Feb. 25, 1941. O. E. PIERSON ET AL 2,233,347

MULTICHANNEL SIGNALING SYSTEM

Filed May 14, 1938 8 Sheets-Sheet 1

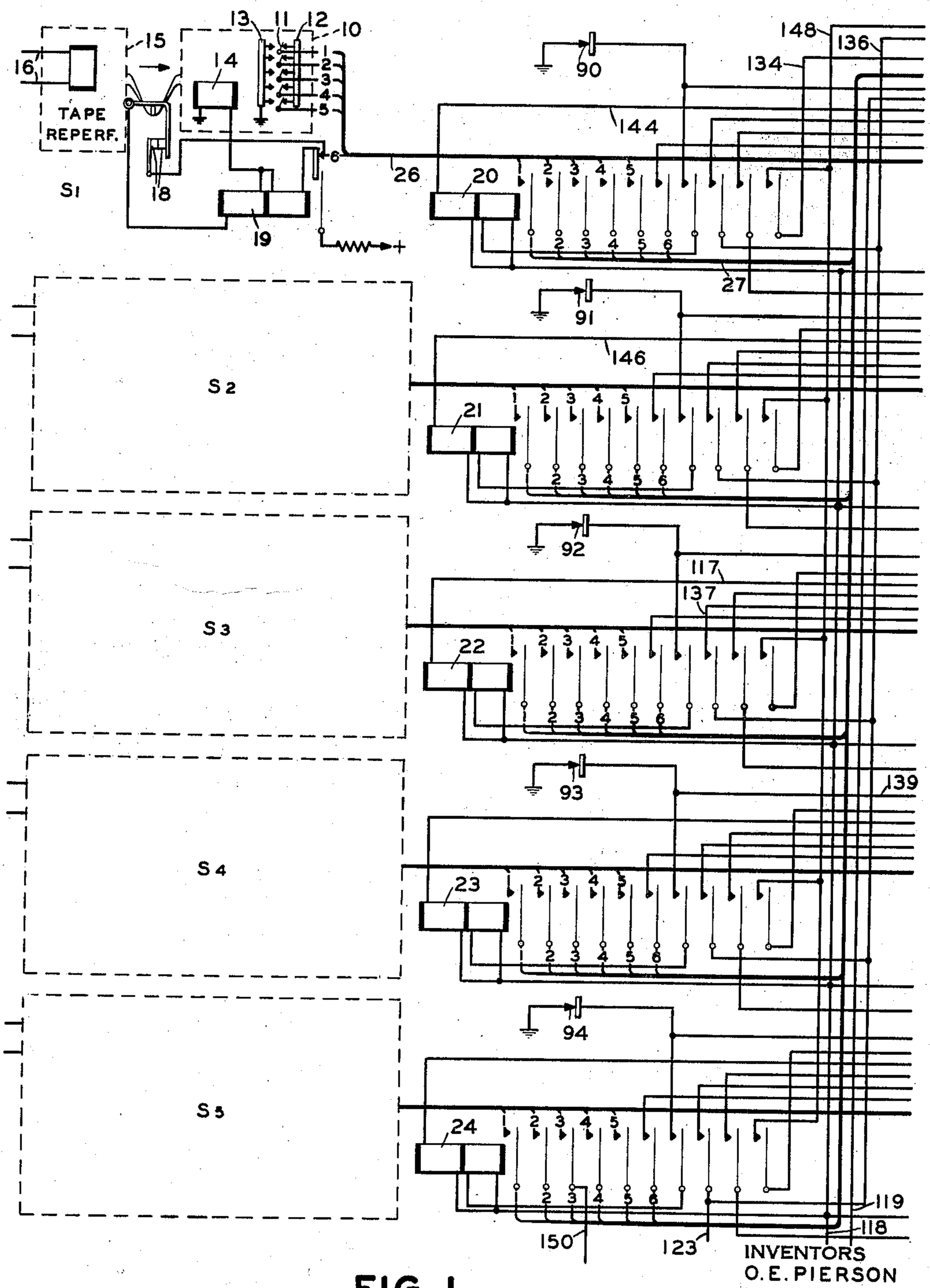

FIG. 1

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MULTICHANNEL SIGNALING SYSTEM

Filed May 14, 1938 8 Sheets-Sheet 2

FIG. 2

Feb. 25, 1941. O. E. PIERSON ET AL 2,233,347

MULTICHANNEL SIGNALING SYSTEM

Filed May 14, 1938 8 Sheets-Sheet 3

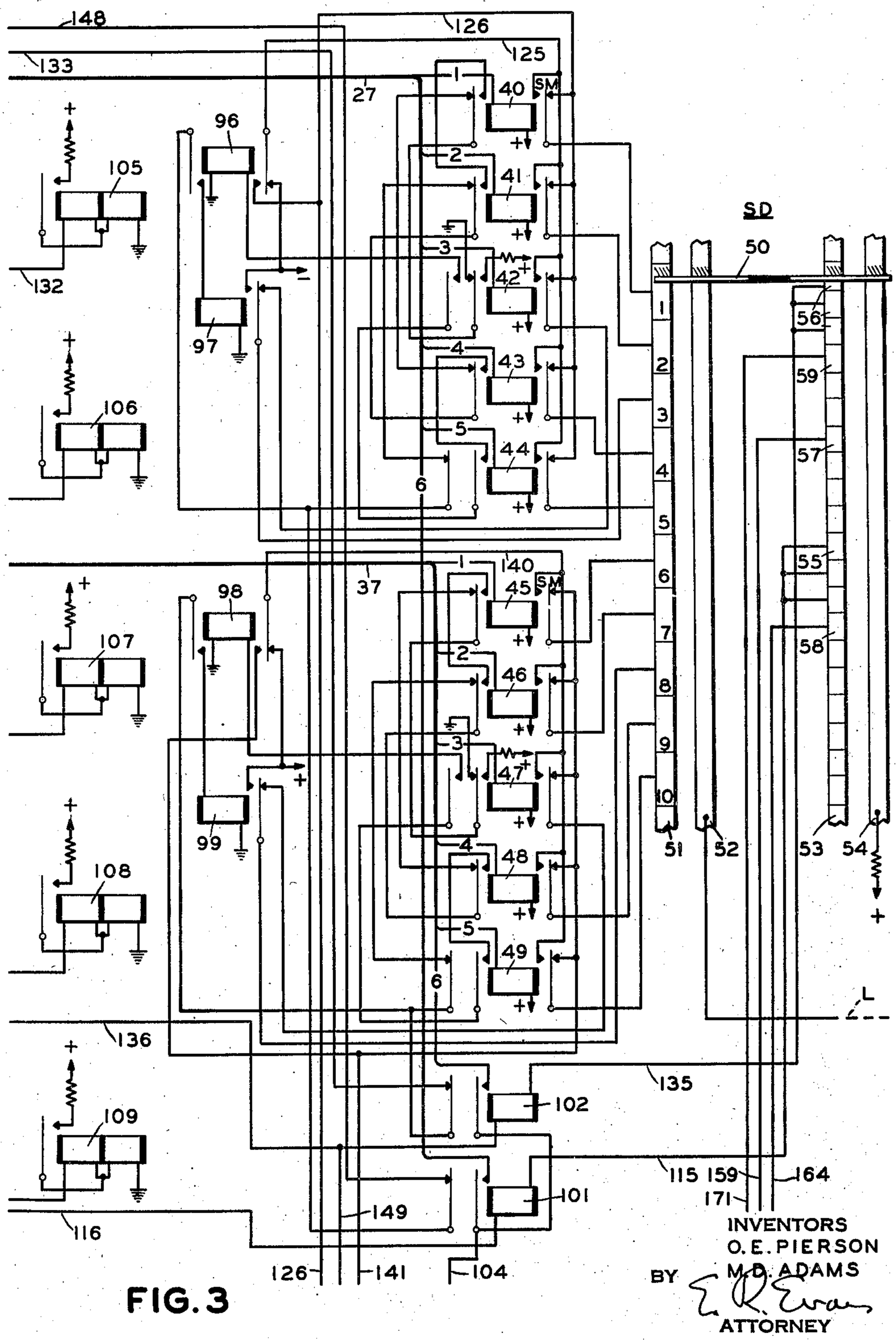

FIG. 3

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MULTICHANNEL SIGNALING SYSTEM

Filed May 14, 1938 8 Sheets-Sheet 4

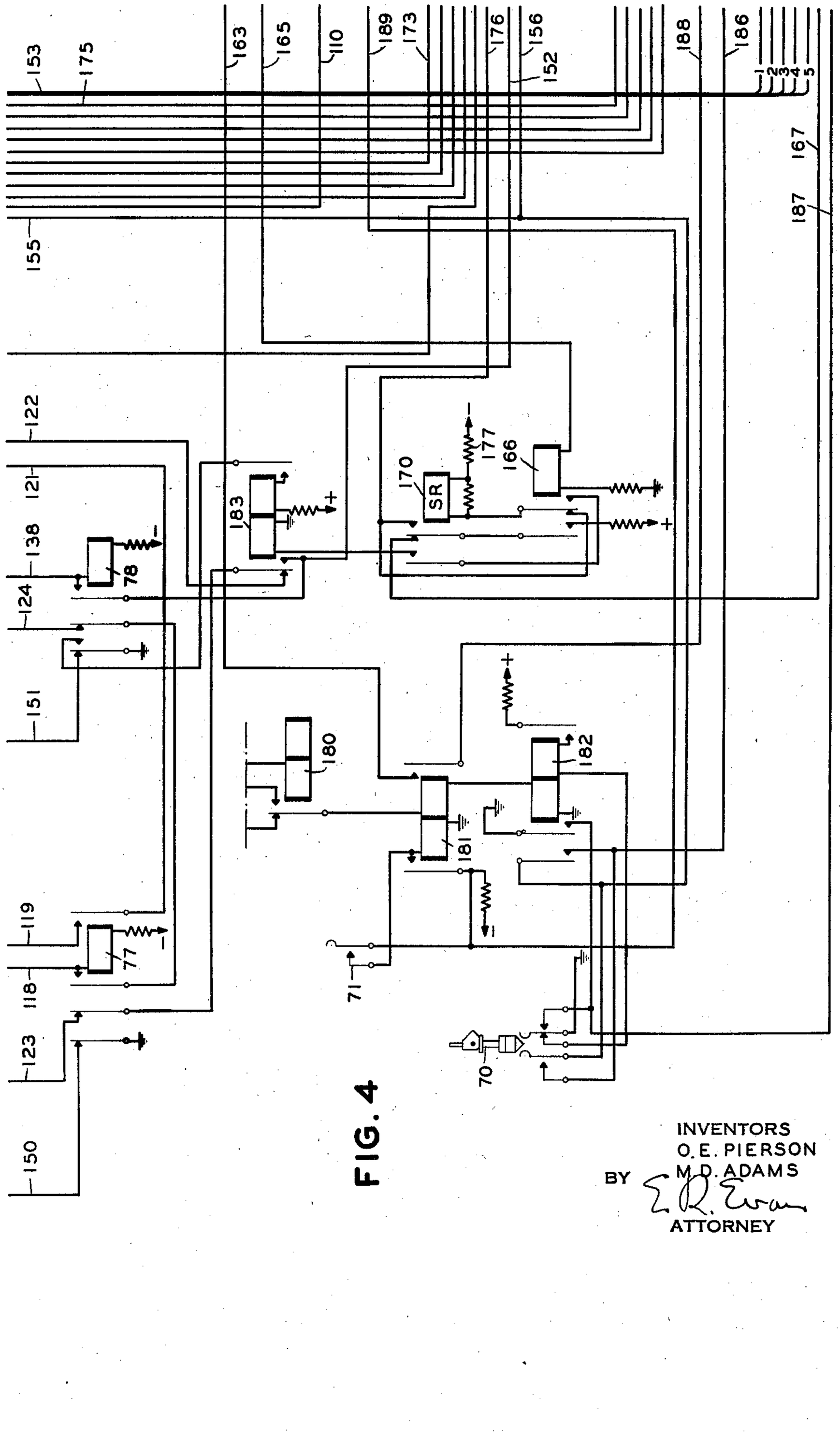

FIG. 4

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MULTICHANNEL SIGNALING SYSTEM

