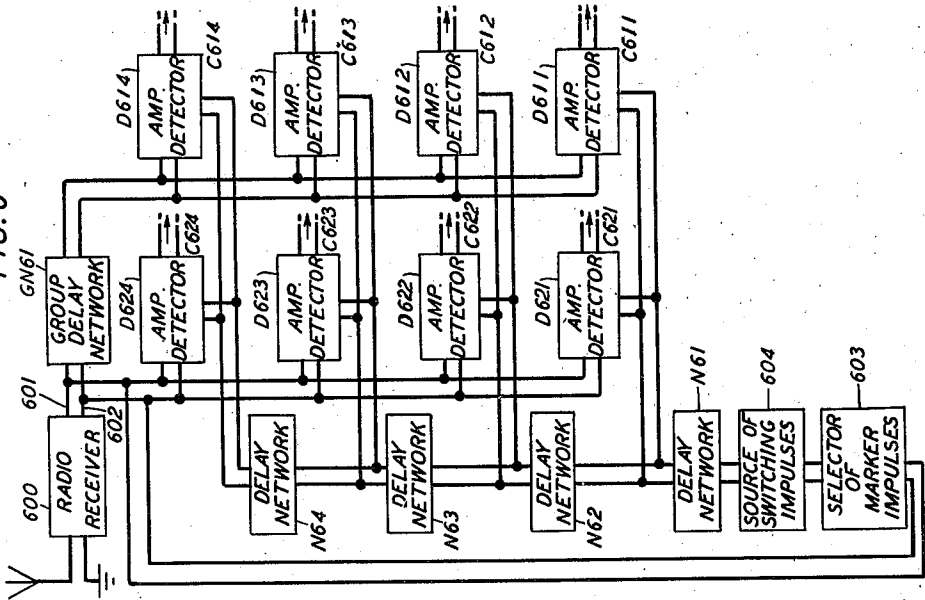
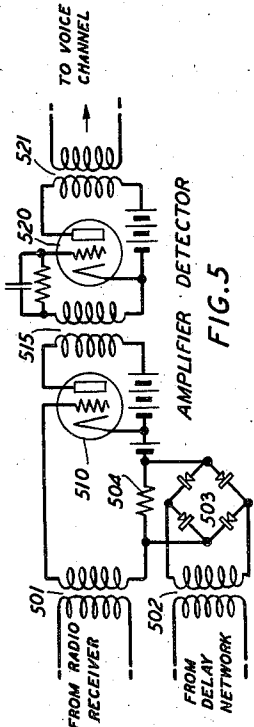
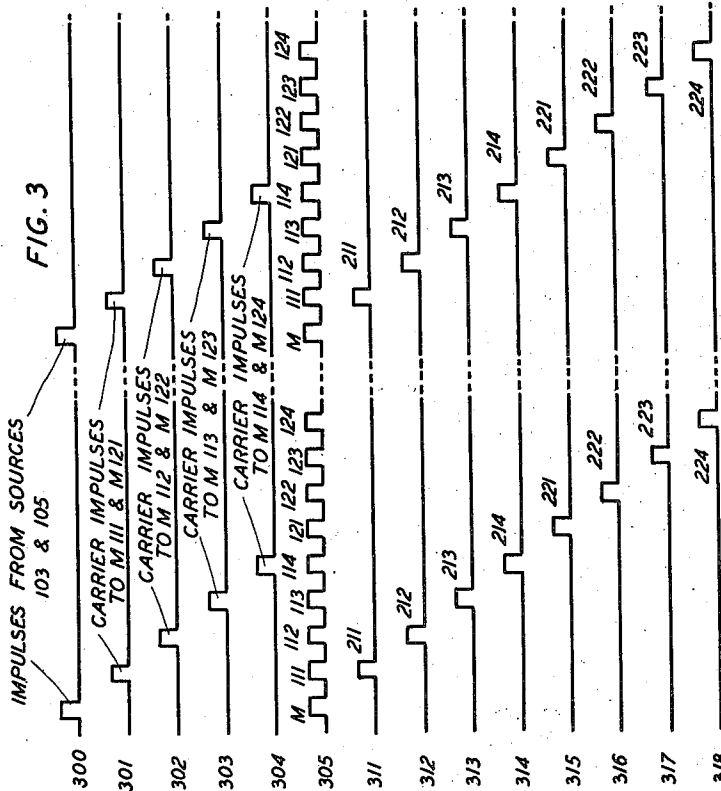


