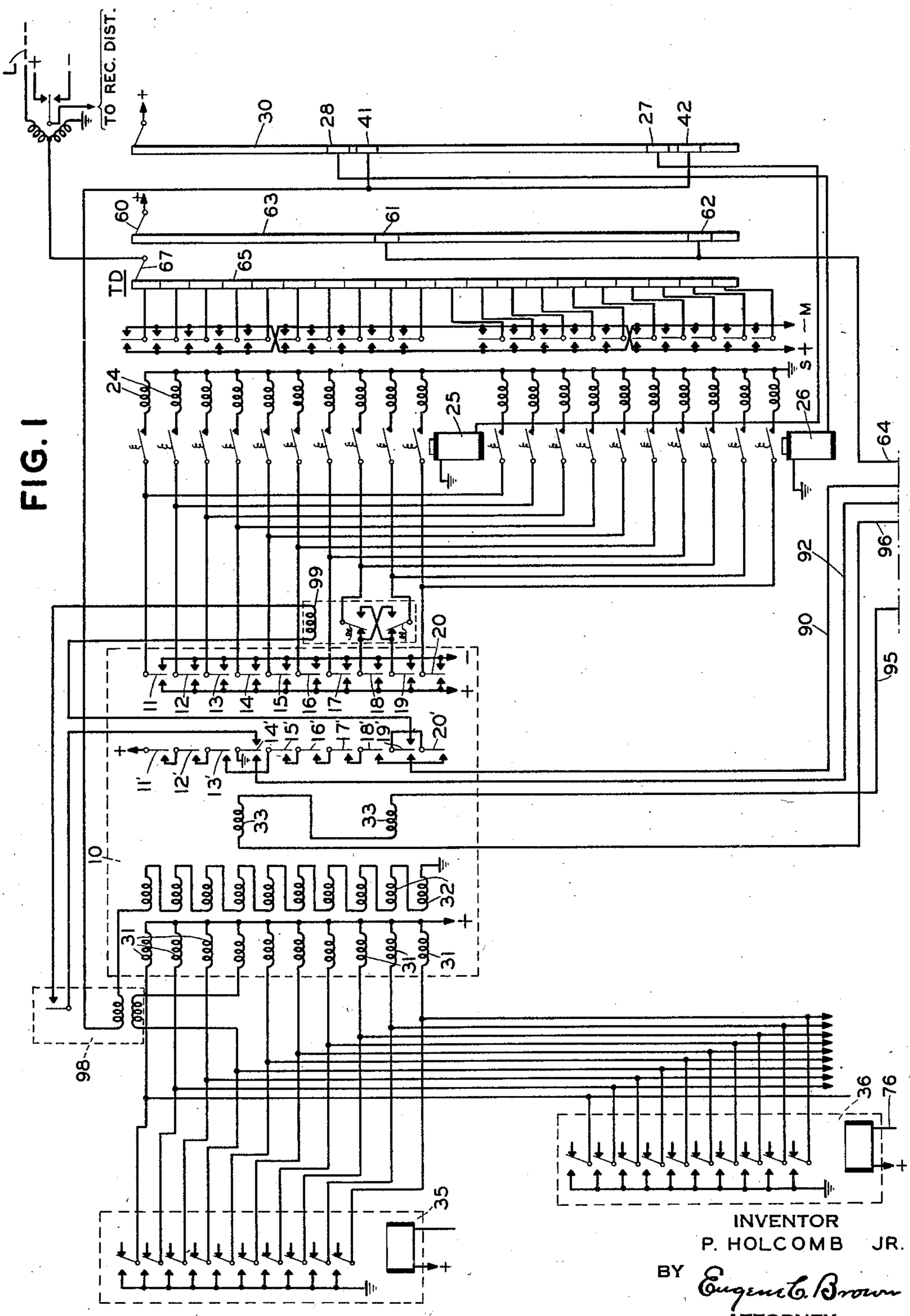
May 12, 1942. P. HOLCOMB, JR 2,282,357

SIGNALING SYSTEM

Filed Jan. 30, 1937 5 Sheets-Sheet 1

FIG. 1



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SIGNALING SYSTEM

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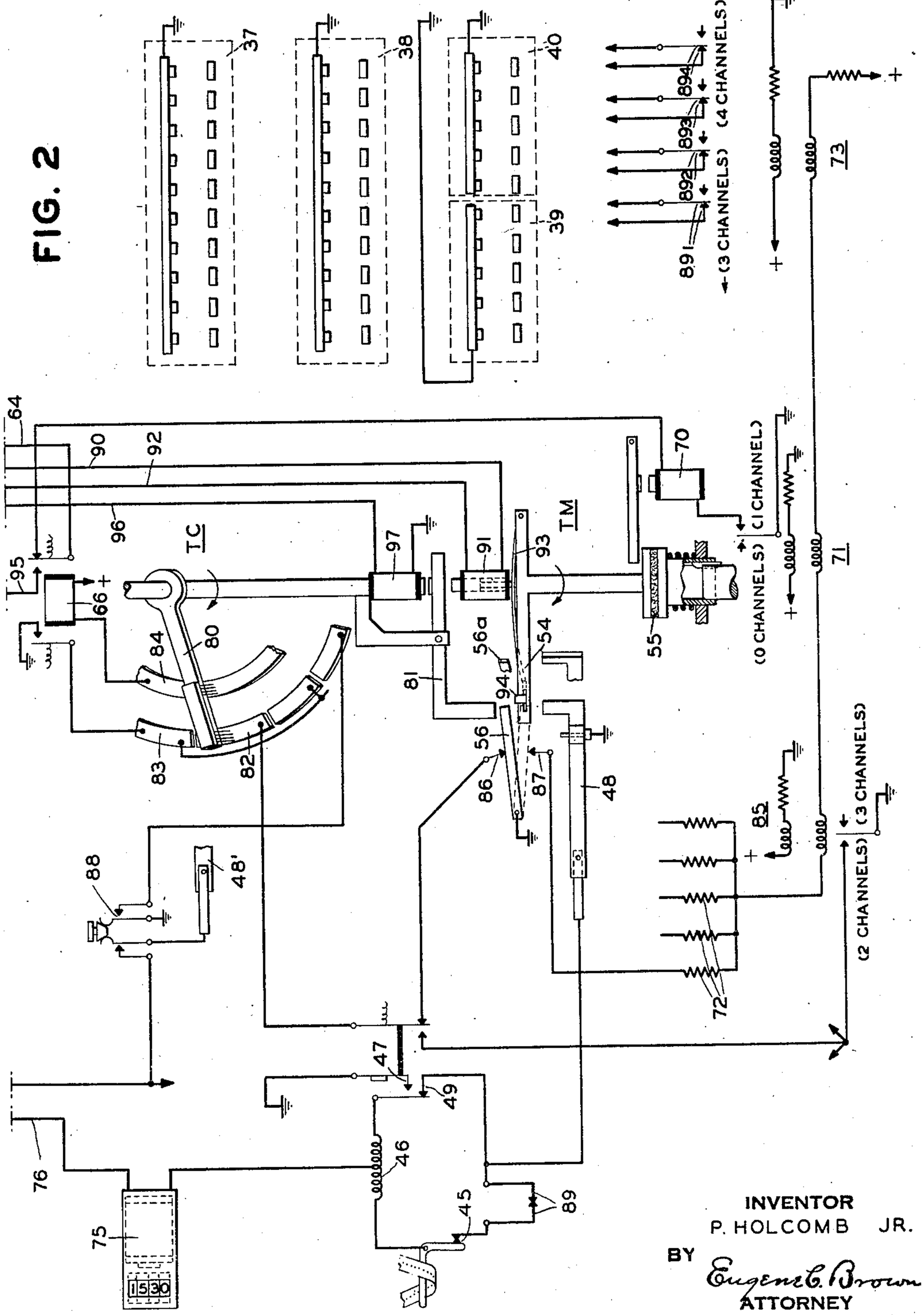
5 Sheets-Sheet 2

FIG. 2



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SIGNALING SYSTEM

Filed Jan. 30, 1937 5 Sheets-Sheet 3

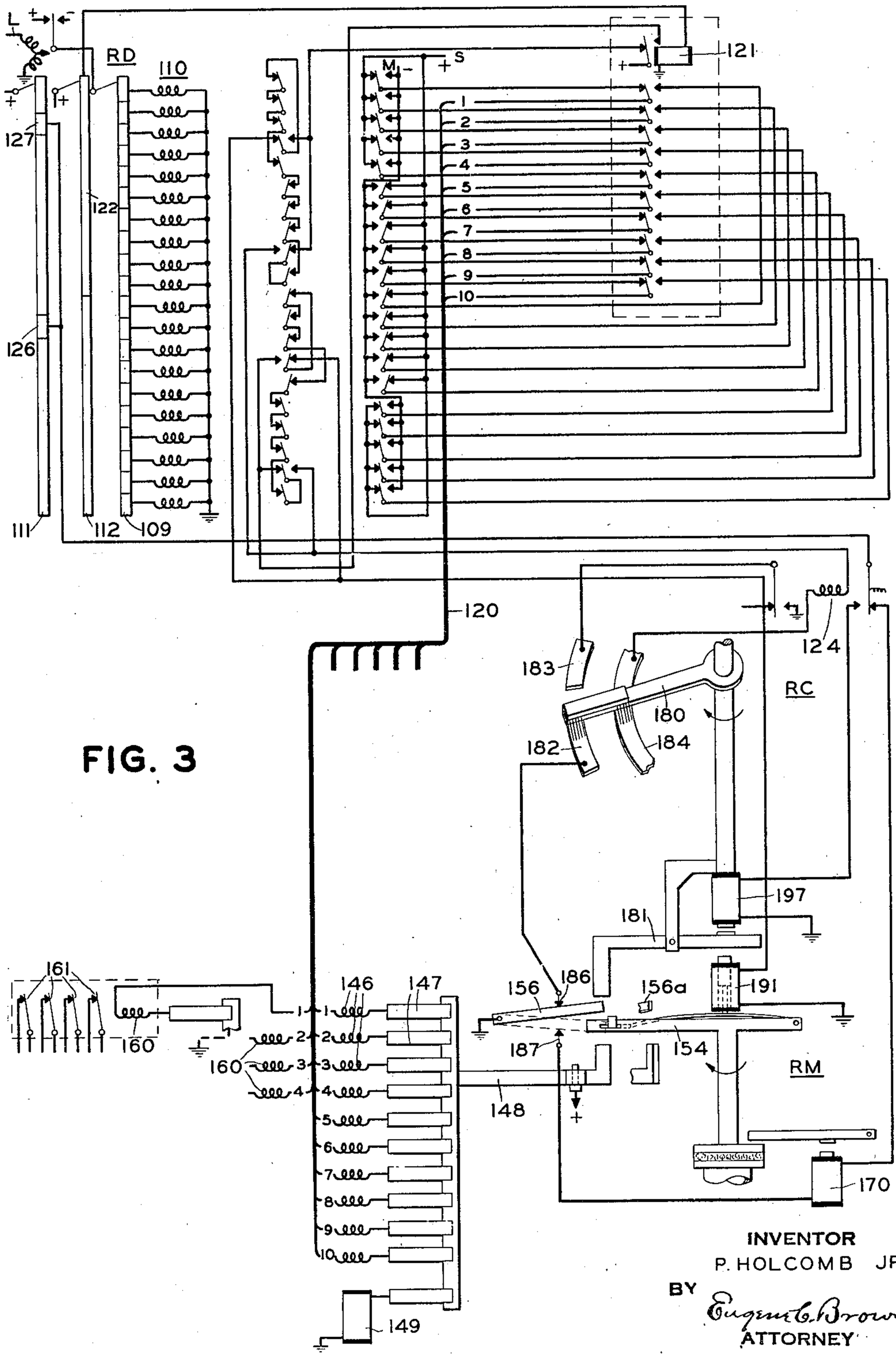

FIG. 3

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May 12, 1942. P. HOLCOMB, JR 2,282,357