Filed May 14, 1938 8 Sheets-Sheet 5

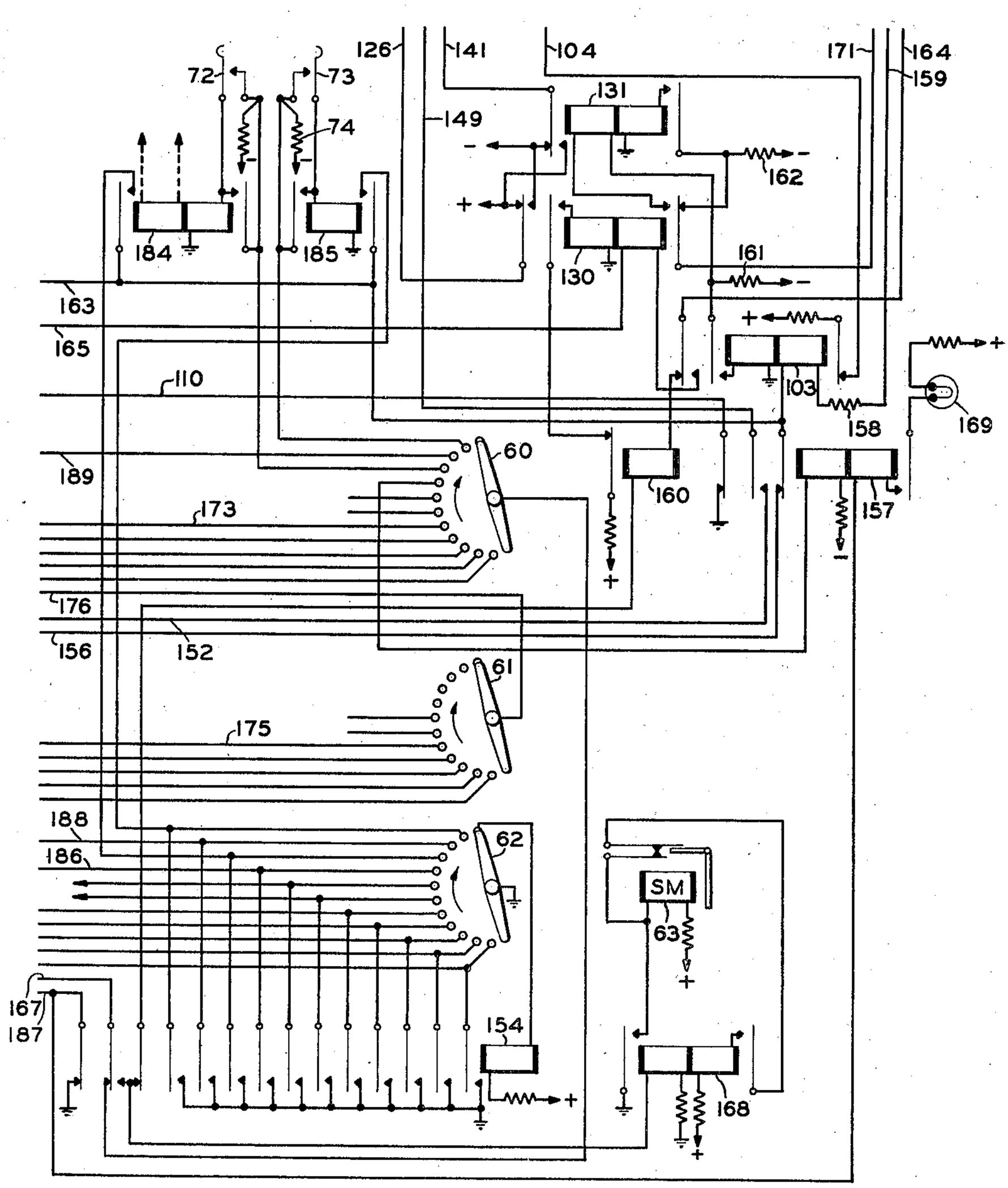

FIG. 5

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MULTICHANNEL SIGNALING SYSTEM

Filed May 14, 1938 8 Sheets-Sheet 6

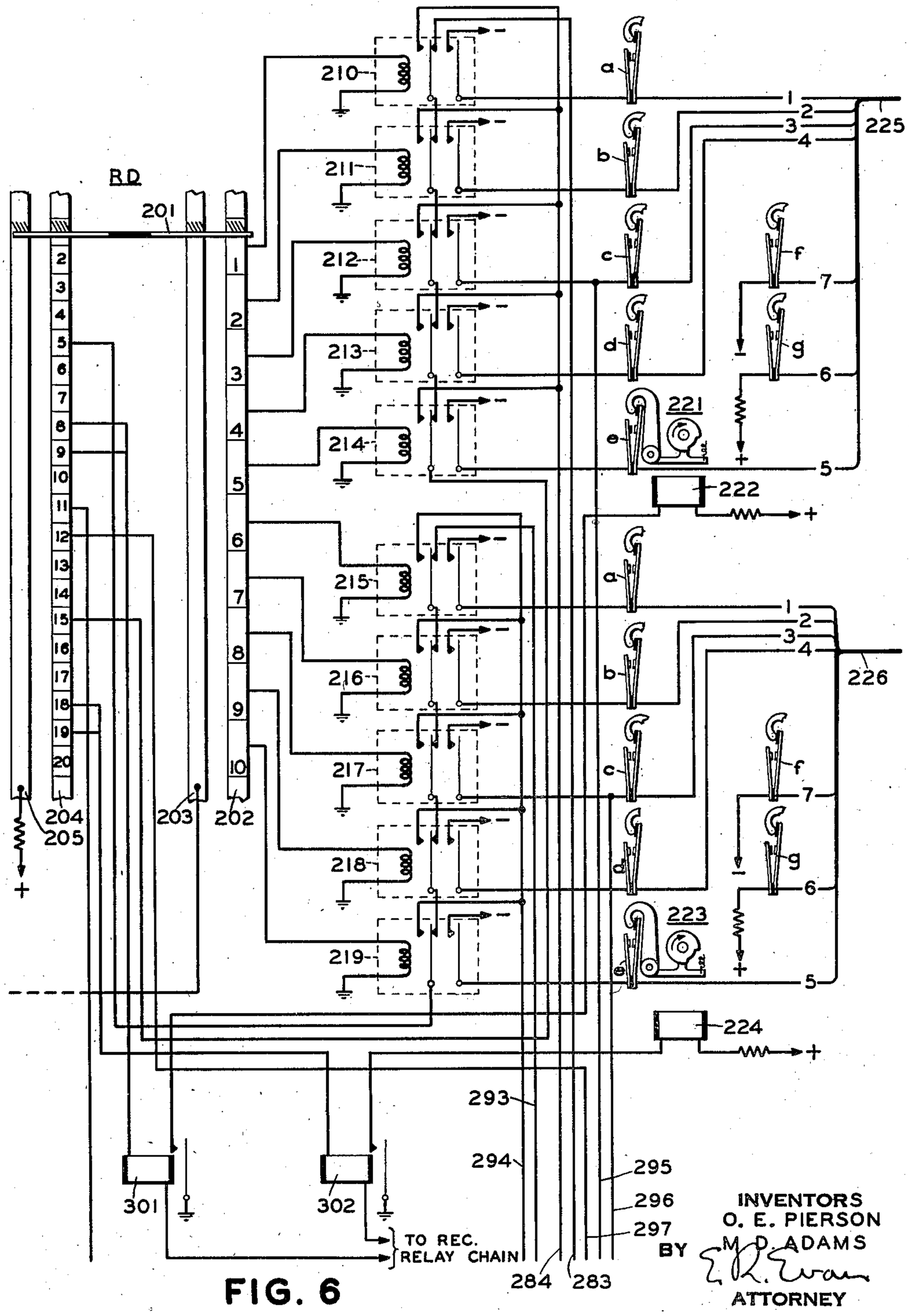

FIG. 6

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MULTICHANNEL SIGNALING SYSTEM

Filed May 14, 1938 8 Sheets-Sheet 7

FIG. 7

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MULTICHANNEL SIGNALING SYSTEM

Filed May 14, 1938 8 Sheets-Sheet 8

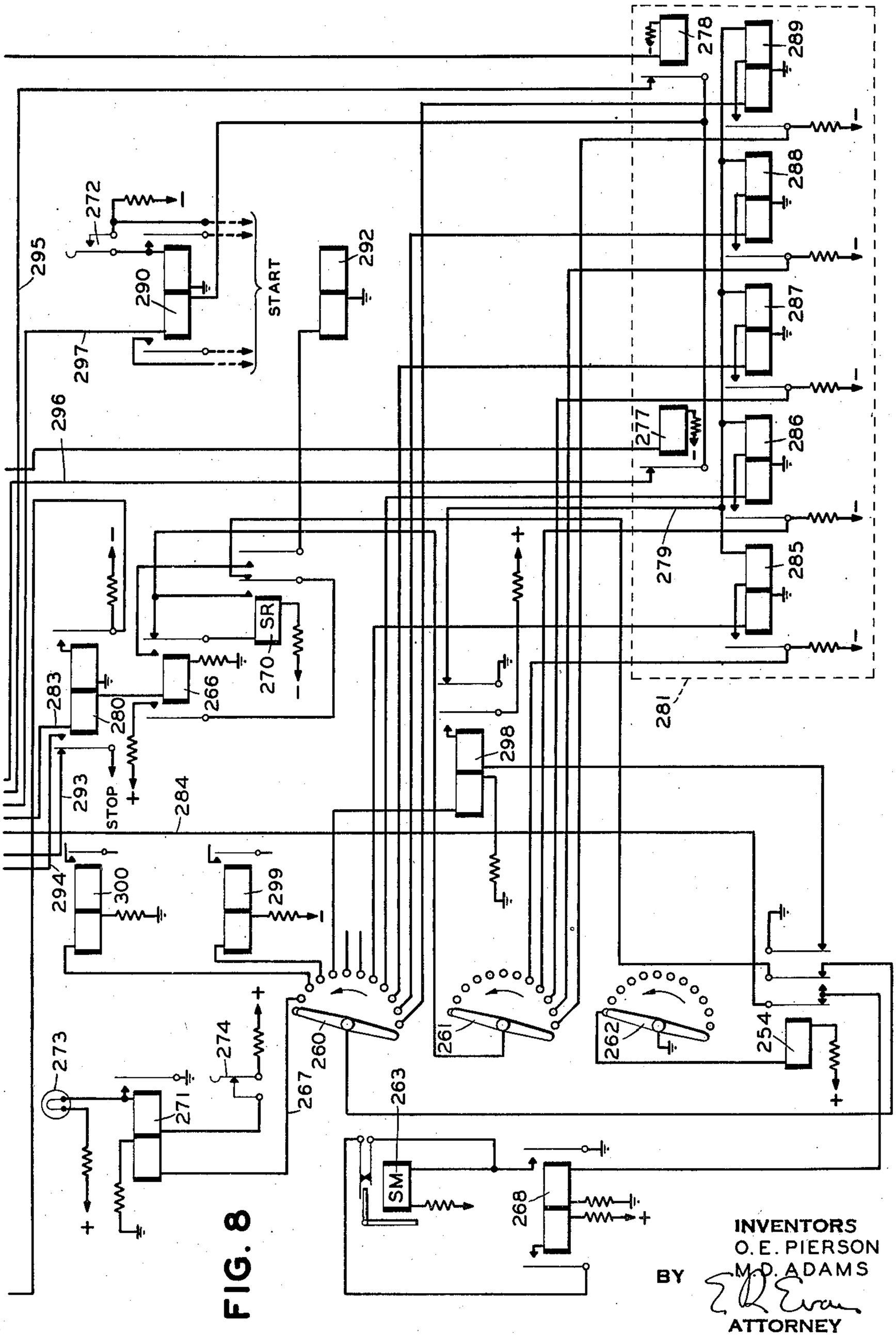

FIG. 8

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Patented Feb. 25, 1941 2,233,347

UNITED STATES PATENT OFFICE

2,233,347

MULTICHANNEL SIGNALING SYSTEM

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Application May 14, 1938, Serial No. 207,912

35 Claims. (Cl. 178—52)

This invention relates to signaling systems and more particularly to expanding-channel or varioplex telegraph systems wherein a channel or channels of a synchronous multiplex system are shared by a variable number of subchannels or sources of telegraph signals.

The term "expanding-channel system" as used herein refers to a system in which a variable number of telegraph transmitters or other sending devices are arranged to control receiving devices corresponding to each sending device over a lane of traffic, substantially the entire lane time in the preferred system being divided among the operating transmitters. The lane of traffic preferably comprises a plurality of channels of a synchronous multiplex system but may comprise a single channel of such a system, one or more wire or carrier current channels or combinations of different types of communication channels. Hence the expression "lane of traffic" as used herein designates any suitable route or medium over which signalling is accomplished.

The expanding-channel or varioplex system thus comprises a multi-channel system in which the number of subchannels operating over the connecting circuit or lane of traffic may be expanded or contracted by cutting in or out transmitting and receiving devices, the operative subchannels sharing the lane of traffic. The present invention relates particularly to a printing telegraph system of this character in which message characters are sent in sequence from one busy subchannel transmitter after another, omitting the idle or inoperative subchannels, although not limited to such systems.

One object of the present invention is to provide an expanding-channel system in which the means for connecting the respective subchannels to the lane of traffic for operation comprise a chain or series of connector relays with means for operating the relays in sequence while omitting the relays corresponding to inoperative subchannels.