FIG. 3



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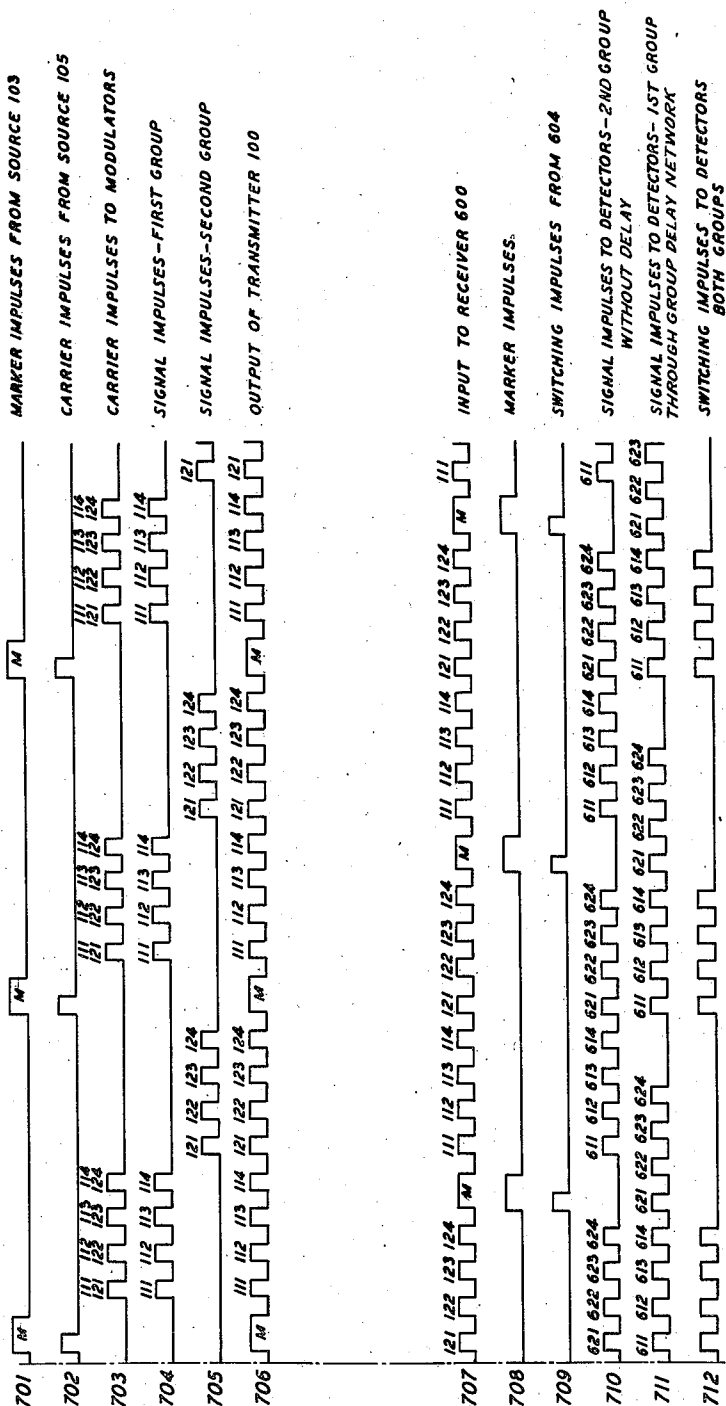
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FIG. 7



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2,428,366

PULSE MULTIPLEX SYSTEM

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Application February 8, 1945, Serial No. 576,834

10 Claims. (Cl. 179-15)

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This invention relates to multiplex transmission and particularly to time division multiplex in communication systems.

Objects of the invention are the provision of a multiplex transmission system of the time division type in which synchronization of the sending and receiving ends is attained without reducing the number of channels available for communication and in which channel commutation is effected by improved and simplified apparatus and circuit arrangements.

The invention is an improved multiplex transmission system of the time division type in which commutation is effected electrically by the cyclic application of carrier impulses to the modulator of each of a plurality of voice channels in succession.

A feature of the invention is a time division multiplex transmission system in which marking impulses of one frequency are transmitted directly to a common transmission medium and carrier current impulses are transmitted through delay networks in succession to each of the modulators of a plurality of voice frequency channels, whereby the transmission of each marking impulse over said common medium is followed by the successive transmission of the corresponding voice modulated carrier impulses from the modulators.

Another feature of the invention is a multiplex system of the time division type wherein timing or marking impulses incoming over a transmission medium are each applied through a chain of delay networks successively to each of a plurality of amplifiers, thereby to render the amplifiers effective to transmit each signal impulse following a marking impulse through the associated detector to a different voice channel.