SIGNALING SYSTEM

Filed Jan. 30, 1937

5 Sheets-Sheet 4

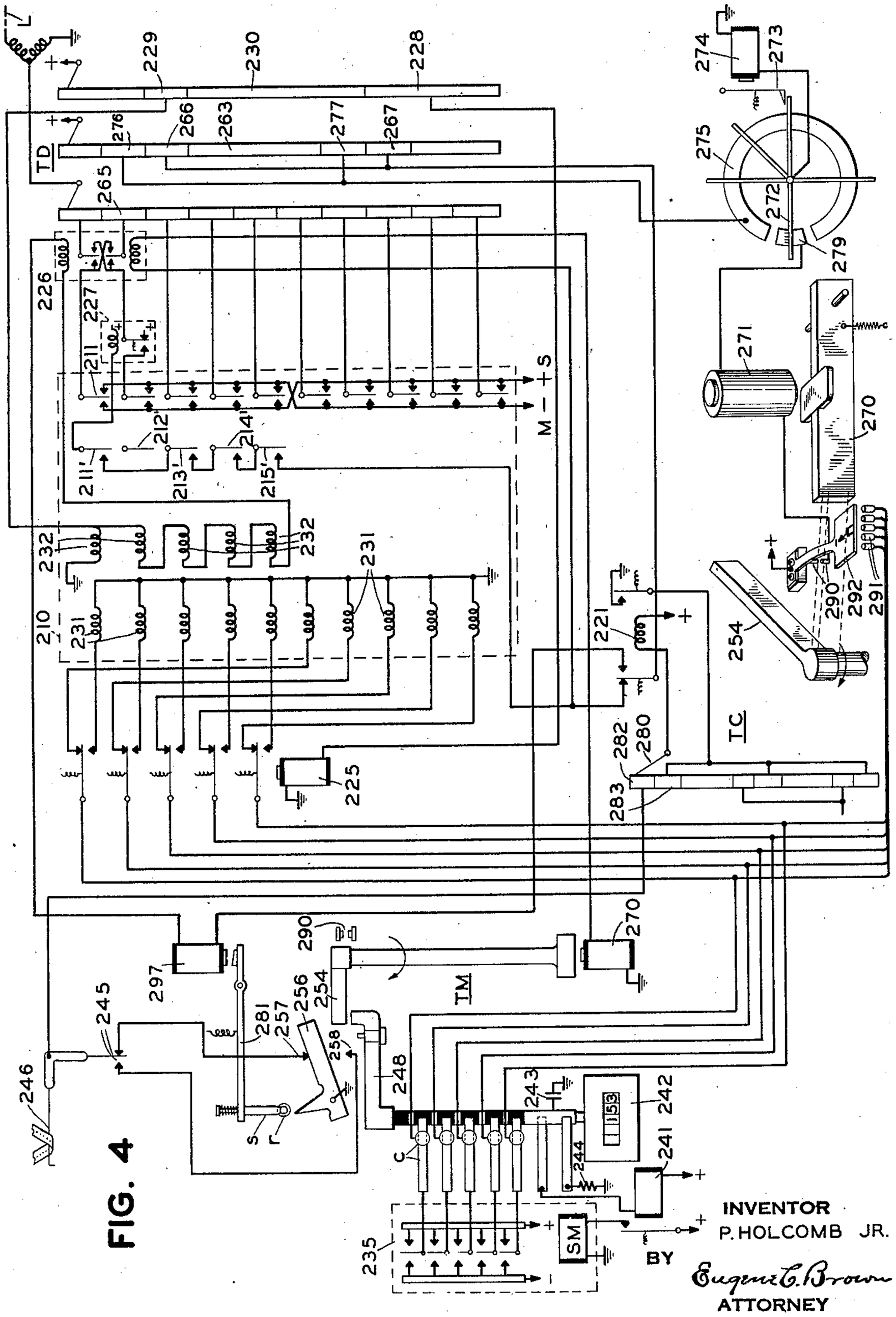

FIG. 4

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SIGNALING SYSTEM

Filed Jan. 30, 1937 5 Sheets-Sheet 5

FIG. 7

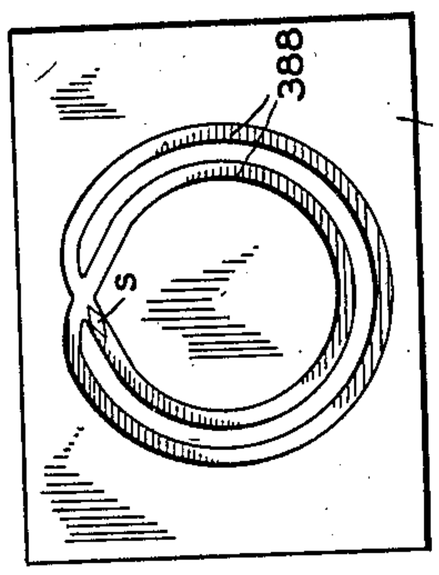


FIG. 6

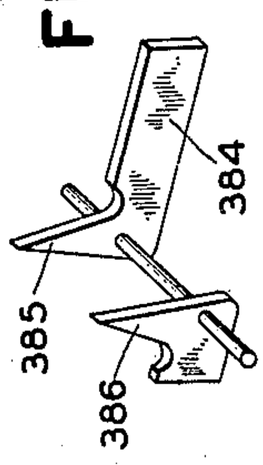
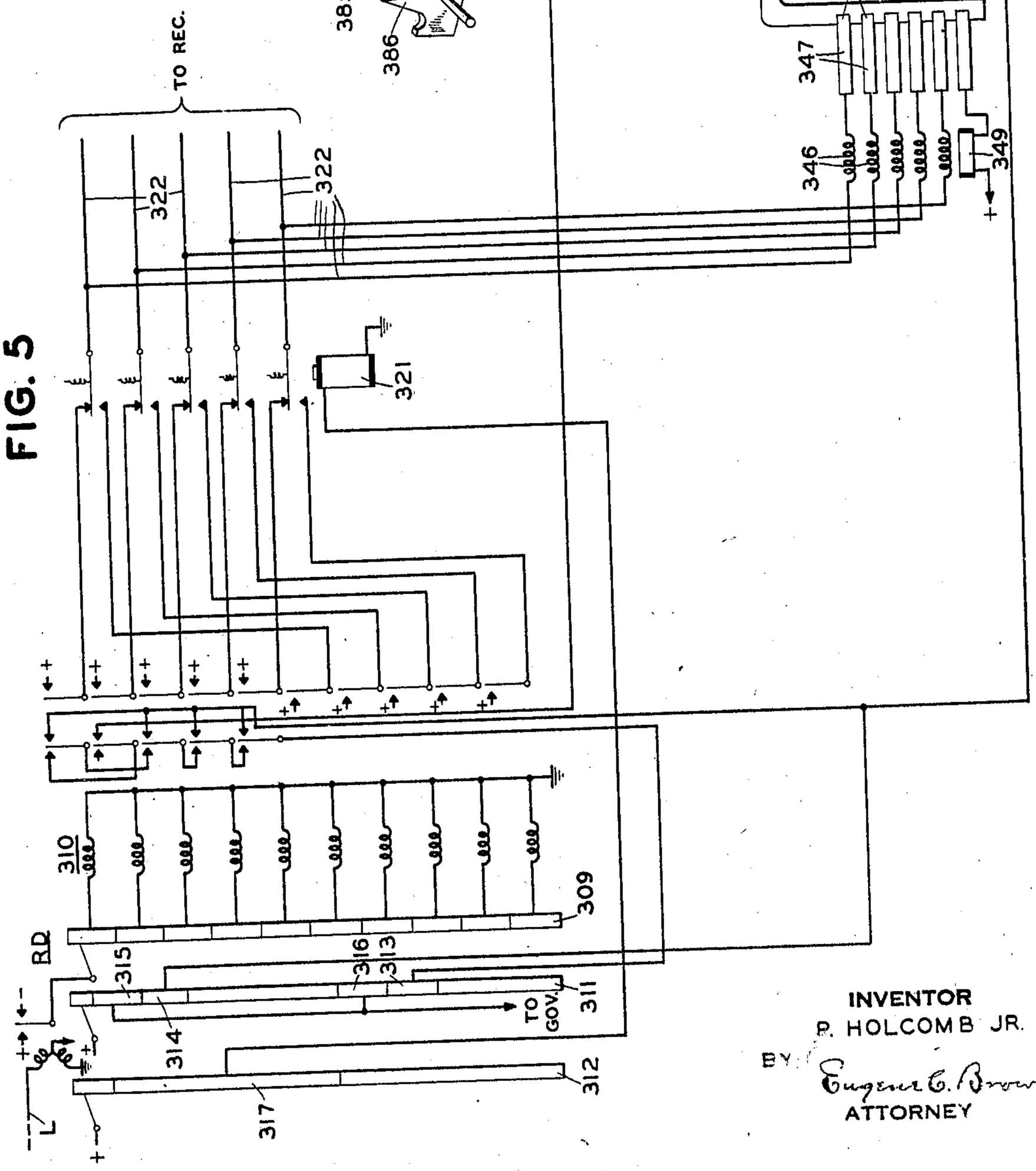


FIG. 5



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Patented May 12, 1942

2,282,357

UNITED STATES PATENT OFFICE

2,282,357

SIGNALING SYSTEM

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Application January 30, 1937, Serial No. 123,266

41 Claims. (Cl. 178—52)

My invention relates to signaling systems and more particularly to systems such as telegraph systems wherein a plurality of sources of signals are employed.

In my prior application Ser. No. 666,004, filed April 13, 1933, I have disclosed a telegraph system embodying the basic principle of the expanding channel system, i. e., 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. In the system illustrated in said patent the lane of traffic comprises a single channel of a synchronous multiplex system. The expression "lane of traffic" as used herein designates the route or medium over which signaling is accomplished.

It is the object of the present invention to improve and simplify the system disclosed in my above mentioned prior application and the mechanical construction and arrangement of the apparatus employed for controlling the signaling channels.

More specifically, an object of the invention is to provide an expanding channel system in which the lane time, or a predetermined part thereof, is divided either equally or unequally, as desired, between the transmitters having message signals to transmit over the lane of traffic If only a few transmitters are operative, the capacity of the lane of traffic may be greater than the capacity of the operative transmitters, and in that event it is desirable to slow down the transmission over the lane of traffic sufficiently so that the operating transmitters function properly. It may also be desirable to render certain transmitters incapable of seizing a subchannel of the lane of traffic when a predetermined number of other transmitters are operative, as for example where certain transmitters are allocated to deferred messages and the deferred traffic should be held up until the regular traffic is below a predetermined amount. In accordance with a preferred form of the invention, certain transmitters or channels are only operative when less than a predetermined number of other transmitters are sending over the lane of traffic.