Another object of the invention is to provide an expanding channel system having connector relays for connecting sub-channels to the lane of traffic, a group of relays for each channel of the lane of traffic comprising a relay individual to each subchannel in each of said groups, and in which the connector relays upon operating prepare a circuit for operating a relay in another of said groups.

Another object of the invention is to provide an expanding channel system having a series of connector relays for connecting subchannels to the lane of traffic with means for operating said relays in sequence to connect operative subchannels one after the other to the lane of traffic and in which the connector relays corresponding to operating subchannels remain operated under certain conditions, as for example when the number of operative subchannels does not exceed the number of channels provided by the lane of traffic.

Another object of the invention is to provide an expanding channel system having connector relays for connecting operative subchannels to the lane of traffic, each of said connector relays being provided with separate operating and locking windings, and means for controlling the circuits of one or both of said windings of the respective connector relays in accordance with the transmission of characters over the lane of traffic, as for example by a momentary current impulse from the multiplex distributor where the lane of traffic comprises a synchronous multiplex system.

Another object of the invention is to provide an improved relay chain for controlling a multiplicity of circuits, more particularly for connecting a plurality of circuits one after the other to another circuit or alternately to a plurality of other circuits.

Another object of the invention is to provide an expanding channel system in which the lane of traffic consists of a synchronous multiplex system, and a single distributor-transmitter for each multiplex channel, each distributor-transmitter being common to all of the subchannels.

Another object of the invention is to provide an expanding channel system in which the lane of traffic consists of a synchronous multiplex system, said expanding channel system including means for transmitting a predetermined character such as "figures shift" over a channel or channels of the multiplex system during idle periods.

Another object of the invention is to provide an expanding channel system having improved means for cutting the receiving ends of subchannels in and out and in which transmission is automatically stopped if a switching signal is distorted in transmission or if a partial switching signal is generated as a result of transmission errors.

Another object of the invention is to provide an expanding channel system having improved means for cutting subchannels in and out in response to ordinary code combinations not required for communication purposes and

for deleting such code combinations if they are inadvertently transmitted from the sending keyboard or tape transmitter.

Another object of the present invention is to provide an expanding channel system embodying improved control functions, for example arrangements permitting the operator or attendant at the transmitting station to stop transmission to him from the remote station as well as to stop his own transmission; and an arrangement to instantaneously release all subchannels at the sending and receiving ends to reallocate the subchannels.

Another object of the invention is to provide an expanding channel system with control channels which are independent of the connecting means for associating transmission subchannels with the lane of traffic so that failure or lack of synchronism of the connecting means for the communication subchannels will not interfere with the operation of the control channels.

Another object of the invention is to provide an expanding channel system having synchronous control switches at the sending and receiving stations and means including said switches for associating and disassociating subchannels from the system in accordance with the busy or idle condition thereof.

Another object of the invention is to provide an expanding channel system having step-by-step switches at the sending and receiving stations arranged to enter subchannels which have traffic to send and also providing auxiliary control channels, for example, for controlling the operation of the apparatus at one station from the remote station.

Another object of the invention is to provide an expanding channel system with auxiliary control means by which transmission may be stopped and started from either the local or the remote station without introducing errors into subsequent transmission.

Another object of the invention is to provide an expanding channel system having automatic means for entering and cutting out subchannels and means for automatically stopping transmission if the subchannel connecting means at the sending and receiving stations falls out of synchronism.

For a better understanding of the present invention reference may be had to the accompanying drawings, the eight figures of which taken together constitute a circuit diagram of a system embodying the invention.

Figs. 1 to 5 inclusive represent the transmitting apparatus at one station and Figs. 6, 7 and 8 represent the receiving apparatus at a remote station. It will be understood that the system is ordinarily arranged for two-way communication by duplication of the receiving and sending apparatus at the first and second stations respectively.

The general operation of the system, omitting reference to detailed circuits, is as follows:

The system as shown comprises five subchannels including subchannel transmitting units S1, S2, S3, S4 and S5, Fig. 1, and corresponding receiving units S11, S12, S13, S14 and S15, Fig. 7. Each subchannel, for example, comprises at the sending end, a tape transmitter 10 having tape-controlled contact members 11 arranged to engage the contacts of marking and spacing bus bars 12 and 13 to set up desired code combinations representing message characters, and a stepping magnet 14 to advance the tape through the transmitter; tape perforating means such as a tape reperforator 15 adapted to be controlled by signals received over a circuit 16 from a branch or patron's office; means such as the autostop contacts 18 controlled by the tape arm to indicate that the transmitter unit has message signals to transmit; and an autostop relay 19 controlled by the contacts 18. The tape transmitter 10 may be similar to that disclosed in the patent to Benjamin No. 1,298,440 dated March 25, 1919 or any suitable source of signals. The subchannel transmitting unit is intended to represent any source of intelligence signals and may include a keyboard or locally controlled tape transmitter at the transmitting station instead of means for repeating signals from a remote office or substation. Each subchannel at the receiving end comprises a start-stop printer 250 or a printer or reperforator 254.

Allotting circuit means including a plurality of connector relays 20, 21, 22, 23 and 24 and 30, 31, 32, 33 and 34 are provided to connect the respective subchannels when operative one after the other to the respective channels of the lane of traffic. As shown, the contacts of the tape transmitter 10 are connected through a cable 26 to five contacts of relays 20 and 30 in parallel, the corresponding armatures of said relays being connected through cables 27 and 37 respectively to separate channels of the lane of traffic. The other subchannels S2 to S5 are similarly adapted to be connected through the contacts of relays 21 to 24 and 31 to 34 to the same channels of the lane of traffic.

In the system shown the cables 27 and 37 terminate in two storage relay banks comprising relays 40 to 44 and 45 to 49 respectively. By way of example the lane of traffic comprises a synchronous multiplex system having a sending distributor SD (Fig. 3) at the transmitting station and a synchronous receiving distributor RD (Fig. 6) at the receiving station. The sending distributor SD comprises a rotatable brush arm 50 provided with brushes engaging the sending rings 51 and 52 and the local rings 53 and 54. The first and second channels of the sending distributor SD, which in the present instance are utilized as the lane of traffic of the expanding channel system, comprise segments 1 to 10 of the segmented sending ring 51 and the sending ring 52, connected to the transmitting circuit, line or channel L extending to the receiving station. As shown the respective segments of the sending ring 51 are connected to the ring hand armatures of the storage relays 40 to 49 and the associated contacts normally have marking and spacing potential applied thereto whereby the operation of the storage relays under the control of the respective operative subchannels serves to set up code combinations on the channls of the multiplex distributor corresponding to the code combinations set up on the respective tape transmitters 10.

If only one or two of the subchannels are in operation said subchannel or subchannels are connected through the respective connector relays to one or both of the multiplex channels represented by the ten segments shown on the sending ring 51, and there is no cyclic operation and release of the connector relays. If however three or more subchannels are in operation the connector relays 20—24 and 30—34 are operated in sequence to send a character from the operative subchannels in order alternately to the two multiplex channels. Thus if subchannels S1, S2 and S3 are in operation and the subchannel S1 is con-

nected by the connector relay 20 to the first multiplex channel, while the character set up on the tape transmitter 10 is being transmitted over the multiplex system, connector relay 31 is operated to connect subchannel S2 to the second multiplex channel. Then while the second subchannel is transmitting over the multiplex system, connector relay 22 is operated and the connector relay 20 is released so as to connect subchannel S3 to the first multiplex channel. Then the connector relay 30 is operated to connect the first subchannel to the relay bank associated with the second multiplex channel and so on, each subchannel being connected in sequence to one or the other of the multiplex channels. If the subchannel S4 or S5 had been operative and subchannel S3 inoperative, the connector relays 22 and 32 associated with the third subchannel are passed over in the cycle of operations so that the third subchannel is omitted from the sequence. The connector relays 20 to 24 and 30 to 34 are interconnected as will be described hereinafter so that when any three or more subchannels are operative, the same are connected in sequence to first one and then the other of the multiplex channels.

At the receiving station, Figs. 6, 7 and 8, a similar set of connector relays 230 to 234 and 240 to 244 are provided to connect the two multiplex channels to the receiving devices or printers corresponding to the transmitters 10, one after the other. The receiving distributor RD comprises a rotating brush arm 201 having brushes engaging the receiving rings 202 and 203 and the local rings 204 and 205. Segments 1 to 10 of the segmented receiving ring 202 comprising two receiving channels are connected to windings of the receiving relays 210—219 respectively. The receiving relays are polar relays with unbiased armatures and so adjusted that their armatures remain in contact with either their left hand or right hand contacts when actuated against one or the other contact depending upon the polarity of the signals received over the line L. When marking signals are received over the line circuit, the armatures of the receiving relays are actuated against their left hand contacts, and vice versa. Thus marking or spacing potential is applied through the contacts of the receiving relays to the cam-controlled contacts *a*, *b*, *c*, *d*, and *e* of the distributor transmitters 221 and 223 controlled by the release magnets 222 and 224, respectively. The distributor transmitters 221 and 223 may be of the type disclosed in the patent to Rothermel, No. 1,805,374 dated May 12, 1931. The received character code combinations are thus applied through the contacts of the connector relays 230—234 and 240—244 to the start-stop receiving printers 250, 251, 252 and 253 and the multiplex printer or reperforator 254. As shown, the distributor transmitters 221 and 223 are further provided with start contacts *f* and operating or sixth-pulse contacts *g* whereby either start-stop or multiplex receiving units may be controlled directly from the receiving relays 210—219.

The subchannels at the transmitting and receiving stations of the system are automatically cut in when the subchannels have signals to transmit, and out when transmission has been completed from the subchannel. When the transmitting apparatus of a subchannel has signals to transmit this fact is indicated by the closure of the auto-stop contacts 18 upon the lengthening of the tape loop between the reperforator 15 and the tape transmitter 10. thereupon a step-by-step control switch comprising three switch wipers 60, 61 and 62 operated by a stepping magnet 63 starts to hunt for the subchannel to be cut in. At the same time a start signal is transmitted over the multiplex system to initiate the operation of a second step-by-step control switch comprising wipers 260, 261 and 262 operated by a stepping magnet 263 at the receiving station. Upon each revolution of the distributor brush arms 50 and 201 of the sending and receiving distributors the above-mentioned control switches are stepped one contact. When the wipers of the switch at the transmitting station reach the subchannel that should be cut in, another switching signal is transmitted over the multiplex system and the sending and receiving ends of the subchannel are cut in to take their regular turn with the other operative subchannels. The sending and receiving ends of any subchannel that should be cut out are controlled by the synchronous control switches in a similar manner upon the opening of the auto-stop contacts 18 of the subchannel which has completed transmission.

The switching signal sent to the receiving station is preferably a character signal which does not have to be employed in the transmission of messages. Various character code combinations would be suitable but it is preferred to use a blank or all-spacing code combination, as this character is not required in ordinary communication and can be used without necessitating any changes in keyboard or printer mechanism. The blank character code combination is used exclusively as a cut-in or cut-out signal and, therefore, means is provided whereby if the all-spacing code combination or blank character is sent from one of the subchannel transmitters this code combination is automatically changed into either a "letters shift" or "figures shift" combination depending upon whether the receiving printer is in lower case or upper case. In this manner the blank combinations inadvertently sent from the transmitter are converted into code combinations which are deleted by the printer and which do not effect the entry or cutting-out of a subchannel.

In the preferred embodiment of the invention as shown, an all-spacing code combination is sent over both multiplex channels whenever the receiving end of a subchannel is to be cut in or cut out, one double blank signal to initiate the stepping of the receiving control switch and another to switch the subchannel. The reception of this switching signal effects the entry of the particular subchannel which has been selected by the wipers 260, 261 and 262 of the receiving control switch if it has previously been cut out and the cutting out of the subchannel if it has previously been entered. If an all-spacing code combination is received over only one of the multiplex channels which might occur if line trouble or inductive interference mutilated the signals being transmitted, transmission is automatically stopped from all subchannels, the subchannels being disconnected from the system.

When idle periods occur during which one or more multiplex channels are not connected to subchannels, means is provided to transmit the "figures shift" code combination during such idle periods.

The rotary step-by-step control switches at the transmitting and receiving stations comprising the wipers 60, 61 and 62 and the wipers 260, 261 and 262 respectively are employed in connection

with the multiplex channels to provide auxiliary signalling or control channels. These control channels are independent of the chains of connector relays employed for connecting the subchannels to the multiplex system, and therefore, if loss of synchronism occurs on the relay chains, the control channels are not affected thereby. The key 70, Fig. 4, is connected to contacts of the sending control switch in a manner to stop transmission from the local station and cut out all subchannels when it is operated. The switches 71, 72 and 73, Figs. 4 and 5, are likewise connected to contacts of the sending control switch. The key 71 when it is operated stops transmission from the remote station over the other half of the varioplex system involving receiving apparatus (not shown) at the station represented by Figs. 1 to 5. The transmission is started from the remote station again by actuating the key 72. The key 73 when actuated merely serves to operate a signal such as the call lamp 273 at the remote station so that an attendant may be called, or the control circuit at the remote station may be used for any other desired purpose.