A further feature of the invention is an arrangement of modulators common to a transmission medium in a time division multiplex system in which carrier impulses are transmitted successively through delay networks, the output of each network being connected to the carrier input conductors of a plurality of modulators one in each of a plurality of groups, whereby the modulators in each group are successively rendered effective to transmit a voice modulated carrier impulse to the transmission medium, group delay means being provided to delay the succession of voice modulated impulses from the modulators of the various groups so that the signal impulses of all modulators are successively applied one at a time to the transmission medium following each marking impulse applied thereto.

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A further feature of the invention is a receiving arrangement in a multiplex system of the time division type in which incoming marker impulses effect the generation of switching impulses which are transmitted through delay networks in succession to each of the amplifier detectors of a plurality of voice frequency channels, whereby each of the incoming voice modulated carrier impulses following each marker impulse is transmitted to a different voice frequency channel.

Another feature of the invention is a receiving arrangement in a multiplex system of the time division type in which the voice frequency channels and associated amplifier detectors are divided into groups corresponding to groups of modulators in the transmitting office, means being provided to delay the transmission of the voice modulated carrier impulses following each marker impulse to each group of amplifier detectors so that these impulses are applied to each group in succession, the marker impulses being effective to generate switching impulses which are transmitted through delay networks in succession to each of the amplifier detectors of the first group and at the same time to the corresponding amplifier detectors of the other groups, whereby each of the incoming voice modulated carrier impulses following each marker impulse is transmitted to a different voice frequency channel.

A clear and complete understanding of the invention will be facilitated by consideration of the system shown schematically in the drawing which forms a part of this specification, this system constituting a specific embodiment of the invention and its features. The invention is, however, not limited in its application to the system shown in the drawing but is generally applicable to multiplex transmission systems of the time division type.

Referring to the drawing:

Fig. 1 shows in a first telephone office a transmitting arrangement for a multiplex communication system of the time division type;

Fig. 2 shows in a second telephone office a receiving arrangement for a time division multiplex communication system having a transmitting arrangement according to Fig. 1;

Fig. 3 shows the relative spacing of the marking impulses, the carrier input impulses for each voice channel, the voice and carrier modulated radio impulses transmitted by the arrangement of Fig. 1, and the signal or voice impulses trans-

mitted to the various voice channels in the arrangement of Fig. 2;

Fig. 4 shows a modulator circuit suitable for use in the transmitting arrangement of Fig. 1;

Fig. 5 shows an amplifier-detector circuit suitable for use in the receiving arrangement of Fig. 2;

Fig. 6 shows a receiving arrangement alternative to that of Fig. 2; and

Fig. 7 shows the relative spacing of the marker, carrier, signal and switching impulses in a system comprising Figs. 1 and 6.

The telephone office shown in Fig. 1 comprises a radio transmitter 100 common to a plurality of groups of voice channels and associated individual modulators, two groups being shown. One group consists of voice channels C111, C112, C113 and C114 and modulators M111, M112, M113 and M114; and a second group consists of voice channels C121, C122, C123 and C124 and modulators M121, M122, M123 and M124. Each of the modulators may be similar to that shown in Fig. 4. While each of the groups is shown to consist of four channels each, the groups may consist of a larger number of channels. Two sources of alternating current are shown, the source 105 being a source of carrier current impulses for the modulators and the source 103 being a source of marking impulses each of which marks the beginning of a train of signal impulses, one from each modulator in succession. The marking impulse source 103 generates current of one frequency, for instance, 100,000 cycles per second and the carrier current source 105 generates current of some other frequency, for instance, 300,000 cycles per second, suitable for modulation by voice current. Timing means 104 controls both sources 103 and 105 to transmit impulses in synchronism at a desired rate, for instance, 10,000 impulses per second. The marking impulses are applied directly through conductors 101 and 102 to the input terminals of the radio transmitter 100. The carrier current impulses are applied to the modulators of each group through a train of similar delay networks N1, N2, N3 and N4 connected in series, there being as many of these networks as there are modulators in a group. A different modulator of each group is connected in parallel to the output side of each network and each of the networks delays each carrier current impulse for a like desired interval of time; so that the modulators in each group are successively rendered effective to transmit a voice modulated carrier current impulse to the radio transmitter. Thus the application of each carrier current impulse from source 105 to modulators M111 and M121 is delayed by network N1 for the desired interval following the transmission of the corresponding marking impulse from source 103 to radio transmitter 100; the application of each carrier current impulse to modulators M112 and M122 is delayed by networks N1 and N2 in series; the application of each carrier current impulse to modulators M113 and M123 is delayed by networks N1, N2 and N3 in series; and the application of each carrier current impulse to modulators M114 and M124 is delayed by networks N1, N2, N3 and N4 in series. Thus, the application of each marking impulse to the radio transmitter 100 is followed in succession by a voice modulated carrier current impulse from each of modulators M111, M112, M113 and M114 in the first group. A group delay filter GN1 connects the output of each of the modulators M121, M122, M123 and M124 in the second group to the radio transmitter