Another object of the invention is to provide an expanding channel system in which certain channels have constant speeds or transmitting rates. In the usual expanding channel system operating channels share the lane time equally and thus the speed of transmission for each channel varies depending upon the number of other channels in operation. In some cases, however, it may be desirable to have one or more channels operate at a constant speed irrespective of the number of other channels in operation and a system of this character embodies one feature of the present invention.

Another object of the invention is to provide a multichannel telegraph system in which multiple character transmitters are employed, namely, transmitters from which two or more characters are sent during each cycle of operation. This feature of the invention permits a higher speed of transmission from the channels when only a few channels are in operation and likewise permits the lane to be operated more nearly at full capacity when only a few channels are in operation.

Another object of the invention is to provide an expanding channel system utilizing a plural-channel multiplex as the lane of traffic and arranged to transmit from a subchannel simultaneously over a plurality of the channels of the multiplex system.

Another object of the invention is to provide an expanding channel system wherein the entry and/or exit signals for cutting the receiving devices in and out consist of multiple character code combinations, such as two or more successive characters which together constitute an entry or exit signal; and a system wherein the component parts of the entry and/or exit signals are sent over different multiplex channels thereby reducing the possibility of the occurrence of false entry or exit signals as the result of line trouble.

Another object of the invention is to provide an expanding channel system utilizing a plurality of synchronous multiplex channels in which the entry and/or exit signals are invariably sent over one only of the multiplex channels. One advantage of this arrangement is that code combinations used for regular message characters may be employed as entry or exit signals.

Another object of the invention is to provide an expanding channel system in which ordinary code combinations are employed as entry or exit signals and in which, when said signals are originated from a transmitter instead of from the control apparatus, they are momentarily deferred or converted into other signals or both.

Another object of the invention is to provide a governor for controlling the speed of opera-

tion of the control equipment whereby when only a few transmitters are operative, the transmission rate over the lane of traffic is reduced in accordance with the capacity of the operative transmitters.

Another object of the invention is to provide an expanding channel system in which certain channels are only operative under predetermined system conditions as when the number of other channels, such as preferred channels, in operation is fewer than a predetermined number whereby deferred traffic may be held up until regular traffic is below the capacity of the lane of traffic.

Another object of the invention is to provide in an expanding channel system a simple and effective arrangement for metering the traffic in each channel or means arranged to provide a basis for rendering equitable charges for service in a system of this character.

Another object of the invention is to provide in connection with an expanding channel system means for signaling over the channel, as for example for the purpose of operating a signal to call an attendant at a remote station, and means for controlling the system, as for example to stop transmission from a distant station or office.

Another object of the invention is to provide an expanding channel system in which the maximum number of operating channels is substantially constant.

Another object of the invention is to improve the method of entry in a system which does not require the exclusive use of a code combination for an entry signal; and in which accidental entry or exit of a channel as a result of line trouble is obviated.

Other objects and advantages of the invention will become apparent from the following description of the systems embodying the invention shown on the accompanying drawings. Referring to the drawings,

Figs. 1, 2 and 3 are views, partly diagrammatic, of a system embodying the invention, Figs. 1 and 2 illustrating the circuits and apparatus of the transmitting station and Fig. 3, the circuits and apparatus at the receiving station;

Figs. 4 and 5 are similar views of a modified system embodying the invention;

Fig. 6 is a detail view of a modified form of stop or latch member; and

Fig. 7 is a detail view of an element of the mixer.

Referring to Figs. 1, 2 and 3 of the drawing, the system illustrated is an expanding channel system utilizing a four-channel or quad-multiplex as the lane of traffic. The transmitting distributor of the synchronous multiplex at the first station is indicated at TD in Fig. 1 and the receiving distributor at the second station at RD in Fig. 3. The distributors are interconnected through the line circuit L arranged for duplex operation in accordance with the usual practice. It will be understood that ordinarily the system is also arranged for transmission from the second to the first station, the apparatus illustrated being duplicated for this purpose.

Referring more particularly to the transmitting apparatus shown in Figs. 1 and 2, the code combinations representing characters to be transmitted over the lane of traffic are stored in the relay bank 10 comprising ten relays (in the case of a five-unit code) having armatures 11 to 20 connected through the armatures of relay 25 to the segments of channels A and B of the transmitting distributor TD or through the armatures of relay 26 to the segments of channels C and D of said distributor, depending upon whether relay 25 or 26 is energized. The relays 25 and 26 are connected to segments 27 and 28 respectively of the local ring 30 of the transmitting distributor TD in such a manner that the relays are alternately energized whereby the characters stored in relay bank 10 are alternately transmitted over first one pair and then the other pair of channels of the transmitting distributor.

The operating windings 31 of the relay bank 10 are multipled to the contacts of the transmitters of the respective channels of the system, such as the tape transmitters 35, 36, 37, 38, 39 and 40. The tape transmitters may be similar in construction to that shown in patent to Benjamin No. 1,298,440, dated March 25, 1919, except that transmitters 35, 36, 37 and 38 are provided with ten selecting contacts and the stepping magnet of each transmitter is arranged to step the tape two characters at a time whereby upon each cycle of operation, each transmitter is arranged to actuate relays of relay bank 10 in accordance with the code combinations representing two successive characters perforated in the tape. The transmitter may obviously be constructed in various ways to effect the transmission of two or more characters during each cycle of operation. For example, two or more characters might be perforated side-by-side in a wide tape.

The relays of relay bank 10 are also provided with restoring windings 32 arranged when energized from segments 41 and 42 of the local ring 30 of the distributor to restore the armatures 11 to 20 to their spacing condition. The fourth and ninth relays of relay bank 10 are also provided with operating windings 33 for a purpose to be hereinafter described.

The transmitter 36 is automatically entered on the lane of traffic upon the closure of the autostop contacts 45 controlled by the tape loop adjacent the transmitter. Each of the other transmitters is likewise entered under the control of its associated autostop contacts. The autostop contacts 45 are in series with one-half of the winding of the usual autostop relay 46, the midpoint of said winding being connected in series with the stepping magnet of the tape transmitter 36. The autostop relay 46 is normally energized when the associated tape transmitter is inoperative as indicated by the opening of the autostop contacts 45 upon the shortening of the tape loop, the relay being locked up in series with the stepping magnet of the tape transmitter through its front contact 47 to ground. Upon the lengthening of the tape loop and the resultant closure of the autostop contacts 45, a parallel circuit is closed to ground through the left hand half of the winding of relay 46 and the contacts 45 to ground at the contact 48 of the transmitting mixer TM. The autostop relay 46 becomes deenergized, the described circuit to ground through the contact 47 is opened and the right hand half of the winding of relay 46 is connected to ground through the contact 49 and the above described contact 48 of the transmitting mixer. Thereupon a circuit is closed through the right hand outer armature and back contact of the autostop relay 46 for entering the transmitter upon the lane of traffic in a manner to be described.

The transmitting mixer TM comprises a rotat-

able and axially movable arm 54 driven through a friction clutch 55 and lying normally in the plane of a depressed stop bar or latch member 56 having two operative positions corresponding to the "channel in" and "channel out" conditions. Each of the transmitters is provided with a similar latch member 56, 56*a*, arranged peripherally around the plane of rotation of the mixer arm 54, each of said latch members being adapted to be depressed into the path of the rotating arm to enter the associated transmitter on the lane.

Assuming that the stop or latch member 56 has been depressed into the position shown in dotted lines in Fig. 2, in a manner to be hereinafter described, it will be apparent that the rotation of the mixer arm 54 will be stopped by the engagement of said arm with the inner end of said member. When the local brush 60 engages segment 61 or 62 of the local ring 63 (depending upon whether the previously connected subchannel was connected to channels A and B or C and D of the transmitting distributor), a circuit is closed from battery through the conductor 64, the right hand armature and back contact of relay 66, the winding of magnet 70 and the normally closed contacts of relay 71 to ground whereupon the magnet 70 momentarily depresses the mixer arm 54 to release the same from the latch member 56. As the arm 54 commences to turn in its lowermost position, it engages the inner end of the pivoted contact 48 which is mounted behind the latch member 56 thereby momentarily opening the circuit of the stepping magnet of transmitter 36, said circuit including contacts 45 of the autostop, contact 49 of relay 46, the winding of relay 46, the operating magnet of meter 75 and conductor 76. The meter or integrating means 75 may be a conventional electromagnetic register having counting wheels operated by the successive energization and deenergization of the operating magnet as the associated transmitter is periodically rendered operative, thus registering the number of message characters sent from the transmitter. The registration of the meter or accumulating register 75 provides an equitable basis for billing the customer in accordance with the actual service rendered and avoids the difficulties encountered in the prior systems, such as timed-wire service and the like.

This metering or service-charge arrangement is an important feature of the invention as heretofore charges for telegraph service rendered to customers having printing telegraph apparatus were based upon the time during which a communication channel was furnished as the customer utilized the facilities of the telegraph company all of the time whether actually transmitting a message or not. In the expanding channel system however, a channel is only occupied during the time when the customer is actually sending and therefore charges may be based upon the number of characters or words transmitted. The advantage of this arrangement from the customer's standpoint is obvious. In order to meter the service on a word basis, the counter 75 may be arranged to be operated in accordance with the frequency of the transmission of "spaces" between words.

When the stepping magnet of the transmitter 36 is deenergized as described, the feeler pins of the transmitter are projected against the tape and the transmitter contacts are selectively operated in accordance with the characters perforated in the tape. The contacts which are operated into engagement with the left hand or marking contacts of the transmitter close circuits through corresponding operating windings 31 of relay bank 10 whereby the code combinations are set up in the relay bank. The breaking of the circuit of magnet 70 by the continued movement of the brush 60 releases the mixer arm 54 which rises above the contact arm 48 and rotates into engagement with the latch member of the next channel which is cut in. The contact arm 48, being biased to closed position, recloses the circuit of meter 75 and of the stepping magnet of transmitter 36, whereupon the feeler pins of the transmitter are withdrawn from the tape and the tape is stepped to present the next two characters to the pins.

Upon the completion of the revolution of the mixer arm 54, the stepping magnet of the transmitter 36 is again deenergized by the actuation of contact arm 48 whereby the transmitter 36 is rendered operative to send two characters over the lane of traffic for each revolution of the mixer arm 54 as long as the stop or latch bar 56 is depressed. Likewise the mixer arm, during such revolution, causes the other transmitters which are cut in by the depression of their latch members corresponding to member 56 to be rendered operative in a predetermined order one after the other, the transmitters having nothing to send being passed over by the mixer so that they do not occupy any lane time.

The two characters sent by each transmitter during its operative cycle are set up on the contacts of relay bank 10 comprising ten polar relays each having two unbiased armatures which remain in their operated positions. The armatures 11, 12—20 are arranged to transfer the code combinations received from the respective channels in response to the operation of the mixer alternately to channels A and B of the transmitting distributor TD represented by the first ten segments of the transmitting ring 65 and to channels C and D represented by the eleventh to the twentieth segments of said ring, the changeover from one pair of multiplex channels to the other being effected by relays 25 and 26. The polar relays 24 having their respective armatures connected to the segments of transmitting ring 65 are arranged to store the code combinations from relay bank 10 and impress marking or spacing potential on the segments of said ring so that the characters to be sent over channels A and B of said ring may be set up while the transmitting brush 67 is travelling over channels C and D, and vice versa. As shown, the marking potential of channels B and C is reversed with respect to channels A and D in order that transmission cannot be effected if the transmitting and receiving distributors are accidentally shifted 90°, 180° or 270° out of phase, the out-of-phase relation being apparent from the distorted signals received. Obviously any other out-of-phase condition also interrupts communication.