The subchannels may terminate at the receiving station on start-stop printers 250—253 or a multiplex printer or reperforator 254. The printers may be located at the receiving station or in branch or patron's offices. The reperforator 254 may have an associated tape transmitter by which the corresponding subchannel may be connected through to another varioplex system or a fully assigned multiplex transmitting channel. By employing the distributor transmitters 221 and 223, the five unit code combinations received over the multiplex system may be converted into seven unit start-stop code. Also, where the receiving channels are connected to multiplex equipment the distributor transmitters are arranged to provide a sixth pulse for the operation of the multiplex units as will be described. Thus the distributor transmitters are used for transmitting both to receiving devices of the start-stop type and of the multiplex type.

The detailed operation of the system is as follows:

Transmission from operative subchannels

Two guard relays 77 and 78 (Fig. 4) are provided in connection with the chain of connector relays, relay 77 being associated with connector relays 20—24 and relay 78 with connector relays 30—34. Auxiliary relays 80 to 84 inclusive are provided, one for each subchannel. These relays are energized as long as the corresponding subchannel has any message characters to transmit. Auxiliary relays 85 to 89 inclusive are also provided in connection with the respective subchannels and are operated as long as the corresponding subchannels are connected for operation. Rectifiers 90 to 94 inclusive are also provided in the locking circuits of the connector relays, one rectifier being common to the pair of connector relays associated with each subchannel. These rectifiers are poled to pass current from ground at the rectifier to negative battery.

When the transmission apparatus associated with any of the subchannels is idle and the tape loop is shortened to raise the tape arm of the transmitter 10 and open the associated autostop contacts 18, the auto-control relay 19 and the stepping magnet 14 of the tape transmitter 10 are energized through a circuit including the winding of the stepping magnet 14, the right hand winding of the auto-stop relay 19 and the right hand armature and make contact of said relay. The energization of the stepping magnet 14 withdraws the pins from the tape in the tape transmitter and when the stepping magnet is deenergized the pins are projected through the tape and the transmitter contacts are selectively operated as described in the above mentioned Benjamin patent.

When signals are received over the line circuit 16 the tape loop between the tape reperforator 15 and the tape transmitter 10 lengthens, thereby permitting the auto-stop contacts 18 to close. Thereupon a circuit is closed from ground through the winding of the stepping magnet 14 of the tape transmitter, the left hand winding of the auto-stop relay 19, the auto-stop contacts 18, the sixth conductor of the cable 26 and the windings of relay 80 in series relation to positive battery whereupon relay 80 becomes energized. The left hand winding of relay 80 is of low resistance and few turns, whereas the right hand winding thereof is of high resistance and a large number of turns. Therefore the high resistance of the described circuit of relay 80, which may include external resistance as shown, limits the current in this circuit to a low value, for example, a few milliamperes. This current is sufficient to energize relay 80 but does not materially affect the auto-stop relay 19 of the stepping magnet 14, and the auto-stop relay and stepping magnet remain energized.

After the subchannels have been connected to the system for operation in a manner to be described hereinafter in response to the energization of relay 80, (or relay 81, etc.) the tape transmitter 10 of each operative subchannel is controlled by the stepping magnet 14 to set up successive character code combinations in accordance with the successive characters perforated on the tape as often as the subchannel is connected to the multiplex transmitting system. The pulsing of the stepping magnets in the respective transmitters is controlled by the local rings of the sending distributer SD through the control relays 101 and 102 (Fig. 3) individual to the first and second multiplex channels, respectively. The windings of said relays are connected in operating circuits which may be traced from positive battery at the local ring 54 through the segment groups 55 and 56 respectively of the local ring 53 of the sending distributer SD, the opposite sides of the windings of said relays being connected to the chain of connector relays in order to effect cyclic operation of the latter in a manner to be described.

The pulsing circuit for the transmitting channel closed in response to the energization of relay 101 extends from positive battery through the right hand armature and back contact of relay 103 (Fig. 5), the conductor 104, the left hand inner armature and front contact of relay 101, the sixth conductor of cable 27, the sixth armature and front contact of relay 20, the left hand low-resistance winding of relay 80, the sixth conductor of cable 26, the auto-stop contacts 18, the left hand winding of auto-stop relay 19 and the winding of the stepping magnet 14 to ground. The first stepping pulse through the left hand winding of the auto-stop relay 19 as described effects the deenergization of said relay since the windings thereof are in opposition. The relay 19 remains deenergized since the subsequent stepping pulses traverse both windings of the relay

until transmission has been completed from the subchannel and the auto-stop contacts 18 are opened by the shortening of the tape loop between the transmitter 10 and reperforator 15. It will be noted that cable 27 is multiplied to the armatures of all the connector relays 20 to 24 whereby the above mentioned stepping pulse for the tape transmitters is directed through the sixth armature of the particular connector relay which is energized to the corresponding transmitter. Similarly a stepping pulse for the second multiplex channel is transmitted through a circuit including the inner armature and front contact of relay 102 and the sixth conductor of the cable 37 connected to the connector relays 30 to 34 inclusive associated with the second multiplex channel. In this instance the pulsing circuit includes the sixth armature and front contact of the particular connector relay of the second group associated with the subchannel which is at that moment connected to the second multiplex channel.

When the last message character perforated in the tape at the subchannel transmitter is transmitted from a particular subchannel, for example subchannel S1, the stepping of the tape in the transmitter opens auto-stop contacts 18. The opening of the auto-stop contacts 18 interrupts the above-described stepping circuit through the left hand winding of the auto-stop relay 19 and the current flowing through the right hand winding of said relay when the stepping pulse is received causes the relay to become energized and a locking circuit therefor and for the stepping magnet 14 of the tape transmitter 10 is closed through the right hand armature and make contact of said relay. Upon the energization of the auto-stop relay 19, the above described circuit of relay 80 is interrupted at the make-before-break contacts of the auto-control relay whereupon relay 80 becomes deenergized. This effects the cutting out of the subchannel S1 in a manner to be described. Relays 81 to 84, inclusive, are similarly energized whenever their corresponding subchannels have any traffic to send and deenergized when the message characters perforated in the tape in each tape transmitter have been sent, and effect the cutting in and out of the other subchannels.

The manner in which the connector relays 20 to 24 and 30 to 34 inclusive, are operated in sequence to connect the transmitters associated with their respective subchannels to the multiplex channels will be apparent from the following detailed description of the operating circuits. As pointed out above, the control relays 80 to 89, inclusive, are energized when all of the subchannels S1 to S5 inclusive are cut in. Assuming that all of the subchannels have been cut in and that connector relays 24 and 33 have previously been operated to connect subchannel S5 to the first multiplex channel and sub-channel S4 to the second multiplex channel, when the brush arm 50 of the sending distributor SD engages the segments 55 of the local ring 53, a circuit is closed from positive battery through the local ring 54, the right hand brushes of the brush arm 50, the segments 55 of the local ring 53, conductor 115, the winding of relay 101, conductor 116, the eighth armature and front contact of connector relay 33, the outer left hand armature and front contact of control relay 87, conductor 117, the left hand operating winding of connector relay 22, conductor 118 and the winding of guard relay 77 to negative battery, whereupon relays 101 and 22 become energized. The energization of relay 101 energizes the stepping magnet of the tape transmitter of subchannel S3 as described above. Prior to the energization of relay 22, since connector relay 24 is assumed to be energized as stated above, a circuit is closed from ground through the rectifier 94, the seventh armature and front contact of relay 24, the right hand or locking winding of said relay, conductor 118 and the winding of guard relay 77 to negative battery, whereby said connector relay 24 has been locked up for the transmission of a character code combination from subchannel S5. Upon the connection of positive battery at the local ring of the sending distributor SD through conductor 118 and the winding of guard relay 77 as described in shunt relation to the locking circuit of connector relay 24, the potential across the locking winding of relay 24 is reversed, thus insuring the rapid deenergization of the relay. Thus relay 24 becomes deenergized the instant that relay 22 is energized. When the local brushes of the sending distributor SD leave the lower segment 55 of the local ring 53 thereby interrupting the operating circuit for connector relay 22, a locking circuit is closed from ground through the rectifier 92, the seventh armature and front contact of relay 22, the right hand locking winding of relay 22, conductor 118 and the winding of guard relay 77 to negative battery, whereby relay 22 remains locked up. The deenergization of relay 24 and the energization of relay 22 substitutes the subchannel S3 for the subchannel S5 in the cyclic operation of the relay chain and the transmitter of subchannel S3 is now connected through the cable 27 to the storage relay bank comprising relays 40 to 44 inclusive associated with the first multiplex channel. The storage relays which receive ground potential from the spacing busbar 13 of the tape transmitter 10 of the third subchannel are energized and the right hand armatures of said storage relays connect spacing potential to segments of the first multiplex channel of the sending distributor SD. The front or spacing contacts of the relays 40 to 44 are connected to negative battery through the conductor 125 and the right hand armature and back contact of control relay 96. The back or marking contacts of said control relays are connected to marking or positive battery through the conductor 126 and the left hand armature and back contact of relay 130 (Fig. 5).

Upon the continued rotation of the brush arm 50 of the sending distributor SD, the sending brushes will engage the segments 1 to 5 of the sending ring 51 whereupon the code combination set up on the storage relays 40 to 44 from the tape transmitter of subchannel S3 are transmitted over the line L. As the local brushes of the brush arm 50 engage the segments 56 of the local ring 53, a circuit is closed from positive battery through the local ring 54, said local brushes and segments 56, the conductor 135, winding of relay 102, conductor 136, the eighth armature and front contact of connector relay 22, conductor 137, the inner left hand armature and front contact of control relay 86, conductor 147, the left hand operating winding of connector relay 31, conductor 138, and the winding of guard relay 78 to negative battery, whereupon relays 102 and 31 become energized. Prior to the energization of relay 31, relay 33 was locked up through a circuit including rectifier 93, conductor 139, the seventh armature and front con-

tact of relay 33, the right hand locking winding of said relay, conductor 138, and the winding of relay 78 to negative battery. Thus the operation of connector relay 31 by the local brush of the sending distributor SD effects the deenergization of relay 33 at the same time that relay 31 is operated in a manner similar to the operation and deenergization of relays 22 and 24 as described above.

The energization of relay 31 substituted the subchannel S2 for the subchannel S4, the transmitter contacts of subchannel S2 being now connected through the contacts of connector relay 31 and the cable 37 to the windings of the storage relays 45 to 49 associated with the second multiplex channel. The storage relays associated with the second multiplex channel operate in response to spacing potential on the spacing contacts of the tape transmitter of the subchannel and transfer the code combination set up in said transmitter to the segments 6 to 10 inclusive of the sending ring 51 of the sending distributor SD in the same manner as described above in connection with the first multiplex channel. However the spacing potential on the front contacts of relays 45 to 49 is positive battery which is connected to said contacts through conductor 140 and the right hand armature and back contact of relay 93. The negative marking potential applied to the back contacts of said relays is connected through conductor 141 and the left hand armature and back contact of relay 131.

As the brush arm of the sending distributor SD continues to rotate, the connector relays are operated through circuits as described above including contacts of the connector relays which have previously been operated in the following order: relays 20, 34, 23, 32, 21, 30, etc., whereby the operative subchannels are connected in sequence to first one multiplex channel and then the other.

The locking circuits of the connector relays of each subchannel include one of the rectifiers 90 to 94 and those of relays 20 to 24 include the winding of the guard relay 77, whereas the locking circuits of relays 30 to 34 include the winding of guard relay 78. The operating circuits are similar to those traced above in the foregoing detailed description. Thus the operating circuit of relay 20 includes the conductor 144 and the front contact associated with the outer left hand armature of relay 85. The operating circuit of relay 30 includes the conductor 145 and the front contact associated with the inner left hand armature of relay 95. The operating circuit of relay 21 includes the conductor 146 and the front contact associated with the outer left hand armature of relay 86. Thus the operating circuits for the chain of connector relays include front contacts of the respective control ralays 85 to 89 and it will be apparent that if one of these subchannels is not cut in and the associated control relay is deenergized, the operating circuit for the next relay to be operated is shunted through a back contact of said control relay to the next control relay, thereby passing over the inoperative subchannel in the cyclic operation of the relay chain. In this manner inoperative subchannels are omitted from the selection, and the transmitting time of the lane of traffic is divided among the operating channels. Furthermore, if the number of operative subchannels does not exceed the number of multiplex channels, two in this instance, the operative subchannel or subchannels are permanently connected to the lane of traffic during transmission as the relay chain does not step.