100; and each of the voice modulated carrier current impulses from each of these modulators is thereby delayed for an interval equal to the total delay of a carrier impulse by all of networks N1, N2, N3 and N4. Thus, the successive application of the voice modulated carrier current impulses from the modulators of the second group to the radio transmitter 100 follows the application of the voice modulated impulses from the modulators of the first group. If there are other groups of modulators, a group delay filter similar to GN1 will be provided for each such other group to delay the application of the voice modulated carrier impulses from the modulators of each group in succession.

Referring to Fig. 3 the line 300 represents the spaced application of marker impulses to the radio transmitter and the simultaneous transmission of carrier current impulses to the first delay network N1; the lines 301 to 304 represent the application of the corresponding carrier current impulses to the modulators of both groups; and the line 305 represents the spaced transmission of the voice modulated carrier current impulses from both groups of modulators, each marker impulse M being followed in succession by signal impulses 111, 112, 113, 114, 121, 122, 123 and 124 from the correspondingly numbered modulators.

The telephone office shown in Fig. 2 comprises a radio receiver 200 common to a plurality of amplifier-detector units and associated voice channels for selectively receiving signal impulses from the modulators and voice channels of Fig. 1. The receiver output is transmitted through conductors 201 and 202 to the input terminals of each of the normally non-responsive amplifier-detectors D211, D212, D213, D214, D221, D222, D223 and D224 associated individually with voice channels C211, C212, C213, C214, C221, C222, C223 and C224, respectively. Each of the amplifier-detectors may be similar to that shown in detail in Fig. 5. The radio receiver 200 is also connected to filter 203 which is tuned to pass the marker impulses from source 103 without passing the impulses successively transmitted from the modulators of Fig. 1. Thus each incoming marker impulse is applied through filter 203 and delay networks N211, N212, N213, N214, N221, N222, N223 and N224 in succession to the amplifier-detectors in succession. Each of these delay networks delays the marker impulses for an interval equal to the delay of the carrier current impulses in the delay networks of Fig. 1. Thus each marker impulse is applied through network N211 to render the amplifier-detector D211 responsive to the signal impulses from modulator M211; through networks N211 and N212 in series to render the amplifier-detector D212 responsive to the signal impulses from modulator M212; through networks N211, N212 and N213 in series to render the amplifier-detector D213 responsive to the signal impulses from modulator M213; through networks N211, N212, N213 and N214 in series to render the amplifier-detector D214 responsive to the signal impulses from modulator M214; through networks N211, N212, N213, N214 and N221 in series to render the amplifier-detector D221 responsive to the signal impulses from modulator M221; through networks N211, N212, N213, N214, N221 and N222 in series to render the amplifier-detector D222 responsive to the signal impulses from modulator M222; through networks N211, N212, N213, N214, N221, N222 and N223 in series to render the amplifier-

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detector D223 responsive to the signal impulses from modulator M223; and through networks N211, N212, N213, N214, N221, N222, N223 and N224 in series to render the amplifier-detector D224 responsive to the signal impulses from modulator M224. Thus the incoming signal impulses 111, 112, 113, 114, 212, 222, 223 and 224 represented in line 305 of Fig. 3 are selectively transmitted in succession through amplifier-detectors D211, D212, D213, D214, D221, D222, D223 and D224, respectively, as indicated in lines 311 to 318 of Fig. 3.

The modulator shown in Fig. 4 comprises a voice current input transformer 401, a carrier current input transformer 402, vacuum tube amplifier 403 and an output transformer 404. The amplifier-detector shown in Fig. 5 comprises a signal input transformer 501, a marker impulse input transformer 502 and rectifier 503, resistor 504, vacuum tube amplifier 510, coupling transformer 515, detector tube 520 and voice output transformer 521. The amplifier 510 is normally biased to the cut-off point. Each marker impulse is applied through transformer 502 and rectifier 503 across resistor 504, thereby to reduce the bias on the grid of tube 510 and thereby render this tube effective to amplify the signal impulse then being applied through transformer 501 to the grid. Any other known type of modulator and amplifier-detector, suitable for use in such a system, may be used in place of those shown in Figs. 4 and 5.