The transmitters of the respective channels of the expanding channel system may be of any type adapted to operate in conjunction with the lane distributor and are preferably adapted for operation in accordance with characters stored in a tape or other storage medium under the control of the mixer. Each transmitter may be located in a patron's office and adapted to receive tape from a keyboard perforator or may be in the telegraph office and associated with a

reperforator controlled from a keyboard transmitter in a branch office or patron's office.

When the transmitter 36 has completed the transmission of the message characters perforated in the tape, the channel is automatically disconnected from the lane of traffic and the lane time is divided between the operating channels. The shortening of the tape loop opens the autostop contacts 45 whereupon the autostop relay 46 becomes energized and locks up in series with the stepping magnet of the transmitter 36, the locking circuit including the inner armature and contact 47 of said relay. After the message characters stored in relay bank 10 from the channel or transmitter preceding transmitter 36 have been transferred to the transmitting distributor storage relays 24, the tongues 11—20 and 11'—20' of relay bank 10 are operated against their spacing contacts by the restoring windings 32 energized from local segment 41 or 42 of the local ring 30.

The subsequent engagement of the mixer arm 54 with the stop or latch member 56 and the energization of magnet 70 operates the contact arm 48 as described above but the stepping magnet of transmitter 36 does not become deenergized as during transmission from this channel since the stepping magnet is locked up through contact 47 of the autostop relay. Thus the armatures of relay bank 10 remain all spacing and the double-character exit signal in which both characters comprise five all-spacing impulses (blank character) is sent over the lane of traffic to cut out the receiving device of this channel in a manner to be described. The armatures 11'—20' of relay bank 10 constitute baffle circuits which are completed when the entry and exit signals are set up in the bank. Thus when the armatures 11'—20' are all operated to spacing and remain in these positions after the mixer arm 54 has operated the contact arm 48 on account of the energization of autostop relay 46 as described, a circuit is closed from battery through the armatures 11', 12', 13', 15', 16', 17', 18', 20', 19', and their respective spacing contacts, conductor 90, cut-out magnet 91 of the transmitting mixer TM, conductor 92, spacing contact and armature 14' to ground whereupon magnet 91 is energized. The energization of magnet 91 depresses the arched central portion of a leaf spring 93 carrying an offset lug 94, thereby moving the lug 94 underneath the end of the latch member 56 so that as the mixer arm 54 carrying the spring 93 rises, the latch member is raised to the position shown in full lines in Fig. 2 and the associated channel is cut out. As the mixer arm 54 rotates, the remaining channels are cut out at the completion of each message in the same manner by the properly timed energization of magnet 91. The stop or latch members 56, 56*a*, etc., are preferably biased against both upper and lower stops by a spring toggle device so that the cut-in and cut-out mechanism is only required to actuate the members past the central point of their travel.

The entry of each channel upon the lane of traffic as soon as a channel has message characters to transmit is effected automatically in response to the closure of the autostop contacts 45 as a result of the lengthening of the tape loop from the associated perforator or reperforator. In order to effect the simultaneous entry of a transmitter at the sending station and a receiving device at the receiving station, a transmitting clock TC at the sending station and a receiving clock RC at the receiving station are provided. The transmitting and receiving clocks comprise contact arms 80 and 180 respectively, rotating at the same speed; for example, said arms may be geared to or controlled by the transmitting and receiving distributors of the synchronous multiplex system. As shown, the transmitting and receiving clocks also comprise rotating cut-in bars 81 and 181 which are also maintained in synchronism. The contact arm 80 of the transmitting clock is provided with brushes bearing upon segments 82 and 83 and upon a contact ring 84 extending around the periphery of the clock. Each channel is provided with a pair of segments such as the segments 82 and 83 and the receiving clock is similarly provided with pairs of segments for each channel arranged in the same order as the segments of the transmitting clock.

Upon the closure of the autostop contacts 45, as a result of the lengthening of the tape loop, a circuit is closed from ground through the contact arm 48, the autostop contacts 45 and the left hand half of the winding of relay 46 which is in parallel to the circuit through the right hand half of the winding of said relay, and the autostop relay 46 becomes deenergized, thereby opening the locking circuit through contact 47 but closing a parallel circuit through contact 49 to the ground at contact arm 48, of the transmitting mixer. Upon the deenergization of relay 46 a circuit is closed from segment 82 of the transmitting clock TC through the outer armature and back contact of relay 46 to ground at the stop or latch member 56 through the upper contact 86 which is in engagement with said latch member. When contact arm 80 of the transmitting clock reaches segment 82, the circuit is closed from the grounded segment 82 through contact ring 84 and the winding of relay 66 to battery, whereupon relay 66 becomes energized. When the contact arm 80 engages contact segment 83, a locking circuit is provided through the latter segment and the left hand armature and front contact of relay 66 whereby said relay is maintained energized for a sufficient time to insure the cutting-in of the channel.

The energization of relay 66 closes a circuit from local segment 61 or 62 when the local brush 60 reaches one or the other of these segments through conductor 64, the right hand armature and front contact of relay 66, conductor 95, coils 33 of the fourth and ninth relays of relay bank 10 and conductor 96, for energizing cut-in magnet 97 of the transmitting clock. The energization of magnet 97 depresses the outer end of the cut-in bar 81 of the transmitting clock which at this moment is positioned above the stop or latch member 56 thereby actuating said member to its lower or channel-in position. At the same time, as a result of the energization of coils 33 of relay bank 10, the entry signal is transmitted from the relay bank 10 to one pair of the channels of the transmitting distributor TD and the remote receiving device is cut in upon receipt of this signal in a manner to be described. It will be noted that the diversion of the local pulse from local ring 63 which normally energizes the magnet 70 of the transmitting mixer prevents the transmission of characters from the channel which has been selected by the mixer arm 54 so that the transmission from this channel is delayed during the time required for sending the entry signals over the lane of traffic. Upon the next operating cycle, however, the characters

which have been held up will be transmitted, since the mixer arm 54 has not been released from the stop member of the channel which it had selected.

In the embodiment of the invention illustrated, the double entry signal consists of two characters in which the fourth impulse is marking and the remaining impulses spacing ("carriage return" character). The energization of coils 33 of the fourth and ninth relays of relay bank 110 operates the armatures of the fourth and ninth relays to marking, the remaining armatures of the relay bank having been actuated to spacing by the restoring windings 32 in the manner described above.

The double entry signal consisting of two code combinations having the fourth impulse marking has been selected because this selection is ordinarily employed for "carriage return" and if used at all, need not be transmitted twice in succession. Obviously, any desired code combination may be utilized as the entry signal although it is preferred that an entry signal be employed which is not normally used or at least is not required for regular communication. Another useful signal would be an upper case code combination such as "figure shift" followed by "F."

Referring to Fig. 3, the receiving distributor RD at the receiving station comprises a receiving ring 109 having the respective segments thereof connected to the windings of the relays of receiving bank 110, and local rings 111 and 112. Each of the relays in the relay bank 110 is a polar relay having two unbiased armatures adapted to remain in engagement with corresponding marking or spacing contacts after each impulse until the reception of an impulse of opposite polarity from the line relay. In this manner the code combinations received over the line are stored upon one set of armatures and the other set is arranged to close baffle circuits when the entry and exit signals are received.

The cable 120 which is multipled to the receiving reperforators or other receiving devices comprises ten conductors which are connected through the armatures of relay 121 alternately to the right hand armatures of the first ten relays of relay bank 110 and to the right hand armatures of the remaining (11th to the 20th) relays of said bank. The relay 121 is energized as long as the distributor brush of the local ring 112 remains in engagement with the segment 122 of said ring whereby the code combinations set up on the second half of the receiving relay bank are connected through the cable 120 to a receiving device while the receiving distributor brush is resetting the first ten relays of said bank, and the last mentioned relays are connected through the back contacts of relay 121 and the cable 120 to another receiving device while the receiving distributor brush is resetting the eleventh to the twentieth relays of said bank in accordance with incoming signals.

The ten selecting windings of a reperforator, printer or other receiving or storing device, are represented at 146, said windings being connected to separate contacts 147 adapted to be simultaneously connected to battery by the pivoted normally open contact member 148 when the latter is engaged by the mixer arm 154 of the receiving mixer RM. If a ten-unit reperforator is employed, it may utilize a wide tape or be arranged to step the tape two characters during each cycle of operation. The normally open circuits of the other receiving devices are similarly controlled, when the channels are cut in, by the mixer arm 154 under the control of the stop bars 156, 156*a*, etc. In general, the construction and mode of operation of the receiving mixer RM are similar to the construction and mode of operation of the transmitting mixer TM, the stop bars 156, 156*a* being depressed from the position indicated in full lines when the channels are cut in and the mixer arm 154 selecting the operative receiving channels one after the other in the same order and at the same time (taking the transmission lag into account) that the mixer arm 54 of the transmitting mixer selects the corresponding transmitting channels. The receiving devices of the operative channels are operated by momentarily closing the circuits, by the contact member 148, of the selecting windings 146 and of the operating magnet 149 to print, store or perforate the characters set up at that instant on the connected group of relays of the receiving bank 110.

As has been described above, the entry signal which is transmitted over the line to enter a receiving device on the expanding channel system comprises two successive characters, each having only the fourth impulse marking (double "carriage return"). This signal may be sent over either channels A or B or channels C and D depending upon the time when the clocks TC and RC reach a subchannel which is to be cut in.

Assuming that the entry signal is received on channels A and B of the receiving distributor represented by the first ten relays of the receiving bank 110, as the brushes of the receiving distributor continue to travel, the circuit of relay 121 is interrupted at the local segment 122 of the distributor. Upon the deenergization of relay 121 during the time when the received signals are being stored in the channels C and D of the receiving bank 110, a circuit is closed through the upper armature and back contact of relay 121, through the left hand armatures and marking contacts of the fourth and ninth relays of relay bank 110, the spacing contacts of the first, second, third, fifth, sixth, seventh, eighth and tenth relays of bank 110, through the winding of relay 124, brush arm 180 and segments 182 and 184 of the receiving clock, upper contact 186 and the stop bar 156 to ground, whereupon relay 124 becomes energized.

It will be noted that this circuit is only closed upon the transmission of the entry signal and the position of the brush arm 180 of the receiving clock when said signal is received determines the receiving device which is to be entered on the channel, said device corresponding to the transmitter 36, Fig. 1, in this instance. The selection of the proper receiving device or channel is thus determined as stated above by the time of transmission of the entry signal. A short signal with interspersed traffic signals is thus operative to select any one of a large number of channels. The lane of traffic is utilized for message signals while the brushes of the clocks move on to the next point of entry which may be hundreds of message characters farther on. The significant lapse of time to effect proper entry is not wasted.