During the time that one or both of the multiplex channels are idle, the "figures shift" code combination is transmitted over the idle channel. If the first multiplex channel is idle, none of the connector relays 20 to 24 is operated and the storage relays 40, 41, 43 and 44 are all deenergized. Since the guard relay 77 is deenergized except when one of the connector relays 20 to 24 is energized, a circuit is closed from ground through the outer left hand armature and back contact of relay 77, the conductor 150, the third conductor of the cable 27 and the winding of storage relay 42 to positive battery. Thus relay 42 is energized while the first multiplex channel is idle and the code combination impressed upon the segments 1 to 5 of the sending ring 51 of the sending distributor SD is the "figures shift" code combination in which the third impulse only is spacing. In a similar manner when the second multiplex channel is idle the connector relays 30 to 34 and guard relay 78 are deenergized. Therefore the storage relays 45, 46, 48 and 49 are deenergized whereas the relay 47 is energized through a circuit including the left hand outer armature and back contact of relay 78, the conductor 151 and the third conductor of cable 37 whereby the "figures shift" code combination is also set up on the second multiplex channel whenever it is idle.

At the receiving station the code combinations of the transmitted message characters are set up on the segments of the receiving ring 202 of the receiving distributor RD in the usual manner thereby effecting the corresponding operation of the polar receiving relays 210 to 219, inclusive. The receiving relay chain is controlled by a group of control relays 281 corresponding to the relays described above in connection with the relay chain at the sending station. It is assumed that the receiving ends of the operating subchannels have been cut in so that the relays 285 and 289 corresponding to sending control relays 85 and 89, Fig. 2, of the operative channels have been energized, and that these receiving control relays are arranged to control the receiving relay chain comprising the connector relays 230 to 234 and 240 to 244 in the same manner as the relays at the sending station control the operation of connector relays 20 to 24 and 30 to 34 respectively.

Two relays 301 and 302 corresponding to the transmitter control relays 101 and 102 at the sending station are operated from the eighth and ninth segments, and the eighteenth and nineteenth segments respectively of the local ring 204 of the receiving distributor RD. The release magnets 222 and 224 of the distributor transmitters 221 and 223 at the receiving station are energized by the relays 301 and 302 in proper timed relation to the rotation of the brush arm 201 of the receiving distributor to transfer code combinations stored at the receiving relay bank through the contacts of the receiving connector relays to the receiving devices or printers. As shown, the distributor transmitters 221 and 223 are provided with cam-controlled contacts *a*, *b*, *c*, *d* and *e* adapted to close the control circuits of the receiving devices; a start contact *f* adapted to operate just before the closure of the transmitting contacts *a* of the distributor transmitter to start the cyclic operation of the start-stop printer 250, 251, 252 or 253; and a sixth-pulse contact *g* connected to the sixth conductor of

the connecting cable and arranged for operating the stepping magnet or printing magnet of a multiplex receiving device **254**. Since the connector relay of the receiving relay chain are stepped in synchronism with the sending relay chain, passing over the subchannels which have not been connected for operation, the signals originating at the various transmitting devices of the several subchannels at the sending station are distributed to the corresponding receiving devices forming the receiving ends of the various subchannels.

Cutting subchannels in and out

In explaining the operation of connecting and disconnecting the subchannels from the lane of traffic, it will be assumed that the first subchannel comprising transmitting unit S1 and receiving device S11 is disconnected from the lane of traffic but that signals are being received over the line **16** which are to be transmitted to the receiving unit **250** of said subchannel.

As has been pointed out above the control relays **80** and **85** associated with the first subchannel are deenergized when the subchannel is cut out but relay **80** becomes energized as soon as the transmitting unit has message characters to transmit as indicated by the closing of the autostop contacts **18**. The armature of relay **80** is provided with front and back contacts connected respectively to a back contact and a front contact of one of the armatures of relay **35**. Thus a test circuit is closed through these contacts whenever either relay is energized and the other relay deenergized which condition occurs when subchannel S1 is to be cut in or cut out. The manner in which the closure of this test circuit actuates the switching mechanism to cut in or out the transmitting and receiving ends of the corresponding subchannels will now be explained. It will be noted that each subchannel is provided with a similar test circuit and therefore an explanation of the operation of the switching equipment to enter and cut out any one of the subchannels will be sufficient.

The test circuits of the respective subchannels include the five conductors of a cable **153** which are connected to the armatures of the control relays **80** to **84**, inclusive. The conductors in the cable **153** as shown are connected to the first five contacts of the contact bank of the control switch associated with the switch wiper **62**. Additional test circuits for additional subchannels may be connected to other contacts of the switch bank such as those represented by the sixth and seventh contacts on the drawing.

When the control relay **80** is energized as described above to close the test circuit of the first subchannel, a circuit is closed from ground through the fifth armature and front contact of relay **154** which is normally energized when the control switch at the sending station is in its initial or rest position as shown through a circuit including the grounded switch wiper **62**. The test circuit further includes the first conductor of the cable **153**, the armature and front contact of relay **80**, the right hand inner armature and back contact of **85**, the conductor **155**, the conductor **156**, left hand inner armature and back contact of relay **157**, right hand winding of relay **103**, the resistance **158** and conductor **159** connected to the segment **57** of the local ring **53** of the sending distributor SD. When the local brush of the sending distributor engages the segment **57**, the described test circuit is closed thereby energizing relay **103**, and this relay is locked up through its left hand locking winding, the left hand inner armature and front contact of said relay and the resistance **161** to negative battery. The energization of relay **103** further opens at its right hand armature and back contact the stepping circuit for the subchannel transmitters so that the particular subchannel transmitter which is connected to the lane of traffic for transmission is not operated during this cycle of the relay chain and the character code combination in the transmitter is not sent until said subchannel is later connected in its regular turn to the lane of traffic. It will also be noted that closure of the test circuit of any of the other subchannels causes the energization of relay **103** in a similar manner.

As the local brushes of the sending distributor SD continue to rotate, a circuit is closed from positive battery through the segment **58** of the local ring **53**, conductor **164**, the left hand outer armature and front contact of relay **103**, the right hand winding of relay **130**, the conductor **165** and the winding of relay **166** to ground whereupon relays **130** and **166** become energized. Relay **130** becomes locked up through its left hand winding and left hand inner armature and front contact and the armature and back contact of relay **160**. The operation of relay **130**, through its left hand outer armature and front contact and the conductor **126**, applies negative or spacing battery to the marking contacts of the storage relays **40** to **44** associated with the first multiplex channel so that even though some of these relays may be deenergized an all-spacing or blank character code combination is sent over the line L upon the next revolution of the brush arm of the sending distributor SD.

Upon the energization of relay **166**, a circuit is closed from positive battery through the outer armature and front contact of said relay, the inner armature and back contact of relay **170**, the conductor **167**, the thirteenth armature and front contact of relay **154** and the left hand winding of relay **168** to ground whereupon relay **168** becomes energized. Relay **168** controls the circuit of the stepping magnet **63** of the sending control switch, causing the stepping magnet **63** to be energized and to advance wipers **60**, **61** and **62** to the first contact position, said relay **168** being provided with a locking winding and locking contacts arranged as shown to insure that the stepping magnet is fully energized even upon a short current impulse applied to the relay **168**.

As the sending distributor SD transmits the blank character code combination over the first multiplex channel as described above, a circuit is closed through the local brushes thereof, segment **59** of the local ring **53**, conductor **171**, the right hand armature and front contact of relay **130**, the left hand winding of relay **131** and the resistance **161** to negative battery whereupon relay **131** becomes energized and relay **103** is deenergized by neutralization of the current through its left hand locking winding. Relay **131** becomes locked up through a circuit including its right hand locking winding, its right hand armature and front contact and resistance **162** to negative battery. The operation of relay **131** through its left hand armature and front contact, applies positive or spacing battery through the conductor **141** to the marking contacts of the storage relays **45** to **49**, inclusive, associated with the second multiplex channel. Thus even though one or more of the said storage relays may be de-

energized as the sending brushes of the sending distributor traverse the segments of the second mulitplex channel, a blank or all-spacing code combination is sent over the second multiplex channel also. Thus it will be seen that whenever the relay 103 is energized, a double blank character code combination is sent over the two multiplex channels, this code combination serving to initiate the stepping of the receiving control switch at the same time that the sending control switch commences to step, and, when the wipers of said switches reach the subchannel which is to be cut in or out, to effect the switching of the receiving end of the subchannel at the same time that the sending end is cut in or out in a manner which will be described hereinafter.

It will be noted that the deenergization of relay 154 which occurred when the wipers 62 stepped to the first position has removed the ground connection normally applied to the contacts of the sending control switch associated with the test wiper 62 through the front contacts thereof and as the test wiper moves over the associated contacts of the test contact bank, said contacts are grounded one after the other through said test wiper 62. Assuming that the first subchannel is to be cut in as indicated by the closure of the test circuit through the front contact of relay 80 and a back contact of relay 85 and the test circuits of the other subchannels are open, when the local brush of the sending distributor engages the segment 58 of the local ring 53, a circuit is closed from positive battery through the local brushes of the distributor, the conductor 164, the left hand outer armature and back contact of relay 103, the winding of relay 160, the twelfth armature and back contact of relay 154 and the left hand winding of relay 168 to ground, whereupon relay 168 becomes energized to cause the wipers of the sending control switch to step to their second contacts. The energization of relay 160 interrupts at its armature and back contact the locking circuit of relay 130 whereupon this relay becomes deenergized. During the continued rotation of the brushes of the sending distributor SD, a circuit is closed from positive battery through the local brushes, segment 59 of the local ring 53, conductor 171, and the right hand armature and back contact of relay 130 to neutralize the current in the locking circuit of the relay 131 whereupon this relay becomes deenergized. The deenergization of relays 103, 130 and 131 as described restores these relays to normal thereby permitting the transmission of character code combinations from operative subchannels while the sending control switch continues to step once during each revolution of the brushes of the sending distributor. However, when the test wiper 62 of the sending control switch engages the fifth contact, a circuit is closed from ground through said wiper and fifth contact, conductor 1 of the cable 153, and the test circuit through relays 80 and 85 whereupon relay 103 again becomes energized and a double blank character code combination is transmitted over the multiplex channels as described above. The energization of relay 103 also interrupts the above described circuit of relays 160 and 168 so that the sending control switch remains with its wipers in engagement with their fifth contacts for two revolutions of the sending distributor. After the double blank character code combination has been transmitted as described above relays 103, 130 and 131 are again deenergized and the sending control switch resumes stepping.

When the second switching signal is transmitted from the sending station at the time when the wipers of the sending control switch were in engagement with their fifth contacts, relay 166 becomes energized in series with relay 130 as described above in connection with the transmission of the first switching signal which started the receiving control switch stepping. Upon the energization of relay 166 as described a circuit is closed from positive battery through the outer armature and front contact of relay 166, the inner armature and back contact of relay 170, conductor 167, the thirteenth armature and back contact of relay 154, the wiper 60 of the control switch in engagement with its fifth contact, conductor 173 and the right hand winding of relay 85 to ground through conductor 110 and the left hand outer armature and back contact of relay 157, whereupon relay 85 becomes energized and locks up through its left hand locking winding and its right hand outer armature and front contact and resistance 174 to negative battery. The energization of relay 85 opens the test circuit through the contacts of relay 80, referred to above, and as has been explained enters the transmitting end of the subchannel S1 so that by the energization of the chain relays 20 and 30 this subchannel now shares the transmitting time of the lane of traffic with the other operative subchannels.

If the subchannel S1 had been previously entered on the lane of traffic and the test circuit is closed by the deenergization of relay 80, the sending control switch operates to cut out the subchannel and transmit a switching signal to cut out the receiving end of the subchannel at the receiving station. The same switching signal is used and upon the reception of this signal if the subchannel is in it is cut out, and if it is out it is entered on the lane of traffic. In cutting out the transmitting end of the subchannel, when the wipers of the control switch at the transmitting station reach their fifth contacts in the manner described above, a circuit is closed from ground through the left hand locking winding of relay 85, the right hand outer armature and front contact of said relay, the conductor 175, switch wiper 61 which is in engagement with its fifth contact, conductor 176, the inner armature and back contact of relay 166, the winding of slow-release relay 170 and resistance 177 to negative battery whereupon relay 170 becomes energized. Thereafter relays 130 and 166 become energized upon the engagement of the local brushes of the sending distributor with the local segment 58 and a circuit is closed from positive battery through the outer armature and front contact of relay 166, the inner armature and front contact of relay 170, conductor 176, switch wiper 61, conductor 175 and the resistance 174 to negative battery thereby neutralizing the locking current of said relay whereupon relay 85 becomes deenergized. In this manner the transmitting end of the subchannel S1 is cut out when the control switch reaches the contact, associated with the switch wiper 61, individual to said subchannel providing the associated test circuit has been closed to indicate that the subchannel has completed transmission.