The alternative receiving arrangement shown in Fig. 6 for use with a transmitting arrangement similar to that shown in Fig. 1 comprises a radio receiver 600 and two groups of amplifier-detector units and associated voice channels. The first group includes the amplifier-detectors D611, D612, D613 and D614 individually associated with voice channels C611, C612, C613 and C614; and the second group includes the amplifier-detectors D621, D622, D623 and D624 individually associated with voice channels C621, C622, C623 and C624. The output of radio receiver 600 is directly connected by conductors 601 and 602 to the input side of each of the amplifier-detectors of the second group and is connected through a group delay network GN61 to the amplifier-detectors of the first group. The output of radio receiver 600 is also connected to the selector of marker impulses 603 which in response to each incoming marker impulse causes the generation of a switching impulse by source 604. The switching impulses thus generated are transmitted through delay networks N61, N62, N63 and N64 in succession. The switching impulses are thus applied to amplifier-detectors D611 and D621 at the same time; then to amplifier-detectors D612 and D622 at the same time; then to amplifier-detectors D613 and D623 at the same time; and last to amplifier-detectors D614 and D624 at the same time. Due to the delay introduced by group delay network GN61, the signal impulses from modulator M111 are applied to amplifier-detector D611 at the same time that the signal impulses from modulator M121 are applied to amplifier-detector D621; and at this time a switching impulse from network N61 renders these amplifier-detectors effective to pass signal energy into the associated voice channels C611 and C621. The signal impulses from modulator M112 are applied to amplifier-detector D612 at the same time that the signal impulses from modulator M622 are applied to amplifier-detector D622; and at this same time a switching impulse from net-

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work N62 renders these amplifier-detectors effective to pass signal energy into the associated voice channels C612 and C622. The signal impulses from modulator M113 are applied to amplifier-detector D623 at the same time that signal impulses from modulator M623 are applied to amplifier-detector D623; and at this same time a switching impulse from network N63 renders these amplifier-detectors effective to pass signal energy into the associated voice channels C613 and C623. Finally, the signal impulses from modulator M114 are applied to amplifier-detector D614 at the same time that the signal impulses from modulator M124 are applied to amplifier-detector D624; and at this same time a switching impulse from network N64 renders these amplifier-detectors effective to pass signal energy into the associated voice channels C614 and C624.

The relation of the marker, carrier, signal and switching impulses in a system comprising Figs. 1 and 6 is shown in lines 701 through 712 of Fig. 7. The legends adjacent these lines render them self-explanatory.

What is claimed is:

1. In a time division multiplex telephone system, a plurality of voice frequency channels, a modulator for each of said channels, a transmission medium, means connecting each of said modulators to said medium, a carrier current source, means for successively applying impulses of carrier current from said source to each of said modulators in succession thereby to effect the cyclic transmission of a voice modulated carrier impulse from each of said modulators in succession to said transmission medium.

2. In a time division multiplex telephone system, a plurality of voice frequency channels, a modulator for each of said channels, a transmission medium, means connecting each of said modulators to said medium, a carrier current source, means comprising timing means and delay networks for successively applying impulses of carrier current from said source to each of said modulators in succession thereby to effect the cyclic transmission of a voice modulated carrier impulse from each of said modulators in succession to said transmission medium.

3. In a time division multiplex telephone system, a plurality of voice frequency channels, a modulator for each of said channels, a transmission medium, means connecting each of said modulators to said medium, a source of marker impulses connected to said medium, means for generating carrier current impulses synchronized with said marker impulses, and means for transmitting each carrier current impulse to said modulators in succession thereby to effect the cyclic transmission to said medium of a marker impulse followed by a voice modulated impulse from each of said modulators in succession.

4. In a time division multiplex telephone system, a plurality of voice frequency channels, a modulator for each of said channels, a transmission medium, means connecting each of said modulators to said medium, a source of marker impulses connected to said medium, means for generating carrier current impulses synchronized with said marker impulses, and means comprising delay networks, one for each of said modulators, for transmitting each of said carrier current impulse to said modulators in succession thereby to effect the cyclic transmission to said medium of a marker impulse followed by a voice modulated impulse from each of said modulators in succession.