Relay 124 remains locked up through the segment 183 of the receiving clock, the latter circuit including the left hand armature and front contact of said relay. On the continued movement of the brush arm of the receiving distributor RD, a circuit is closed through the local segment 126, the right hand armature and

front contact of relay 124 and the entry magnet 197 of the receiving clock RC. At this moment the cut-in bar 181 of the receiving clock is above the outer end of the stop bar 156 and the tilting of the cut-in bar 181 depresses the latter, as described in connection with the transmitting clock TC. The stop bar 156 is thus depressed to the position shown in dotted lines representing the channel-in position. As soon as the brush arm 180 of the receiving clock RC leaves the segment 183, the locking circuit of relay 124 is interrupted and the relay is restored to normal. During the time the relay 124 was energized, the circuit of the operating magnet 170 of the receiving mixer RM was interrupted at the right hand armature and back contact of said relay, thereby preventing release of the mixer arm 154 from the stop bar with which it was engaged.

In this manner the characters forming the entry signal on channels A and B are prevented from reaching a receiving device and the transmitting and receiving apparatus is maintained in synchronism since, as has been described above, transmission of regular character signals over the lane of traffic is momentarily interrupted during the transmission of the entry signal. If the entry signal had been received on channels C and D of the receiving distributor, the operation would have been substantially as described except that relay 121 is energized when the local brush of the distributor engages segment 122 of the local ring 112, and the baffle circuit for reading the entry signal comprises upper armature and front contact of relay 121 and contacts of the eleventh to the twentieth relays instead of the first to tenth relays of relay bank 110.

Upon the subsequent engagement of the mixer arm 154 with the stop bar 156, the selections stored in one half of the receiving bank 110 are connected through the contacts of relay 121 to the windings 146 of the receiving device which is operated by the closure of the contacts 147 and 148 when the mixer arm 154 is depressed beneath the stop bar 156 by the magnet 170. The circuit of the magnet 170 includes the stop bar 156, the lower contact 187 engaging said bar, the right hand armature and back contact of relay 124 and segment 126 or 127 of local ring 111 of the receiving distributor RD. Each of the receiving channels which has been cut in is thus rendered operative concurrently with the corresponding one of the transmitting channels connected successively to the lane of traffic under the control of the transmitting mixer TM irrespective of the number of operative channels, the entire lane time being divided among the operating channels when more than a predetermined number of channels are operative.

It is desirable in a system of this character to provide auxiliary signaling or control channels in addition to the channels used for communication. These auxiliary channels may be employed for various purposes such as signaling between the attendants at the respective offices or for controlling the operation of the equipment in any desired manner. Thus if difficulty is experienced in reception at one office, it may be desirable to direct the attendant at the remote office, to stop transmission into that office. If desired, the control channel may be used, for example, to stop the apparatus and reconnect the operative channels one by one from an inoperative condition to insure that the same number of transmitting and receiving channels are in operation. In the system shown, the signaling or control channel is provided with space on the transmitting mixer, as in the case of each of the communication channels, and the control device is a key switch 88 having contacts controlling the entry circuit corresponding to the outer right hand armature and contacts of the autostop relay 46, the key being provided in addition with contacts arranged to connect marking battery to the operating winding 31 of the first relay of the transmitting relay bank 10. Other keys could also be arranged to transmit code combinations for effecting different functions at the receiving end of the circuit in the same manner as the key 88. When one of the keys is operated, the signaling channel is entered in the same manner as one of the communication channels and thereby causes the entry of the receiving signaling channel represented by the windings 160. Windings 160 may represent separate polar relays arranged to be operated in accordance with the application of marking or spacing potential upon the respective receiving relays under the control of the contacts of the relays of the relay bank 110 in accordance with the adjustment of the control key switches. For example, the first relay 160 connected to conductor No. 1 of cable 120, and corresponding to key 88, is provided with a series of armatures 161 arranged in series relation with the autostop relays associated with the transmitters at the second station, Fig. 3, which are intended for transmission to the first station shown in Figs. 1 and 2 (as shown in Fig. 2, contacts 89). In this manner the operation of the first relay 160 in response to marking battery upon conductor No. 1 of cable 120 will open the autostop relay circuits of the transmitters at the second station and thereby effect disconnection of all of said transmitters from the expanding channel system. When the control key at the first station is again restored, the distant autostop circuits of the operative transmitters would be reclosed and after the transmitters were entered on the lane of traffic in the usual manner, transmission would be reestablished. The receiving station of Fig. 3 would also be provided with a signaling channel or channels for stopping transmission from the station shown in Figs. 1 and 2 and for any other desired purposes. For example, the application of either marking or spacing battery, as desired, upon any one of the other windings 160 could be arranged to operate signals or effect other functions at the remote station.

In accordance with a further feature of the invention, transmission from certain of the transmitters may be made dependent upon the operation of the other or regular channels of the system. Thus, for example, the transmitters 37, 38, 39 and 40 may be deferred traffic transmitters and arranged to seize a channel of the expanding channel system only when less than a certain number of other or regular channels are in operation. The deferred channels may be precisely the same as regular channels except that a relay contact 89_1, 89_2, etc. of relay 73 is inserted in each of the autostop circuits of these transmitters which will bid for entry or exit of the deferred channels when the number of regular channels reaches a certain figure. Transmitters 39 and 40 having different tapes are five-unit transmitters arranged to operate in unison

on one expanding channel. Corresponding five-unit receiving devices may be employed.

The respective contacts **87** associated with the stop bars **56**, including those of deferred channels, of the transmitting mixer TM are connected through separate resistances **72**, the common terminal of said resistances being connected in series relation with windings of relays **85**, **71** and **73**. It will be apparent that the current through said relays varies according to the number of channels which have been cut in. The relay **85** is adapted to close a contact when the number of operative channels is less than three. Similarly, the relay **71** is adapted to close a contact when one or more channels is cut in, and the relay **73** is arranged to close the autostop circuits of the deferred or special transmitters **37**, **38**, **39** and **40** only when less than four regular channels have been entered. The contacts 89_1, 89_2, 89_3 and 89_4 are in series relation with the autostop contacts in a manner similar to the contacts **89**.

When no channels are cut in, relay **71** remains on its left hand contact, mixer arm **54** spins freely without being depressed by the armature of magnet **70**. When any stop bar such as stop bar **56** is lowered to the channel-in position by clock armature **81**, a circuit is established through the operating winding of the relay **71**, resistance **72**, ground and battery, which will overcome the spacing bias of relay **71** and close the ground circuit of mixer operating magnet **70**. Thus the selector arm of the transmitting mixer resumes its regular function when the first channel is entered upon it. If several channels are in operation at once, the speeds of the various expanding channel transmitters are comparatively slow. Let us assume that three channels of the first station give a satisfactory rate of operation for each channel, even though the multilever transmitter were capable of keeping the circuit completely full. In that case the one busy operator would find it extremely difficult to keep the line full of traffic, and therefore it is desirable to permit deferred transmitters to share the lane when fewer than a certain number of regular transmitters are cut in at any time. When less than three of the regular transmitters are cut in, contacts of relay **85** close on account of the reduced current through the operating coil. This applies a ground to the segments corresponding to segment **82** of the transmitting clock TC through added contacts of the autocontrols on the various expanding channels which are cut out at the time. These cut out channels are therefore entered again and since the transmitting mixer TM does not step to a new position during the entry function, the rate of transmission is curtailed, to that extent constituting a kind of governor device on the regular channels which remain in operation. The channel which has nothing to send but which is cut in in the aforesaid manner by the operation of the relay **85**, remains entered until it has an opportunity to send one all-spacing combination. This removes it from the sequencing cycle but another idle channel is immediately entered to take its place.

The successive entry and exit operations performed on the idle channels govern the speed of the regular operating channels until the necessity for entry occurs at a time when the brushes of transmitting clock TC are on segments corresponding to **82** for one of the deferred channels **37**, **38**, **39**—**40**. It is assumed that prepared tape is in place over the pins of the deferred channels and when the opportunity for entry comes to these channels, transmission of deferred traffic commences and is maintained until the cutting in of other channels increases the total number of channels cut in to four or more. At this moment, due to the preponderance of operating over biasing currents in relay **73**, the autostop circuits of the deferred traffic transmitters controlled by this relay are broken, thus initiating the exit cycle of these transmitters, and suspending operation until the cut-in cut-out situation is again favorable for the transmission of deferred traffic.

Deferred traffic transmitters **39** and **40** are of the standard five-contact variety and though employed in transmission of two separate messages, their magnets are in series and their operation is in all respects equivalent to that of the transmitters **37** and **38**. At the receiving end the devices for receiving impulses transmitted by the transmitters **39** and **40** may be the usual five-unit printers or reperforators, both connected to one group of contacts of the receiving mixer. The governing action of relays **85**, **71** and **73**, and their associated circuits need not be repeated at the receiving end in connection with receiving mixer RM and receiving clock RC as the time consumed in cut-in and deferred channel functions are identical in all respects with those employed for the operation of the regular channels.

In systems embodying the invention various lanes of traffic may be employed and where multiplex channels are employed as a lane of traffic, more or less than four channels may be utilized if desired. The multiplex channels may utilize two or more lines or carriers to transmit the signals from the sending distributor to the receiving distributor in a manner well known in the art. Furthermore, other methods of effecting entry and exit of the channels from the expanding channel system may be employed without departing from the scope of the invention, and various methods of governing the speed of the transmitters may be employed. Figs. 4 and 5 illustrate a modified system embodying the invention utilizing a mixer and clock somewhat similar to those shown in Figs. 1 to 3 but entry and exit of a transmitting channel are both effected by the same signal; that is, if a channel is in it is cut out when the signal is transmitted and if it is out, it is cut in by the same signal. This signal may be any character in the alphabet and need not be one exclusively devoted to these functions. Furthermore, in this system the lane of traffic comprises two multiplex channels and the entry and exit signals are always transmitted over the A channel. Other modifications in the detailed arrangement of the apparatus will appear from the following description. but it is to be understood that the system merely illustrates certain modifications coming within the scope of the invention by way of example, and many other changes may be made in the circuit arrangement and construction of the apparatus. including the structural details of the mixer and clock or other means for controlling the entry and exit of the channels and the mixing of the operating channels, without departing from the scope of the invention.

In the system shown in Figs. 4 and 5, two multiplex channels are represented by the ten segments on the transmitting ring **265** of the transmitting distributor TD, the entry and exit signals

being sent over the A channel represented by the first five segments of ring 265 in a manner to be described. The same signal is employed for entering and for disconnecting a channel and this signal is the line feed character having only the second impulse marking although other entry and exit signals may be employed if desired. This use of line feed or other character as an entry or exit signal does not interfere with the normal usage of that functional character in communication. Any other code combination such as the letter X, figures shift or even a blank may with proper arrangement of the circuits be utilized as an entry and exit signal.

As shown, the transmitters, of which one is represented at 235, comprise the usual five-unit tape transmitters or other suitable storage transmitters of known construction. Each transmitter is connected through contacts corresponding to the contacts C of the transmitting mixer TM and the armatures of a transfer relay 225 to the first or second half of the storage relays 231 of relay bank 210 associated with the respective channels of the transmitting distributor TD. The first five relays 231 are provided with auxiliary windings 232 to provide for the transmission of entry and exit signals over the lane of traffic under the control of the transmitting clock TC when a channel is to be cut in or cut out. Relays of the relay bank 210 are provided with armatures for controlling the application of marking and spacing battery to the respective segments of the transmitting distributor and the first, third, fourth and fifth relays of said bank are also provided with armatures for a purpose to be described hereinafter. While only one transmitter or channel is shown in connection with the transmitting mixer TM, it will be understood that a plurality of channels are controlled in accordance with the operation of said mixer as in the system shown in Figs. 1 to 3. Similar parts of the transmitting clock and multiplex distributor have been given the same reference numerals as in Figs. 1 and 2 with the prefix 2 in order to assist in explaining the operation of the system as compared with the system shown in Figs. 1, 2 and 3. Likewise in Fig. 5 the elements of the receiving end of the channels have been given reference characters similar to those employed in Fig. 3 with the prefix 3.