At the receiving station the reception of the double blank switching signal operates all of the polar receiving relays 210 to 129 against their right hand or spacing contacts. The contacts associated with the inner or left hand armatures of relays 210 to 214, inclusive, are arranged to form two baffle circuits, one of which is closed whenever all of the relays are on their spacing contacts upon reception of a blank or all-spacing code combination and the other circuit is closed for all other code combinations. Thus, it will be seen that when the armatures of all of the relays 210 to 214 are actuated against their right hand contacts and the local brush of the receiving distributor engages the segment 15 of the local ring 204, a circuit is closed from positive battery at the local ring 205 through the local brushes of the receiving distributor, the left hand armatures and spacing contacts of relays 214, 213, 212, 211 and 210, respectively, conductor 283, the windings of relays 280 and 266 to ground. If, on the other hand, one or more of the receiving relays 210 to 214 had been actuated to marking position, a circuit is closed from the receiving distributor through the left hand armatures and back contacts of the relays which are operated to spacing position and through the left hand armature and marking contact of the lowest relay operated to the marking position to conductor 284. Similarly the polar receiving relays 215 to 219, inclusive, are provided with contacts associated with their left hand armatures forming similar baffle circuits between the fifth segment of the local ring of the receiving distributor and conductors 293 and 294, respectively.

As stated above, a switching signal consists of a double blank character code combination transmitted over the two channels of the multiplex system. After the first all-spacing code combination has been set up on the receiving segments 1 to 5 of the receiving ring 202, the local brushes of the receiving distributor close the above described circuit through the fifteenth segment of the local ring 204, the left hand armatures and spacing contacts of relays 210 to 214 and the conductor 283 for energizing relays 266 and 280. Relay 266 corresponds to relay 166 at the sending station and intiates the stepping of the receiving control switch upon receipt of the first switching code combination. Thus a circuit is closed from positive battery through the left hand armature and front contact of relay 266, the inner armature and back contact of relay 270, the middle armature and front contact of relay 254 and the winding of relay 268 controlling the stepping magnet 263 of the receiving control switch. In this manner the control switch is stepped off from the rest position shown and continues to step in synchronism with the sending control switch. As long as character code combinations are received over the multiplex channels, these character code combinations being interspersed with the blank or switching signals as described above, a circuit is closed during each revolution of the brushes of the receiving distributor through the baffle circuit associated with the first multiplex channel, the conductor 284, the inner armature and back contact of relay 254, and the winding of relay 268. However, when a blank or all-spacing code combination is received on the first multiplex channel, as for example upon the engagement of the sending control switch with its fifth contacts associated with the first subchannel as described above, the circuit of relays 280 and 266 is again closed through the baffle circuit of the polar receiving relays of the first channel. Thereupon a circuit is closed from positive battery to the left hand armature and front contact of relay 266, the inner armature and back contact of relay 270, the middle armature and back contact of relay 254, switch wiper 260 of the receiving control switch, which is in engagement with its fifth contact, and the left hand winding of receiving control relay 285 to ground, whereupon the receiving end of the subchannel is cut in by the energization of relay 285 corresponding to relay 85 at the sending end of the subchannel. Relay 285 locks up through its right hand locking winding and the locking circuit shown, said locking winding being then also connected through the switch wiper 261 of the receiving control switch to the winding of relay 270 in a manner similar to the relation of the locking winding of relay 85 to the auxiliary relay 170 at the transmitting station. Thus, if the relay 285 is locked up when the switching signal is received over the channel, the consequent operated position of relay 270 causes the unlocking of said relay 285 thereby cutting out the subchannel in the same manner as at the transmitting end of the system.

In case a blank code combination is received over only one of the multiplex channels it is an indication that the system is not operating properly. Such an occurrence might be the result of inductive interference on the line which distorted the signals being transmitted so that a blank or all-spacing code combination was formed from a different combination or if the double blank switching signal is being transmitted, one of the blank code combinations being sent over one of the multiplex channels might be distorted into a different code combination. Therefore, if a blank is received over only one channel, the operation of the system is stopped. Thus assuming that the blank is received over the first multiplex channel, as we have seen, this closes the baffle circuit through the polar relays 210 to 214 and energizes relays 280 and 266, relay 280 being locked from negative battery through its right hand winding as shown. If the character code combination received now over the second multiplex channel is not an all-spacing combination, a circuit is closed from the fifth local segment of the local ring 204 of the receiving distributor through the contacts of one or more of the receiving relays 215 to 219, the conductor 294 and the left hand armature and front contact of relay 280 for stopping transmission by controlling the circuit including relays corresponding to relays 181 and 182 at the sending station. The manner in which relays 181 and 182 stop transmission from both stations will become apparent from detailed description of this operation at the sending station in connection with the control keys 70 and 71. As has been pointed out these keys are provided to enable the attendant to stop transmission whenever necessary.

If it is assumed that the blank code combination was received over the second channel and the preceding code combination transmitted over the first channel had not been a blank, relays 266 and 280 are not energized through the baffle circuit of the first channel. Therefore, when the blank-reading baffle circuit of the second channel is closed, a circuit is closed from the fifth segment of the local ring 204 of the receiving distributor through said baffle circuit, the conduc-

tor 293 and the left hand armature and back contact of relay 280 for stopping transmission. Thus the baffle or reading circuits of the receiving relays 210 to 219 are arranged to control the receiving control switch when a double blank code combination is received and to stop transmission when a single blank code combination is received over only one of the multiplex channels.

Since the blank or all-spacing code combination is employed for switching purposes, means are provided for preventing the transmission of all-spacing code combinations that may be inadvertently sent from the subchannel transmitters to the storage relay bank associated with the multiplex channels. In accordance with the preferred embodiment of the invention if this code combination is set up on any one of the transmitters, it is automatically converted into either "figures shift" (#3 impulse only spacing) if the remote printer is in upper case or "letters shift" (all marking impulses) when the remote printer is in lower case. Relays 105 to 109 are provided for the respective sub-channels to record whether the last shift character sent from the subchannel was "letters shift" or "figures shift." The operating circuit of relay 105 may be traced from ground through the two windings of the relay in series, conductors 132 and 134, the outer armature and front contact of either connector relay 20 or 30, depending upon whether subchannel S1 is connected to the first or second multiplex channel, and the baffle circuits of the storage relays 40 to 44 or 45 to 49 of the channels. In the case of transmission over the second subchannel when "figures shift" is transmitted from the subchannel transmitter only relay 47 is energized and a circuit is closed from positive battery through the left hand inner armature and front contact of 47, the left hand armatures and back contacts of relays 45, 48, 46 and 49, the outer armature and back contact of relay 102, the conductor 133, the outer armature and front contact of relay 30, the conductor 132 and the two windings of relay 105 to ground, causing the relay 105 to be energized and locked from positive through its armature and front contact and right hand winding.

Subsequently when a "letters shift" combination is sent from subchannel S1, the conductor 132 associated with the relay 105 is grounded through the above described circuit and the armature and back contact of relay 42 or 47 since all of the storage relays are deenergized when the "letters shift" or all-marking code combination is received. The closure of this circuit neutralizes the locking current of relay 105 and said relay becomes deenergized. It will be apparent, therefore, that the operated or unoperated condition of relays 105 to 109 indicates whether a "figures shift" or "letters shift" code combination was last transmitted over the respective subchannels.

If a blank or all-spacing code combination is received from one of the subchannels, for example, in the storage relay bank associated with the first multiplex channel, relays 40 to 44, inclusive, are all energized and a circuit is closed from battery through the left hand inner armature and front contact of relay 42, the left hand armatures and front contacts of relays 40, 41, 43 and 44, the left hand outer armature and front contact of relay 42 and the winding of relay 96, whereupon relay 96 becomes energized. If the associated relay 105 is also energized at this moment indicating that the last shift code combination sent from the first subchannel was the "figures shift" code combination, the operation of relay 96 closes a circuit from battery through the armature and front contact of relay 105, the left hand winding of said relay, conductor 132, conductor 134, the right hand outer armature and front contact of relay 20, conductor 148, the left hand outer armature and back contact of relay 101 and the left hand armature and front contact of relay 96 for energizing relay 97. Relay 97 controls the connection of the third sending segment of the sending ring 51 to the armature of the third storage relay 42 and the energization of relay 97 connects spacing battery to the said segment of the sending ring 51. At the same time the energization of relay 96 transfers the battery on the spacing contacts of relays 40, 41, 43 and 44 to marking battery so that the "figures shift" code combination is transmitted over the first multiplex channel. When a blank or all-spacing code combination is received on the storage relay bank associated with the first multiplex channel, if the relay 105 had not been operated, indicating that the last shift code combination sent from the first subchannel was the "letters shift" code combination, relay 97 would not be energized upon the operation of relay 96 since the conductor 132 would be connected to ground through the windings of relay 105. Therefore, in this case the operation of relay 96 would convert the all-spacing code combination received from the subchannel transmitter to a "letters shift" or all-marking combination on the first multiplex channel. Relays 98 and 99 associated with the second multiplex channel are interconnected with the storage relay bank of said channel in the same manner as relays 96 and 97, respectively. Therefore, blank or all-spacing code combinations received on the second multiplex channel are similarly converted to either "letters shift" or "figures shift" code combination depending upon whether the distant printer is in lower case or upper case, so that these code combinations are deleted by the printer.

In accordance with another feature of the invention means are provided for resynchronizing the relay chains of the transmitting and receiving stations when synchronism is lost in case the conditions are such that one of the transmitting subchannels would be sending "to the wind." It will be evident that loss of chain synchronism might be caused by failure to cut in or out the receiving end of a subchannel when the transmitting end of said subchannel is cut in or out by reason of the failure of the control apparatus. In the case of the expanding channel system shown employing two multiplex channels as the lane of traffic, it will be apparent that if three or more subchannels are cut in at the transmitting station and a different number of subchannels are connected at the receiving end, the transmitters and printers will not be connected in the same order to the multiplex channels and the messages received on each printer will be unintelligible. Therefore loss of chain synchronism under these conditions immediately becomes evident. However, if the system has two or more subchannels cut in at the sending station and only one or none is cut in at the receiving station, the signals transmitted from at least one subchannel are sent "to the wind," that is, no corresponding record appears on any printer, whereas one printer may be receiving intelligible messages. In this case the loss of chain synchronism might not be recognized promptly. Therefore, in accordance with the invention means is provided for automatically correcting

the non-synchronous condition of the system under these conditions.

Only "blanks" or "figures shift" code combinations are sent over a multiplex channel when idle, both of these having the third impulse spacing. However when the channels are in use a large proportion of the character code combinations transmitted have the third impulse marking. Therefore, if code combinations corresponding to ordinary message signals are being transmitted over one of the multiplex channels a circuit is closed at frequent intervals from negative battery through the right hand armature and marking contact of receiving relay 212 and the conductor 295 to the back contact of the armature of relay 278 or from the corresponding contact of receiving relay 217 through conductor 296 to the back contact of the armature of relay 277. Since the circuits of guard relays 277 and 278 corresponding to the sending guard relays 77 and 78 include the locking windings of one of the connector relays in the groups 230 to 234 and 240 to 244, these receiving guard relays are only deenergized when one of the groups of connector relays is deenergized. Thus, if character code combinations other than the idle signals referred to above are received on the receiving end of one of the multiplex channels to which no subchannel is connected, a circuit is closed through the armature of either relay 277 or 278, the left hand winding of relay 290, conductor 297 and the twelfth segment of the local receiving ring 204 of the receiving distributor to positive battery at the local ring 205 when the brushes of the brush arm 201 reach said segment. Relay 290 becomes energized and causes all subchannels to be released whereupon the relay chains are synchronized by re-entering the operative subchannels. Relay 290 corresponds to relay 184 at the sending station and its operation will be apparent from the following description of the operation of relay 184 upon the closure of the start key 72. In this manner the relay chains are automatically synchronized upon the operation of relay 290 whenever signals are received over a multiplex channel which is not connected to the receiving end of a subchannel.