5. In a time division multiplex telephone system, a transmission medium carrying marker impulses of alternating current of a supersonic frequency, each marker impulse being followed by a plurality of signal impulses of voice modulated carrier current, said supersonic frequency being different from the frequency of said carrier current, a plurality of voice frequency channels, a detector for each voice channel, an amplifier connecting each detector to said transmission medium, means normally biasing each of said amplifiers to prevent the transmission of signal impulses to the associated detector, means comprising delay networks connected in series one for each of said amplifiers for transmitting each marker impulse to said amplifiers in succession, and means in each amplifier responsive to each marker impulse for rendering the amplifier effective to amplify the signal impulse carried by said transmission medium while the marker impulse is being applied to the amplifier.

6. In combination in a time division multiplex telephone system, a plurality of voice channels, a modulator for each channel, said modulators divided into a plurality of groups, a source of carrier current impulses, said impulses following each other in timed succession, means comprising delay networks connecting said source to said modulators, the output conductors of each network being connected to a plurality of modulators, one in each group and each modulator in a group to a different network, a transmission medium common to said modulators, and means including delay means connecting the modulators of said groups to said medium to cyclically transmit trains of voice modulated carrier impulses thereover, each train consisting of an impulse from each of said modulators in succession.

7. In a time division multiplex telephone transmission system, a plurality of voice channels, a plurality of modulators, one for each of said voice channels, said modulators divided into groups, a transmission medium common to said modulators, the modulators of one group being directly connected to said transmission medium, delay means including a delay network individual to each of the other groups of modulators connecting said other groups of modulators to said transmission medium, a source of carrier current impulses, said impulses following each other in timed succession, means comprising delay networks equal in number to the number of modulators in a group connecting the carrier current impulse source to said modulators so as to apply each carrier current impulse to said modulators, one modulator of each group at a time, means directly connecting the modulators of one group to said transmission medium, and means including delay networks, one for each of the other groups of modulators connecting said other groups of modulators to said transmission medium whereby a voice modulated carrier current impulse is applied to said transmission medium from each of said modulators in succession.

8. In a time division multiplex telephone transmission system, a plurality of voice channels, a plurality of modulators, one for each of said voice channels, said modulators divided into groups, a transmission medium common to said modulators, a source of timing impulses connected to said transmission medium, a source of carrier current and means for generating impulses of carrier current in synchronism with said timing impulses, means comprising delay networks equal in number to the number of modulators in a

group connecting the carrier current impulse generator to said modulators so as to apply each carrier current impulse to said modulators, one modulator of each of said groups at a time, means directly connecting the modulators of one of said groups to said transmission medium, and means including delay networks, one for each of the other of said groups of modulators, connecting said other groups of modulators to said transmission medium whereby a voice modulated carrier current impulse is applied to said transmission medium from each of said modulators in succession following each timing impulse applied thereto.

9. In a time division multiplex telephone system, a transmission medium carrying marker impulses of alternating current of a supersonic frequency, each marker impulse being followed by a plurality of signal impulses of voice modulated carrier current, said supersonic frequency being different from the frequency of said carrier current, a plurality of voice frequency channels, a detector for each voice channel, an amplifier connecting each detector to said transmission medium, means normally biasing each of said amplifiers to prevent the transmission of signal impulses to the associated detector, means responsive only to marker impulses for generating corresponding switching impulses, means comprising delay networks connected in series, one for each of said amplifiers, for transmitting each switching impulse to said amplifiers in succession, and means in each amplifier responsive to each switching impulse for rendering the amplifier effective to amplify the signal impulse carried by said transmission medium while the switching impulse is being applied to the amplifier.

10. In a time division multiplex telephone system, a plurality of voice channels, a transmission medium carrying marker impulses each followed by a plurality of voice modulated carrier current impulses in succession, one for each voice channel, a first group of amplifier-detectors, a second group of amplifier-detectors, each of said amplifier-detectors individually associated with a different one of said voice channels, means directly connecting the amplifier-detectors of said first group to said transmission medium, means including a group delay network connecting the amplifier-detectors of said second group to said transmission medium, means responsive to marker impulses received from said transmission medium for generating corresponding switching impulses, means comprising other delay network for applying each switching impulse to the amplifier-detectors of said first group in succession and at the same time applying each switching impulse to the amplifier-detectors of said second group in succession whereby the signal energy of each voice modulated carrier current impulse is transmitted to a different one of said voice channels.

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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
2,213,941	Peterson	Sept. 3, 1940
2,199,634	Koch	May 7, 1940