Assuming that all channels are cut out and the flexible auto-stop levers lifted by short tape loops, the stop bars 256 of all of the channels are in the raised position as shown in full lines in Fig. 4. It is assumed that the rotating elements 254 and 231 of the transmitting clock TC are in synchronism with the corresponding elements of the receiving clock RC, Fig. 5, and that the transmitting and receiving multiplex distributors are in synchronism. The mixer arm 254 at one point in its rotation will engage a governor stop bar 270 as shown in the lower portion of Fig. 4. The governor stop bar 270 is arranged to be lifted by a magnet 271 from the path of the mixer arm 254 only when the arm 254 is in the vicinity of the stop bar 270 and the brush arm 272 of the governor timer is in the zero position as shown. The brush holder assembly of the governor timer is provided with five stop arms or notches adapted to be engaged by a latch member 273 controlled by a magnet 274. The circuit of the magnet 274 includes the timer brush arm 272, a ring contact 275 and segments 276 or 277 of the local ring 278 of the multiplex distributor TD. With this arrangement it will be apparent that each impulse from the local ring 278 will release the timer brush arm 272 for one step. The timer also includes a contact 279 arranged in series relation with the magnet 271 whereby when the timer brush arm 272 engages segment 279, the magnets 271 and 274 are energized concurrently provided the circuit is closed to battery through the contacts 280 which are arranged to be operated by the passage of the mixer arm 254 and maintain closed as long as the arm 254 is stopped by the stop bar 270. This raises the governor stop bar 270 and permits the mixer arm 254 to continue to revolve. Thus the mixer arm is prevented from rotating faster than the timer brush arm 272, the speed of which is controlled in accordance with the rotation of the brushes of the transmitting distributor TD.

The purpose of this arrangement is to control the rotation of the mixer arm 254 of the transmitting mixer when less than a predetermined number of channels are in operation. Thus with the arrangement shown, if only one channel is in operation, on account of the connection of the timer to the segments of the local ring 278 of the transmitting distributor TD, the operating channel is not again connected to the system until the time of transmitting three additional characters over the multiplex channels has elapsed. It is obvious that the rotation of the timer brush arm 272 is dependent upon the number of stop arms employed and when it is desired to set a lower maximum speed for the mixer arm 254, additional arms would be added to the timer brush arm. In this manner the number of operations of the transmitting apparatus in a definite period is limited so that it will not be necessary that one transmitting unit would be operable at a speed sufficient to fill the lane of traffic requiring perhaps two or three hundred words per minute, if that is undesirable. With the governor the maximum speed of operation of any channel can be held quite close to the limit for which it is designed even if the speed of the circuit is substantially higher than the channel speed.

Likewise it will be noted that by the proper allocation of channels into the preferred and deferred groups and by properly regulating the relay biasing circuits, the speed of the preferred channels may be held substantially constant irrespective of the number of channels having messages to transmit. This result is accomplished by limiting the number of preferred channels in the system and properly adjusting the biasing circuits of relays 73 and 85 so that there is no substantial increase or decrease in the operating speed of the preferred channels whether one or all of said channels are operative. In order to fill the lane of traffic, there will of course be great changes in the operating rates of the deferred channels. In this manner a group of "constant speed" preferred channels can be obtained which is desirable for transmission of market quotations, press, et cetera.

It is also obvious that the stop arms of the timer can be detachable or variable in number to vary the rotative speed of the timer brush arm 272 in case the transmitting speed of the lane of traffic varies from day to day. On the other hand the full capacity of a high speed lane of traffic is utilized at any time when several channels are in operation without causing difficulty when the number of channels decreases. If the multiplex were operating at one hundred words per minute per channel, a single operating

transmitter would not exceed fifty words per minute with a timer brush arm having five rest positions. If one, two, three or four transmitting channels were operating, the speed would remain fifty words per minute for each channel. If five transmitting channels are in operation, the speed of the lane which is two hundred words per minute would provide a channel speed of two hundred divided by five, or forty words per minute. When above a predetermined number of channels are in operation, the approach of the mixer arm **254** will close contacts **290** and energize magnet **271** to raise stop bar **270** and permit unimpeded passage of the mixer arm.

The mixer arm **254** does not go beneath the stop bar **270** as in the case of an ordinary channel stop bar. The bar **270** must be raised to release the mixer arm. When the operating pulse depresses the mixer arm **254**, the contacts **291** and **292** of the governor are operated without disturbing the closed condition of contacts **290** and the relays of relay bank **210** are thus controlled from the governor to transmit the "space" character over the line circuit (only the third impulse marking). These contacts **291** and **292** are not essential for ordinary operation but may be desirable under certain other conditions. It will be obvious that contacts **291** and **292** may be arranged like contacts C to connect a transmitter having deferred traffic to the relay bank **210**.

When sufficient tape accumulates on any channel, for example at the transmitter **235**, the autostop contacts **245** are closed and the channel is entered on the expanding channel system in response to this operation. Thus when the autostop contacts **245** close, a circuit is closed from ground through the stop bar **256**, upper contact **257**, the autostop contacts and the segment **282** of the transmitting clock TC. When the proper clock time occurs, a circuit is established from segment **282** through the coil of entry relay **221** whereupon relay **221** becomes energized and is locked up as the brush **280** of the clock reaches segment **283**, the locking circuit including the right hand armature and front contact of relay **221**. During the time that the brush **280** is in engagement with segments **282** or **283** of the transmitting clock TC, battery is applied from a local brush of the transmitting distributor TD through segment **266** or segment **267** of the local ring **263** whereupon a circuit is closed from one of said segments through the left hand armature and front contact of relay **221**, the winding of entry and exit magnet **297**, the upper winding of transposing polar relay **226** and the windings of relays **232** to ground. The magnet **297**, the first five relays of relay bank **210** and relay **226** become energized. The first relay of relay bank **210** throws its armatures **211** and **211'** to the right, the second, third, fourth and fifth relays of relay bank **210** throw or retain their armatures to the left and the two armatures of transposing relay **226** engage their right hand contacts. The energizing of entry and exit magnet **297** lowers the horizontal roller *r* pivotally carried on the end of the operating arm **281** over the sword-shaped projection on the stop bar **256** for the channel desiring to cut in, depressing said stop bar to its lowermost or operating position. When the local brush passes off from the segment **266** or **267** of local ring **263**, the actuating bar **281** is restored to normal, the roller *r* now being in such relation to the sword-shaped projection on the stop bar **256** that upon the subsequent actuation of the arm **281**, the stop bar will be raised to the position shown in full lines in Fig. 4.

In response to the operation of the relays of relay bank **210** and relay **226** as described, positive or spacing potential is applied to the first, third, fourth and fifth segments of the transmitting ring **265** of the transmitting distributor TD and negative or marking potential is applied on the second segment of said ring. In due course the sending brushes of the distributor will thus transmit the "line feed" character (second pulse only marking) from channel A. It will also be noted that the manufacture of an entry signal by diversion of the sixth pulse through the left hand contacts of relay **221** to the relays of relay bank **210** does not complete the baffle circuit through the armatures **211'** to **215'** of said relay bank since this circuit is open at the armature **211'**. Thus the baffle circuit will only be closed when the "line feed" character is sent from one of the transmitting channels at the time channel A of the multiplex distributor TD is operative.

Shortly after the mixer arm **254** is next released by the raising of the governor stop bar **270**, it will engage the depressed stop bar **256** for the entered channel represented by transmitter **235**. Then a connection is made between the local brush at the transmitting distributor TD and segments **266** or **267** of local ring **263** whereupon a circuit is closed through the left hand armature and back contact of relay **221**, the lower winding of transposing relay **226** and the magnet **270** of the transmitting mixer TM. The mixer arm **254** is depressed for release from the stop bar **256** and momentarily engages the inner end of the contact arm **248** whereupon the normally open contacts C connecting the transmitter tongues of the transmitter **235** to relay bank **210** are momentarily closed. The setting of the tongues of the transmitter **235** corresponds to the character to be transmitted and the code combination is directly transferred through the above described circuit including contacts C and the armatures of relays **225** to the relays of relay bank **210**. In due course the sending brush engaging the transmitting segments of the transmitting ring **265** will transmit the character over the lane of traffic. If desired, the transmitter may be constructed to send more than one character as in the modification shown in Figs. 1–3.

At the expiration of the sixth pulse operating the magnet **270** of the transmitting mixer, the mixer arm **254** rises and rotates under the force of the driving clutch (not shown) to its next stopping point which is the governor stop bar **270** as it is assumed that no other channel is cut in at this time. As explained above, the mixer arm **254** is held at this point until the governor timer completes a circuit of the operating magnet **270** of the governor, whereupon the mixer arm **254** is again released to transmit another character from the transmitter **235** in the same manner as described above. The transmission of each character from the transmitter **235** is effected in part by the oscillating movement of the contact arm **248** of the transmitting mixer and in accordance with the present embodiment of the invention, this periodic movement of the contact arm **248** is utilized to actuate a counter **242** to count the number of characters transmitted for metering purposes.

If in the course of transmission of message traffic a "line feed" character having only the second pulse marking goes to the lower half of

the relay bank 210, the character is transmitted without change from the channel B of the multiplex distributor TD. However, if the transfer relay 225 is energized and thereby connects the upper half of the relay bank 210 to the operating channel when the "line feed" character is transmitted, the baffle circuit including armatures 211', 213', 214' and 215' of the upper half of relay bank 210 is closed, thereby closing a circuit from positive battery through the winding of relay 227, the armatures of the relay bank 210, the lower or resetting coil of relay 226 and the winding of magnet 270 of the transmitting mixer to ground. Magnet 270 is energized and holds the mixer arm 254 depressed so that the "line feed" character will be again applied to the relay bank 210, in this case on the lower half of said relay bank. Closure of the above described circuit resets relay 226 and energizes relay 227 whereupon the second segment of the transmitting ring 265 of the transmitting distributor is disconnected from negative or marking battery and connected to positive or spacing potential. Thus, attempting to send the entry signal on A channel directly from the transmitter is prevented by the substitution of a blank signal for the entry signal on A channel. However, the "line feed" character which is employed for entry in the specific embodiment which has been described may be transmitted on B channel and will also be transmitted on B channel when it is trapped and prevented from being transmitted on A channel. This arrangement has the advantage that characters ordinarily employed in traffic may be also utilized as entry or exit signals but will not be transmitted over the channel which is restricted to the transmission of entry or exit signals, although they are not lost being subsequently transmitted on another channel.

It will be evident that combinations other than the "line feed" character can be employed as described above either as functions to effect entry or exit, or as signaling combinations for any other purpose desired. Thus any character may be employed for a special purpose if transmitted over A channel whereas if transmitted over B channel it has no significance except as a message character. As described in this specification any such combinations occurring in the regular transmission of messages will be held up momentarily if an attempt is made to transmit them over A channel; since these characters will be subsequently repeated over B channel, they are not lost.