Manual switching and control features

The eighth, ninth, tenth and eleventh contacts of the sending and receiving control switches are allotted to signaling and switching channels, the wipers of the respective switches being shown in engagement with their twelfth contacts in the normal or rest position. The control key 73 is associated with the eleventh contact of the sending control switch and the associated signal lamp 273 (Fig. 8) at the receiving station is likewise associated with the relay 271 connected to the eleventh contact of the upper bank of the receiving control switch. When the key 73 is momentarily actuated, a circuit is closed through the contacts of said key for energizing relay 185 and said relay is locked up through its left hand armature and front contact and resistance 74 to negative battery. The energization of relay 185 further closes through its right hand armature and front contact a test circuit for energizing relay 103 whereupon wipers 60, 61, 62 of the sending control switch are stepped from the rest position and a double blank switching signal is transmitted over the line as described above in case a test circuit associated with one of the subchannels is closed. The circuit of relay 103 may be traced from positive battery at the local ring 54 of the sending distributor through the segment 57 of ring 53, the conductor 159, resistance 158, right hand winding of relay 103, the right hand armature and front contact of relay 185, and the eleventh armature and front contact of relay 154 to ground. The energization of relay 103 closes the circuit of relay 166 through its left hand outer armature and front contact, the right hand winding of relay 130 and the conductor 165 as described above. The energization of relay 166 closes a circuit through its outer armature and front contact, the inner armature and back contact of relay 170, conductor 167, and the thirteenth armature and front contact of relay 154 for energizing relay 168 whereupon the sending control switch is stepped from the rest position by the stepping magnet 63. The switch continues to step upon each revolution of the brushes of the sending distributor as described above until the wipers 60, 61 and 62 engage their eleventh contacts. At this point the circuit of relay 103 is reclosed through the wiper 62, the eleventh contact of the associated contact bank, the right hand armature and front contact of relay 185, and the right hand winding of relay 103 to battery at the local ring of the sending distributor whereupon the second double blank switching signal is transmitted over the lane of traffic.

On the operation of relay 166, which occurs while the wiper 60 is resting on its eleventh stud position in the same manner as described for the case in which a subchannel is entered, a circuit is closed from positive through the outer armature and front contact of relay 166, inner armature and back contact of relay 170, conductor 167, thirteenth armature and back contact of relay 154, wiper 60 and its eleventh stud position, resistance 74 to negative. This neutralizes the locking current in relay 185, thereby causing relay 185 to be released.

The transmission of the first double blank switching signal as described upon the operation of the key 73 starts the receiving control switch at the receiving station stepping in synchronism with the sending control switch. The reception of the second double blank switching signal, when the wipers 260, 261 and 262 of the receiving control switch are in engagement with their eleventh contacts, closes the circuit of relays 280 and 266 as described above. The energization of relay 266 closes a circuit from positive battery through the left hand armature and front contact of relay 266, the inner armature and back contact of relay 266, the inner armature and back contact of relay 270, the middle armature and back contact of relay 254, the wiper 260, the eleventh contact of the associated contact bank and the left hand winding of relay 271 to ground. Relay 271 becomes energized, is locked up through a circuit including its armature and front contact, its right hand winding and the key 274, and closes a circuit through its armature and front contact for lighting the "call" lamp 273. The "call" lamp 273 may be employed to summon an attendant at the receiving station who extinguishes the lamp by actuating the key 274 or the operation of relay 271 may be employed for any other desired purpose.

The manual switches or control keys 70, 71 and 72 are associated with the sending control switch in a manner similar to the key 73 and when any of these switches or keys is operated a test circuit is closed similar to that closed by each of the subchannels to initiate the entering or cutting

out of the subchannel. Thus the stepping of the sending and receiving control switches is initiated by the closure of any of these test circuits and when the wipers of the sending control switch reach the subchannel or key which has initiated the switching operation, a second switching signal is transmitted to the receiving station to effect the desired function at that point through the instrumentality of the receiving control switch which at that moment is operated to the same extent as the sending control switch and thus serves to select the receiving end of the subchannel or control channel. However, it should be noted that the control channels are independent of the transmitting subchannels so that the control equipment is not affected by failure or loss of synchronism of the connector relay chains at the sending or receiving stations.

The key 70 associated with the eighth contacts of the sending control switch is adapted to stop transmission from the station at which the key is located to the remote station. When the key 70 is operated relay 103 becomes energized to transmit a switching signal to initiate the stepping of the receiving control switch in a manner described above. The circuit of relay 103 includes the conductor 159 from the local ring of the sending distributor, the resistance 158, the lefthand inner armature and back contact of relay 157, the conductor 156, the lefthand make contacts of the key 70, the conductor 186 and the eighth armature and front contact of relay 154 to ground. The operation of relay 166 in response to the energization of relay 103 as described above operates the relay 168 to initiate the stepping of the sending control switch.

In order to stop transmission from all subchannels it is only necessary to cut out all of the subchannels and prevent them from being cut in again. Relay 157 performs both of these functions for the sending ends of the subchannels and relay 298 performs the function of cutting out the subchannels at the receiving end, since the function of preventing subchannels from being cut in again is only necessary at the sending end. The subchannels are all cut out at the same moment by opening the locking circuits of control relays 85 to 89 at the sending station and of relays 285 to 289 at the receiving station. The locking circuits for relays 85 to 89 include conductor 110 and the lefthand outer armature and back contact of relay 157. Similarly, the locking circuits of relays 285 to 289 include the righthand outer armature and back contact of relay 298. The release of relays 85 to 89 and 285 to 289 is properly timed so that it does not introduce errors in the transmission of any message characters just before transmission is stopped. Relay 157 further prevents the sending ends of the subchannels from cutting in again by opening at its lefthand inner armature and back contact the test circuit of the several subchannels which includes the conductors 155 and 156 as described above.

After the stop key 70 has been operated as described above, when the wipers 60, 61 and 62 of the sending control switch reach their eighth contacts, the circuit of relay 157 is closed from negative through the lefthand winding of relay 157, the eighth contact and its associated wiper 60, the thirteenth armature and back contact of relay 154, the conductor 167, the inner armature and back contact of relay 170 and the outer armature and front contact of relay 166 to positive battery. Relay 157 becomes energized and locks up through a circuit including the signal lamp 169, the right hand armature and front contact and the right hand winding of relay 157, to ground at the outer armature of relay 154 or alternatively through the conductor 187 and the right hand make contacts of the stop key 70 to ground. The lighting of the lamp 169 indicates to the attendant that transmission has been stopped either manually by the stop key 70 or automatically in response to the distortion of switching signals as will be explained hereinafter.

At the same time that the stop relay 157 is operated, the wipers 60 and 260 of the sending and receiving control switches being in engagement with their eighth contacts, a circuit is closed through the wiper 260 for energizing relay 298 to cut out all of the receiving ends of the subchannels. Relay 298 becomes locked up through its inner armature and front contact and right hand locking winding to ground at the outer armature and back contact of relay 254. Thus relay 298 remains locked up until the receiving control switch returns to normal, whereas the relay 157 remains locked up until the sending control switch returns to normal, or if the stop key 70 which is of the locking type is still operated, until said key is returned to normal.

The operation of the relay 157 opens the test circuits of the respective subchannels at its inner left hand armature and back contact as stated above but does not directly release the relay chain. Were this not the case message characters then in process of transmission would be lost or mutilated. When the local brush of the sending distributor SD engages segments 56 of the local ring 53, a circuit is closed from positive battery at the local ring 53, a circuit is closed from positive battery at the local ring 54 through the segments 56, the conductor 135, the winding of relay 102, conductor 149, the left hand middle armature and front contact of relay 157, a conductor 152 and the left hand inner armature and front contact of relay 78 for unlocking the associated connector relay of the group 30 to 34. Since the release of the operated connector relay of this group occurs at a time when the normal transfer of subchannels in this group would be made and while transmission is being effected from one of the subchannels to the first multiplex channel, it will be evident that the relay is released in such a manner as to avoid the loss or mutilation of the message character being transmitted from the operative subchannel over the second multiplex channel. The release of the connector relay in the group 30 to 34 also causes the relay 78 to be released. When the local brush of the distributor SD next engages segments 55 a circuit is closed from positive battery at the local ring 54 through the segments 55, the conductor 115, winding of relay 101, the conductor 116, the conductor 124, the middle armature and back contact of relay 78 and the left hand inner armature and front contact of relay 77 for unlocking the associated connector relay of the group 20 to 24. Since the release of the operated connector relay of this group occurs at a time when the normal transfer of subchannels in this group would be made it will likewise be evident that no mutilation or loss of a character occurs as a result of its release. The release of the relay chain at the receiving ends of the subchannels is effected in a similar manner in response to the energization of relay 298.

Transmission may also be stopped automatical-

ly in response to the operation of relay 182 having contacts in parallel with those of the stop key 70. As pointed out above relays 180 and 280 at the respective stations are provided to detect the reception of a distorted switching signal consisting of a single blank or all-spacing code combination. The closure of a circuit through the left hand armature of relay 280, as described above, upon the reception of a single blank code combination is operative to stop transmission from the second station to the first station over the other half of the system (not shown). The manner in which this is accomplished will be apparent from consideration of the operation of relays 180, 181 and 182 at the first station. The closure of the circuit through the left hand armature of relay 180 as described above in connection with relay 280 energizes relays 181 and 182 in series relation. Relay 182 closes the same circuits which are closed by the stop key 70 so that upon reception of a single blank code combination at the first station transmission from that station is stopped in the same manner as though the stop key 70 had been operated. Relay 182 locks, from positive battery through its right hand armature and front contact and right hand winding to ground at the right hand tongue and break contact of the stop key 70. Upon operation of the stop key 70, this locking circuit is opened and the relay 182 is released and the stopped condition is then maintained by virtue of the operated position of the stop key 70. When key 70 is released normal operation is restored.

The relay 181 which was operated in series with the relay 182 locks up through its left hand winding and left hand armature and front contact to negative battery. This relay, through its right hand armature and front contact, closes the test circuit in the same manner as described above for the case in which the relay 185 was operated from the key 73. The operation of the relay 181 causes a switching signal to be transmitted when the sending control switch reaches its tenth stud position and this signal causes the relay 300 connected to the tenth stud position of the receiving control switch to be operated at the other end of the circuit. The relay 300 has contacts which are connected in parallel to those of the stop key 70 at that terminal and its operation therefore causes a signal to be transmitted from the sending control switch at that terminal to stop transmission of signals in the same manner as described above for the case in which the stop key 70 was operated. Thus when either of the single blank combinations is not received the operation of the system is stopped in both directions.

When this stoppage has occurred, both attendants release their corresponding relays 182 by the operation of the key 70 at each terminal. The system is restarted by closure of the key 70 and the start key 72 which closes the circuit through the right hand winding of relay 184 and the contacts of the key 72 to negative battery whereupon relay 184 becomes energized and locks up through its right hand armature and front contact, the locking circuit being independent of the contacts of the key 72. Relay 184 corresponds to relay 290 at the receiving station which, as described above, is operated whenever loss of synchronism of the relay chains occurs when less than two subchannels are connected at the receiving station. Since the operation of relay 184 effects the re-entry of the operative subchannels in a manner to be described hereinafter, it will be clear that the operation of relay 290 in a similar manner effects re-entry of the operative subchannels to re-synchronize the relay chains.

Relay 184 through its left hand armature and front contact closes the test circuit for operating relay 103 whereupon the sending control switch commences to step and a switching signal is transmitted to the receiving station to start the receiving control switch as described above. When the wipers of the sending control switch reach their ninth contacts, a circuit is closed from positive battery through the left hand outer armature and front contact of relay 166, the left hand inner and back contact of relay 170, the conductor 167, the thirteenth armature and back contact of relay 154, the wiper 60 of the sending control switch to the negative battery connected to the contacts of the relay 184 whereupon relay 184 becomes deenergized. At the same time the closure of the circuit through the wiper 260 of the receiving control switch which is in engagement with its ninth contact energizes relay 299 which is arranged to restart the system at the receiving station, as by unlocking the circuit of relay 300 which was locked up to stop transmission by the operation of stop key 71 as described above. In a similar manner the sending and receiving control switches may be arranged to provide additional control channels for other purposes if desired.

Various modifications in the system shown and described above for the purpose of explaining the invention will occur to those skilled in the art and may be made without departing from the scope of the invention as defined in the appended claims. No claim is made herein to the features of the expanding channel systems which are disclosed in the prior applications of P. Holcomb, Jr., Serial Nos. 666,004, 106,904, 123,266 and 153,748.

We claim:

1. An expanding channel system comprising a lane of traffic, a plurality of subchannels, transmitting and receiving apparatus for said subchannels, means including connector relays individual to each subchannel for connecting the same to the lane of traffic and means for sequentially operating said connector relays to connect operative subchannels to the lane of traffic while omitting the relays of inoperative subchannels whereby the lane time is shared by the operative subchannels, said operating means including a pulsing circuit common to all of said connector relays.

2. An expanding channel system comprising a lane of traffic, a plurality of subchannels, transmitting and receiving apparatus for said subchannels, means including connector relays individual to each subchannel for connecting the same to the lane of traffic, the operating circuits of said relays each including a contact of another of said relays, and means including said contacts for operating said connector relays to connect the subchannels in sequence to the lane of traffic.

3. An expanding channel system comprising a lane of traffic, a plurality of subchannels, transmitting and receiving apparatus for said subchannels, means including connector relays individual to each subchannel for connecting the same to the lane of traffic and means for operating the relays corresponding to operative sub-

channels to connect said operative subchannels successively to the lane of traffic, said operating means comprising a source of current and means for intermittently connecting said source of current to the connector relays.

4. An expanding channel system comprising a lane of traffic, a plurality of subchannels, transmitting and receiving apparatus for said subchannels, means including relays individual to each subchannel for operatively associating certain subchannels with the lane of traffic and means for sequentially controlling the relays of operative subchannels while omitting the relays of inoperative subchannels whereby the lane time is shared by the operative subchannels, said last-mentioned means including a common operating circuit for said relays and means for closing said circuit periodically in predetermined relation to the transmission of successive signals.

5. An expanding channel system comprising a lane of traffic, a plurality of subchannels, transmitting and receiving apparatus for said subchannels, means including connector relays individual to each subchannel for connecting the same to the lane of traffic, other relays individual to the subchannels, means for operating said other relays in accordance with the cut-in or cut-out condition of the respective subchannels, the operating circuits of said connector relays each including a contact of another of said connector relays and a contact of one of said other relays, and means including said contacts for operating said connector relays to connect the operative subchannels in sequence to the lane of traffic.

6. An expanding channel system comprising a synchronous multiplex system having sending and receiving distributors, a plurality of subchannels, transmitting and receiving apparatus for said subchannels, means including connector relays individual to each subchannel for connecting the same to the multiplex system and means including said distributors for operating the relays corresponding to operative subchannels to connect said operative subchannels successively to the multiplex system.

7. An expanding channel system comprising a lane of traffic, a plurality of subchannels, each subchannel embodying transmitting and receiving apparatus, and a chain of relays for operatively associating the subchannels in succession with said lane of traffic, each of said relays having an operating winding and a locking winding interconnected in such a manner that the energization of the operating winding of one relay reduces the current through the locking winding of the previously energized relay.

8. An expanding channel system comprising a lane of traffic, a plurality of subchannels, each subchannel embodying transmitting and receiving apparatus, a chain of relays for operatively associating the subchannels in succession with said lane of traffic, means for controlling said relays including auxiliary relays each individual to one of the subchannels, and means for operating said auxiliary relays in accordance with the busy or idle condition of the associated subchannels.

9. An expanding channel system comprising a lane of traffic, a plurality of subchannels, each subchannel embodying transmitting and receiving apparatus, means including a chain of relays for operatively associating the subchannels in succession with said lane of traffic, means for controlling said relays including a pair of auxiliary relays associated with each subchannel, means for operating one of said pair of relays when the associated subchannel is to be entered on the lane of traffic, means for thereafter operating the other of said pair of relays upon entering the transmitting and receiving ends of the associated subchannel and means including said pair of relays for entering and cutting out the associated subchannel in relation to the lane of traffic.

10. An expanding channel system comprising a lane of traffic, a plurality of subchannels, each subchannel embodying transmitting and receiving apparatus, a chain of relays for operatively associating the transmitting ends of said subchannel with the lane of traffic, a second chain of relays for operatively associating the receiving ends of said subchannels with the lane of traffic and means for variably stepping said relay chains in synchronism to effect successive operation of busy subchannels and omission of idle subchannels.

11. In a multiplex telegraph system, a plurality of transmitters, a circuit, a chain of relays controlling the connection of said transmitters to said circuit, means for stepping said chain of relays to connect the transmitters successively to said circuit and auxiliary relay means to effect the omission at times of predetermined transmitters in the stepping of the relay chain.

12. In a telegraph system, a plurality of circuits, another circuit, a relay chain having contacts in said circuits, means for stepping said relay chain to connect said circuits one at a time to said other circuit and means for variably controlling said stepping means and relay chain to pass over one of said plurality of circuits at times in the stepping of the relay chain.

13. An expanding channel system comprising a lane of traffic, a plurality of subchannels, each including transmitting and receiving apparatus, means for connecting said subchannels to the lane of traffic and for dividing the lane time between the operative subchannels and means for entering subchannels on the system as they become operative, said last-mentioned means comprising control switches at the sending and receiving ends of the system having a normal or rest position and means for simultaneously initiating the operation of said switches when any of the previously inoperative subchannels has signals to transmit.

14. An expanding channel system comprising a lane of traffic, a plurality of subchannels, each including transmitting and receiving apparatus, means for connecting said subchannels to the lane of traffic and for dividing the lane time between the operative subchannels and means for entering subchannels on the system as they become operative, said means comprising a step-by-step switch at the sending station having normally stationary switch wipers and means for stepping the wipers of said switch in predetermined timed relation to the successive transmission of signals over the lane of traffic when a previously inoperative subchannel has signals to transmit.

15. An expanding channel system comprising a lane of traffic, a plurality of subchannels, each including transmitting and receiving apparatus and said lane of traffic comprising a distributor-transmitter at the receiving end common to a plurality of subchannels, said distributor-transmitter embodying a latched distributor member

controlling sequential contact means, means for connecting said subchannels to the lane of traffic and for dividing the lane time between the operative subchannels, means including said distributor-transmitter for controlling the receiving apparatus of the operative subchannels, and means for entering subchannels on the system as they become operative.

16. An expanding channel system comprising a lane of traffic consisting of a plural-channel synchronous multiplex system, a plurality of subchannels, each including transmitting and receiving apparatus, means for connecting said subchannels to the lane of traffic and for dividing the lane time between the operative subchannels and means including a distributor-transmitter on each of said multiplex channels common to all of the subchannels for transmitting signals received over the multiplex system to the receiving apparatus of operative subchannels.

17. An expanding channel system comprising a lane of traffic consisting of a plural-channel synchronous multiplex system, a plurality of subchannels, each including transmitting and receiving apparatus, certain of the receiving subchannels including multiplex receiving devices and others including start-stop receiving devices, and means including a distributor-transmitter individual to each of the multiplex channels and common to all of the subchannels for transferring signals received over the multiplex system to either type of receiving subchannel.

18. An expanding channel system comprising a lane of traffic consisting of a synchronous multiplex system, a plurality of subchannels, each including transmitting and receiving apparatus, means for connecting said subchannels to the lane of traffic and for dividing the lane time between the operative subchannels, and means for transmitting a predetermined character other than a blank over an idle channel of the multiplex system while it is not being used for transmission by said transmitting apparatus.

19. An expanding channel system comprising a lane of traffic consisting of a synchronous multiplex system, a plurality of subchannels, each including transmitting and receiving apparatus, means for transmitting a switching signal to the receiving end of the multiplex system when a subchannel is to be entered on the system and means for stopping transmission over the multiplex system when a switching signal is distorted in transmission.

20. An expanding channel system comprising a lane of traffic consisting of a plural-channel synchronous multiplex system, a plurality of subchannels, each including transmitting and receiving apparatus, means for connecting the operative subchannels successively to the lane of traffic and means for entering subchannels as they become operative, said last-mentioned means including means for transmitting a signal comprising a plurality of characters over the lane of traffic and means for resynchronizing the sending and receiving ends of the subchannels when only a part of the said multiple-character signal is received.

21. An expanding channel system comprising a lane of traffic, a plurality of subchannels, each including transmitting and receiving printing apparatus, means for operatively associating subchannels having signals to transmit with the lane of traffic, said means comprising means for transmitting a switching signal over the lane of traffic, means for preventing the transmission of said switching signal from the transmitting apparatus of any subchannel and means for substituting for said signal when the same is originated from a subchannel a "letters shift" code combination when the receiving printer is in lower case and a "figures shift" code combination when it is in upper case.

22. An expanding channel system comprising a lane of traffic, a plurality of subchannels, each including transmitting and receiving apparatus, means for connecting said subchannels to the lane of traffic and for dividing the lane time between the operative subchannels, an auxiliary channel of said lane of traffic independent of said connecting means and means including said auxiliary channel for stopping transmission over any of the subchannels.

23. An expanding channel system comprising a lane of traffic, a plurality of subchannels, each including transmitting and receiving apparatus, means for connecting said subchannels to the lane of traffic and for dividing the lane time between the operative subchannels, an auxiliary channel of the lane of traffic independent of said connecting means and means including said auxiliary channel for resynchronizing the connecting means of the respective subchannels.

24. An expanding channel system comprising a lane of traffic, a plurality of subchannels, each including transmitting and receiving apparatus, means for connecting said subchannels to the lane of traffic and for dividing the lane time between the operative subchannels, means for detecting lack of synchronism of the connecting means at the transmitting and receiving ends of the system, and means controlled thereby for stopping transmission.

25. An expanding channel system comprising a lane of traffic consisting of a synchronous multiplex system, a plurality of subchannels each including transmitting and receiving apparatus, means for transmitting a switching signal to the receiving end of the multiplex system when a subchannel is to be entered on the system, means for stopping transmission over connected subchannels and means for rendering the last mentioned means effective when a switching signal is distorted in transmission.

26. An expanding channel system comprising a first station, a second station, a lane of traffic connecting said stations, a plurality of subchannels each including transmitting apparatus at the first station and receiving apparatus at the second station, means for connecting said subchannels to the lane of traffic and for dividing the lane time between the operating subchannels, automatic means for cutting out each subchannel in response to its handling of waiting traffic, manually operable means at the first station for simultaneously cutting out all of the subchannels and manually operable means at the second station for simultaneously cutting out all of the subchannels.

27. An expanding channel system comprising a first station, a second station, a lane of traffic connecting said stations, a plurality of subchannels each including transmitting apparatus at the first station and receiving apparatus at the second station, means for cutting said subchannels in and out in relation to the lane of traffic and for dividing the lane time between the operating subchannels which are cut in, said means including means for transmitting a double blank character code combination to the second station, and means controlled by the reception of

a single blank character code combination for stopping transmission over the lane of traffic and cutting out all of the operating subchannels.

28. An expanding channel system comprising a first station and a second station, a lane of traffic connecting said stations, a plurality of subchannels each including transmitting apparatus at the first station and receiving apparatus at the second station, means for cutting said subchannels in and out in relation to the lane of traffic in response to traffic conditions in the respective subchannels, said means including means for transmitting a double blank character code combination to the second station when one of the subchannels is to be cut in or out, and means responsive to transmission of said double blank character code combination under certain conditions for simultaneously cutting out all of the operating subchannels.

29. An expanding channel system comprising a lane of traffic embodying a synchronous multiplex distributor, a plurality of subchannels sharing said lane of traffic, means for cutting said subchannels in and out in relation to the lane of traffic and for dividing the lane time between those subchannels which have signals to transmit, means for simultaneously cutting all of the operating channels out under predetermined conditions, and means for controlling said last mentioned means and interconnected with the multiplex distributor to prevent mutilation of signals being transmitted, at or just prior to the cutting out of the subchannels.

30. An expanding channel system comprising a lane of traffic, a plurality of subchannels, means including a group of relays at each end of the lane of traffic for dividing the lane time between the subchannels which have signals to transmit, the relays of each group being so interconnected that the operation of each relay depends upon the other relays of its group, means for cutting the subchannels in and out in relation to said relay groups and the lane of traffic, and a signaling channel sharing the lane of traffic with the operating subchannels but independent of said groups of relays.

31. A multiplex telegraph system comprising a lane of traffic, a plurality of subchannels, means including a chain of connector relays for successively associating each of said subchannels with the lane of traffic, means for controlling said connector relays to render the subchannels successively operative one after another, and means for stopping the cyclic operation of the relay chain under predetermined conditions without interrupting transmission over one of the subchannels.

32. A relay chain comprising a plurality of relays each having operating and locking windings interconnected in such a manner that the energization of the operating winding of one relay reduces current through the locking winding of the previous energized relay, an operating circuit for said relay chain including contacts of said relays, means whereby the energization of any one of said relays closes a contact in the circuit of the operating winding of another relay of said chain, and means for impressing current impulses on said operating circuit to cause stepping of the relay chain.

33. In combination, a relay chain comprising a plurality of relays each having operating and locking windings interconnected in such a manner that the energization of the operating winding of one relay reduces the current through the locking winding of the previously energized relay, an operating circuit for said relay chain including contacts of said relays, means for impressing current impulses on said operating circuit to cause stepping of the relay chain, a plurality of auxiliary relays provided with contacts in said operating circuit, and means whereby the operation of said auxiliary relays bypass certain of the chain relays whereby the number of relays included in the operation of the relay chain may be varied.

34. In a telegraph system, a main station, a main telegraph channel connected to said station, a synchronous distributor at said main station connected to said channel, a plurality of local stations associated with said main station, local lines operatively connecting said main station to the respective local stations, telegraph signaling apparatus at said local stations and allotting circuit means comprising only relays at said main station for connecting said local stations to said main channel in rotation when said local stations become operative.

35. In a telegraph system, a main line, concentrating apparatus connected to each end of said main line, a plurality of telegraph extension lines associated with the concentrating apparatus at each end of said main line, telegraph signaling apparatus connected to said extension lines, means for rendering said telegraph signaling apparatus operative and means comprising only relays and circuits therefor for connecting any of said extension lines to said main line in rotation in response to the conditioning of said telegraph signaling apparatus.

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