When the local brush of the transmitting distributor next engages segment 229 of local ring 230, the winding 232 of the first relay of relay bank 210 is energized, thereby operating the armature 211' and deenergizing relay 227 and the mixer operating magnet 270. The mixer arm is then permitted to advance to the next stopping position. When the transmission of the message in transmitter 235 is completed and the left hand autostop contacts 245 are closed, the transmitter 235 might not stop at once because the exit or disconnection of a channel is rarely effected simultaneously with the actuation of the autostop contacts. The autostop mechanism is arranged to permit the transmission of a few additional characters if exit does not occur at once, as for example by providing a flexible extension 246 on the autostop lever. Upon the closure of the left hand contacts of the autostop, ground potential is then applied to the segment 282 of the transmitting clock TC from the mixer stop bar 256. In due course the brush arm 280 of the transmitting clock TC engages segment 282 thereby operating entry relay 221 as described above and transmitting the entry and exit signal on A channel of the multiplex distributor. The entry and exit magnet 297 of the transmitting mixer is again energized as described above and because of the position of the sword-like projection on the stop bar 256 in respect to the roller *r*, the stop bar will this time be raised to the channel-out position. Shortly after entry or exit is effected on the commutator of the transmitting clock TC, the brush arm 280 of the clock traverses a long dead segment at the time when the multiplex transmitting brush is passing over the transmitting segments of B channel. Thus no entry or exit as such can be bid for or effected on B channel.

The stepping operation of the transmitter 235 will now be considered. The operating magnet SM of the transmitter is connected to positive through the contacts of a transmitter operating relay 241. This relay 241 is closed by the kick or charge of a condenser 243 immediately after the delivery of a code combination set up in the transmitter to the coils of relay bank 210 through contacts C. It is understood, of course, that the magnet SM of the transmitter is deenergized when the code combination is set up as in the case of the ordinary tape transmitter described above in connection with the system shown in Figs. 1 to 3. If a different type of transmitter is employed, obviously the circuits are arranged to operate in conjunction with such a transmitter.

In the system shown in Figs. 4 and 5, the transfer of a code combination from the transmitter to the relay bank 210 is effected when the mixer arm 254 is depressed and is pushing against contact arm 248. At this time the condenser 243 is discharged through the resistor 244. When the mixer operating magnet 270 releases the mixer arm 254, a spring restores the contact arm 248 and condenser 243 is charged in series with relay 241, thus transmitting an operating pulse to the magnet SM of the transmitter 235 which may be as long or short as desired depending upon the electrical constants of the circuit. Thus the transmitter 235 is operated, stepped, released and prepared for sending out the succeeding character punched in the tape. These operations require a definite time interval which, however, is independent of the operation of the mixer arm 254 and does not delay the rotation of said arm to the stop bars of other channels. Thus the cyclic operation of the operating magnet 270 of the mixer can be speeded up as it is only necessary for the mixer arm to give a momentary operation of contacts C if sensitive relays are employed in the relay bank 210. It is understood that the mixer arm 254 must be capable of making a complete revolution in the length of time required for the transmitting brushes of the transmitting distributor TD to pass over one multiplex channel.

Each transmitter or channel of the expanding channel system has a position on the mixer and the clock similar to that described in connection with the transmitter 235 and each of the channels is cut in and out in the same manner as described above in connection with this transmitter. It will also be apparent that the characters are transmitted from the operative transmitter or transmitters alternately over channels A and B of the multiplex by the cyclic operation of

transfer relay **225** which is energized and deenergized in properly timed relation to the travel of the transmitting brushes of the transmitting distributor by the segment **228** on the local ring **230** of said distributor.

Referring to Fig. 5, when an entry signal is received on A channel of the receiving ring **309** of the receiving distributor RD, it is set up in the first five relays of relay bank **310** at the second station. Assuming that the entry signal is the "line feed" character, the armatures of the first, third, fourth and fifth relays of relay bank **310** are thrown to spacing and the armatures of the second relay of said bank are thrown to marking. Thereupon the baffle circuit is closed through the left hand armatures of said relays and when the local brush of the local ring **311** engages segment **313** of said ring, a circuit is closed through the said segment and the left hand armatures of the first five relays of relay bank **310** for energizing the entry and exit magnet **397** of the receiving mixer RM. The energization of the magnet **397** operates the stop bar **356** of the receiving device corresponding to the transmitter which has been entered at the first station. When the receiving brush of the receiving distributor RD engages the receiving segments of channel B, the character being transmitted will be set up in the lower half of relay bank **310** and transfer relay **321** being deenergized, this character will be transferred from the contacts of said relays of relay bank **310** to the conductors **322** which are multipled to the receiving devices.

As pointed out above, the mixer arm **254** at the transmitting station missed a step while an entry pulse was being transmitted on A channel. As shown in Fig. 5, the receiving mixer arm **354** likewise misses a step when an entry pulse is received on A channel and entry is being effected by magnet **397** since the normal operating circuit of magnet **370** which includes the marking contacts of either the first, third, fourth or fifth relays of relay bank **310** and the segment **313** of the local ring **311** of the receiving distributor is open when the entry signal is received on A channel, but is closed for all other code combinations on this channel except the blank or all-spacing combination.

As has been described, false entry signals sent from a transmitter through A channel were converted into blanks and held up for transmission on B channel as although they were not intended for entry signals, they might be transmitted for some other purpose. The blank code combination set up on the upper half of the relays of relay bank **310** likewise holds the circuit of the mixer magnet **370** open. But when the entry signal is repeated upon B channel, then the mixer operating magnet **370** is energized directly from segment **314** of the local ring **311** of the receiving distributor. On the other hand, it will be apparent that the reception of a blank or all-spacing code combination upon the upper half of the relay bank **310** will not effect energization of the entry and exit magnet **397**. Entry signals, blanks and all other code combinations received on B channel of the receiving distributor RD are stored in the lower half of the receiving bank **310** and transferred to the receiving devices or printers through the armatures of transfer relay **321** and the contacts **347** of the respective channels of the receiving mixer RM.

The mixer arm **354** of the receiving mixer comes to rest against the stop bar **356, 356*a*** of any channel which is cut in. The mixer arm is rotated through a clutch as in the transmitting and receiving mixers shown in Figs. 2 and 3. The mixer arm remains in engagement with one of the stop bars until it is depressed by the magnet **370** to escape the bar whereupon the mixer arm engages the pivoted contact arm **348** and momentarily closes through contacts **347** the circuits of the selecting magnets **346** and operating magnet **349** of the receiving storing device or printer. In this case an ordinary five magnet multiplex printer or tape reperforator may be employed. At the termination of the operating pulse for the operating magnet **370** of the receiving mixer, the mixer arm **354** rises, the contact arm **348** is restored to normal by a spring and the printer connections to the relay bank **310** are broken at the contacts **347**.

On short lines where the possibility of mutilated line signals is very small, it is uneconomical to provide mechanisms to reduce the possibility of false entry or exit or to facilitate the correction of false entry or exit. On long lines which are subject to interference it may happen that traffic characters transmitted over A channel may be modified by induction or in some other way to such an extent that occasionally one of such characters is transformed into an entry or exit code combination. Any entry or exit signals arriving as such on A channel will operate the stop bar of the receiving mixer to its alternate position, the particular stop bar depending upon the position of the clock mechanism at the time of arrival of such false entry or exit signal. It will be evident that the possibility exists of accidentally cutting in or out a receiving channel when the corresponding transmitting channel is not cut in or out, as a result of interference or other line trouble.

In order to aid in the correction of trouble from this source without a material change in the circuits shown in Figs. 4 and 5, a stop bar such as that illustrated in Fig. 6 may be employed. This stop bar **384** is mounted in the transmitting and receiving mixers in place of the stop bars **256** and **356** and takes the place of two of the ordinary stop bars. Two channels of the clock are used for each stop bar constructed along these lines. If an expanding channel wishes to enter when the sending clock brushes are in the one position, entry pulses are transmitted but may only confirm the "out," inoperative position of the special stop bar. When the sending clock brush moves to the next group of segments another entry pulse is transmitted which effects entry on both the sending and receiving mixers. This device consists of the stop bar **384**, one end **385** of which is shaped to operate in an entering or downward direction and the other end **386** to operate in an upward or exit direction. If the armature of the entry and exit magnet attempted to operate through the projection **385** in a downward direction a stop bar **384** which happened to be down already, the motion would be completely ineffective as the roller on the magnet armature would not engage the cam surface of projection **385**.

Similarly, if the armature of the entry and exit magnet attempted to operate through the projection **386** in an upward direction a stop bar which was already raised, the motion would be ineffective and would merely confirm the fact that the channel was cut out. The two adjacent segments of the commutator of the transmitting clock corresponding to the double stop bar **384** would be strapped together so that in effect the

commutator segments of the transmitting clock would use twice the space of an ordinary channel. Obviously, it would not be necessary to arrange all of the stop bars of the transmitting and receiving mixers of the same type, for example of the type shown in Fig. 6, as some of the stop bars might be of this type and others of the type shown in Figs. 4 and 5, the special stop bars being employed on the more important channels, for example signal channels.

Another arrangement for effecting the same purpose as the stop bar **384** of Fig. 6 but without employing stop bars of special construction involves means for swinging the roller *r* outward for one revolution of the actuating arm **381** and inward for the next revolution. This would make it impossible to enter a channel during the first revolution or exit a channel during the second revolution. A magnet may be arranged to swing the arm to which the roller *r* is attached or the roller arm may be extended through a guide plate **387**, as shown in Fig. 7, having the inner and outer slots or tracks **388** arranged to swing the roller to the entry and exit positions above the stop bars during alternate revolutions.

The systems embodying the invention which have been described above have outstanding advantages both from the standpoint of simplicity of the electrical circuits and control apparatus and also with respect to the adaptability of the system to the problems encountered in transmission of telegraphic messages. The system provides for handling different classes of traffic in a simple and effective manner and for utilizing the full capacity of a lane of traffic even though a comparatively small number of channels are in operation. The improved methods of effecting entry and exit embody advantages which will be obvious to those skilled in the art. Furthermore the lane of traffic may comprise two or more wires, channels or carriers.

While several embodiments of the invention have been described in order to explain the underlying principles thereof, other modifications will occur to those skilled in the art and may be made without departing from the scope of the invention as set forth in the appended claims.

I claim:

1. A telegraph system comprising a lane of traffic, a plurality of telegraph channels, means for alternating the channels operating over said lane, said means comprising a series of movable members one individual to each channel, a common actuating device for said members and means to shift said device from one member to another each of said members having two operative positions corresponding to "channel in" and "channel out" respectively, and means including said actuating device for moving each of said members from one position to the other.

2. A telegraph system comprising a lane of traffic, communication channels including a plurality of transmitting devices associated with one end of said lane and a plurality of receiving devices associated with the other end of said lane, means for variably associating the transmitting and receiving devices with said lane and means for dividing the lane time between the operative transmitting and receiving devices, said first mentioned means including mixers at each end of the lane of traffic, each mixer comprising a plurality of movable members, one for each communication channel, each of said members having two operative positions corresponding to "channel in" and "channel out" respectively, and means for concurrently moving corresponding members of both mixers as each channel is cut in or out.

3. A telegraph system comprising a plurality of transmitting and receiving devices and means to render predetermined ones of said devices operative one transmitting device and one receiving device at a time and to vary the number of operative devices, said means including movable latch members which in one position initiate the operation of the associated device and a movable arm adapted to engage said latch members.

4. A telegraph system comprising a plurality of transmitting and receiving devices, means to render predetermined ones of said devices operative one after another, said means comprising a rotatable mixer arm and stop or latch members movable into and out of the path of said arm, means including said arm for actuating said members to one position and means including a clock arm for actuating said members to the other position.

5. In control apparatus for an expanding channel system, a mixer comprising a rotatable arm adapted to engage stop or latch members corresponding to operating channels and means for axially moving said arm to disengage the same from said members.

6. In control apparatus for an expanding channel system, a mixer comprising a rotatable arm adapted to engage stop or latch members corresponding to operating channels, a resetting lug for said members on said arm and means for actuating said lug from its normal position to a position where the movement of said arm will reset one of the stop or latch members.

7. A telegraph system comprising a lane of traffic, expanding channels associated with said lane of traffic, means for controlling the order of transmission of signals from these channels, including stop bars with "in" and "out" positions, a rotating member whose movement is impeded when said stop bars are in the "in" position and means for rendering the corresponding transmitting device operable when the movement of the rotating arm is so impeded.

8. A telegraph system comprising a lane of traffic, expanding channels associated with said lane of traffic, means for controlling the order of transmission of signals from these channels, including stop bars with "in" and "out" positions, a rotating member whose movement is stopped when said bars are in the "in" position, a switching assembly and means for effecting a relative movement between the rotating arm and the stop bars to operate said switching assembly.

9. A telegraph system comprising a lane of traffic, expanding channels associated with said lane of traffic, means for controlling the order of transmission of signals from these channels, including stop bars with "in" and "out" positions, a rotating member whose movement is stopped when said bars are in the "in" position, a switching assembly, means for effecting a relative movement between the rotating arm and the stop bars to operate said switching assembly, and means for varying the number and duration of said switching assembly operations.

10. An expanding channel system wherein at least a part of the transmitting time of an idle channel is utilized by a busy channel, means for transmitting an entry signal consisting of a multiple-character code combination concurrently with intelligence signals on busy channels and

means responsive to such signal for temporarily entering a channel.

11. An expanding channel system wherein at least a part of the transmitting time of an idle channel is utilized by a busy channel, means for transmitting an exit signal consisting of a multiple-character code combination concurrently with intelligence signals on busy channels and means responsive to such signal for disconnecting a channel.

12. An expanding channel system as set forth in claim 10 wherein the component parts of the entry signal are sent over different multiplex channels.

13. A telegraph system comprising a plurality of transmitting and receiving devices and means to render predetermined ones of said devices operative in sequence and to vary the number of operative devices, said means including movable latch members individual to each of the transmitting channels and having two operative positions and further including an actuating bar arranged to operate any of said latch members to either of its respective positions.

14. A telegraph system comprising a plurality of transmitting and receiving devices and means to render predetermined ones of said devices operative in sequence and to vary the number of operative devices, said means including movable latch members having two laterally displaced projections, said projections having oppositely disposed cam surfaces, and an operating member adapted to engage either of the projections of any of said latch members to operate the latch member from one position to another.

15. An expanding channel system comprising a lane of traffic, a plurality of subchannels sharing said lane of traffic and means for connecting selected ones of said subchannels to a lane of traffic while omitting other channels in a manner to utilize at least a part of the transmitting time of an idle channel, said means being arranged to connect invariably the same number of operating channels to the lane of traffic.

16. An expanding channel system wherein at least a part of the transmitting time of an idle channel is utilized by another channel comprising a lane of traffic, a plurality of channels adapted to operate over said lane of traffic, said channels including sending devices provided with contacts, control means for transmitting an entry signal over said lane of traffic and means for trapping code combinations corresponding to said entry signal which are originated at the contacts of the sending devices to prevent the transmission of such code combinations except by said control means.

17. An expanding channel system wherein at least a part of the transmitting time of an idle channel is utilized by another channel comprising a lane of traffic, a plurality of channels adapted to operate over said lane of traffic, said channels including transmitters and receiving devices, means for transmitting an entry signal code combination over said lane of traffic to enter a receiving device and means for converting a corresponding code combination originating at the contacts of one of the transmitters to a different code combination to avoid the transmission of a false entry signal.

18. An expanding channel system wherein at least a part of the transmitting time of an idle channel is utilized by another channel comprising a lane of traffic, a plurality of transmitters adapted to operate over said lane of traffic, control apparatus for transmitting a code combination over said lane of traffic, a device responsive to said code combination when it originates at said control apparatus and means whereby said device is not responsive to the transmission of said code combination from one of said transmitters.

19. An expanding channel system wherein at least a part of the transmitting time of an idle channel is utilized by another channel comprising a lane of traffic consisting of a plurality of multiplex channels, a plurality of transmitters adapted to operate over said lane of traffic, control apparatus for transmitting a code combination over one of said channels and means for preventing the transmission of said code combination from any of said transmitters.

20. An expanding channel system wherein at least a part of the transmitting time of an idle channel is utilized by another channel comprising a lane of traffic, a plurality of receiving devices adapted to be operated over said lane of traffic, means for transmitting an exit code combination over said lane of traffic to disconnect one of said receiving devices from the system and other means for transmitting code combinations over said lane of traffic, said other means being inoperative to transmit said exit code combination.

21. An expanding channel system wherein at least a part of the transmitting time of an idle channel is utilized by another channel comprising a lane of traffic consisting of a plurality of multiplex channels, means for transmitting entry signals over one of said channels and means for deferring the transmission of code combinations from transmitting channels which would normally be transmitted over said one of said multiplex channels.

22. An expanding channel system wherein at least a part of the transmitting time of an idle channel is utilized by another channel comprising a lane of traffic, a plurality of channels adapted to operate over said lane of traffic, means for transmitting an entry signal over said lane of traffic, means responsive to said signal for effecting an entry function and means for rendering non-functional certain errored signals similar in part to the entry signal.

23. An expanding channel system wherein at least a part of the transmitting time of an idle channel is utilized by another channel comprising a plurality of channels, means for entering channels in response to a transmitted signal and means for trapping said signal under predetermined conditions to prevent the entry of a channel under those conditions.

24. In a telegraph system comprising a transmitting channel and a signal transmitting device, signal storage means in circuit with said device for repeating certain character code combinations from said transmitter over said transmitting channel, and means including said signal storage means for automatically preventing the transmission of other character code combinations from said transmitting device over said transmitting channel.

25. An expanding channel system wherein at least a part of the transmitting time of an idle channel is utilized by another channel comprising a plurality of transmitting channels, a mixer for connecting operative ones of said channels to the system and counters controlled by said mixer for metering the service on each channel.

26. In an expanding channel telegraph system,

wherein substantially all of the transmitting time is utilized by a variable number of operative channels that have been entered on the system, the method of varying the number of operative channels which comprises allotting separate time intervals for the control of the respective channels, transmitting a signal over the system during the time interval allotted to any one of channels which is to be controlled and utilizing the signal on receipt thereof to vary the operative relation of the receiving end of said one channel to the system.

27. In an expanding channel telegraph system, wherein substantially all of the transmitting time is utilized by a variable number of operative channels that have been entered on the system, the method of entering a channel for operation which comprises allotting separate time intervals for the control of the respective channels, preparing a circuit at the receiving station during each of said time intervals for effecting entry of the receiving end of the corresponding channel, transmitting a signal during the time interval allotted to a channel which is to be cut in and completing the entry circuit for entering the receiving end of said channel upon receipt of said signal.

28. In an expanding channel telegraph system having a plurality of channels and wherein substantially all of the transmitting time is utilized by a variable number of operative channels that have been entered on the system, the method of entering and disconnecting channels which comprises transmitting the same control signal combination for entering a channel that is out and for disconnecting a channel that is in and entering or disconnecting the channel upon the transmission of said signal.

29. In an expanding channel telegraph system having a plurality of channels and wherein substantially all the transmitting time is utilized by a variable number of operative channels that have been entered on the system, the method of entering and cutting out channels for operation which comprises transmitting a code combination used in the regular transmission of messages, entering or cutting out a channel when said code combination is transmitted as a switching signal and employing said code combination as a message code combination at other times.

30. In a multiplex telegraph system, the method of signaling which comprises allotting a multiplex channel or channels to the transmission of a signaling code combination identical with an intelligence code combination which may be sent over another channel and deferring the transmission of said code combination used as a message character when an attempt is made to transmit the same over said predetermined channel or channels whereby said code combination may be employed either as a signaling or an intelligence code combination depending upon the transmission channel used.

31. In an expanding channel system wherein at least a part of the transmitting time of an idle channel is utilized by another channel comprising two offices, means for transmitting message signals between said offices on the busy channels, one after another and means for interspersing signaling or operating impulses with said message signals.

32. In an expanding channel system wherein at least a part of the transmitting time of an idle channel is utilized by another channel, a plurality of transmitting channels for sending message or character-code signals, one or more signaling channels, means for transmitting exit and entry signals to the receiving side of the system and means controlled thereby for causing said signaling channel or channels to be entered and disconnected from the system in substantially the same manner as the transmitting channels.

33. An expanding channel system wherein at least a part of the transmitting time of an idle channel is utilized by another channel comprising two offices, a lane of traffic connecting said offices, a plurality of transmitting channels at one office, a plurality of receiving channels at the second office and means controlled from said second office for stopping transmission from all of said transmitting channels at the other office.

34. In combination, signal circuits, a signal storing device, a reciprocable member and means including said member for extending the signal circuits and stepping said signal storing device in a single forward and back movement of said member.

35. In combination, signal circuits, a receiving device responsive to signals, a reciprocable member and means including said member for extending the signal circuits and operating said receiving device in a single forward and back movement of said member.

36. An expanding channel telegraph system comprising a plurality of channels, a lane of traffic shared by the operating channels of said system, means for causing channels having message traffic to take their share of the lane of traffic until and only until their traffic has been transmitted, means associated with each channel for generating current impulses varying in number as the messages on the corresponding channel vary in length and varying in frequency as the number of channels operating over the lane of traffic varies, and means actuated by said impulses for metering the traffic on the corresponding channel.

37. An expanding channel telegraph system comprising a plurality of channels, a lane of traffic shared by the operating channels of said system, means for causing channels having message traffic to take their share of the lane of traffic until and only until their traffic has been transmitted, means associated with each channel for generating current impulses and means actuated by said impulses for operating the transmitter of the corresponding channel and for metering the traffic thereon.

38. An expanding channel telegraph system comprising a lane of traffic, a plurality of channels of communication, means for causing a variable number of said channels to share the lane of traffic in turn at a frequency of transmission dependent upon the number of operative channels, means associated with each channel for transmitting over said lane of traffic a group of signaling impulses on each transmission turn of said channel, traffic metering means associated with predetermined ones of said channels, means for generating a metering current-impulse corresponding to predetermined ones but not all of said groups of signaling impulses transmitted over said lane of traffic and means for operating said metering means associated with operative ones of said predetermined channels under control of said metering impulses.

39. An expanding channel system comprising a plurality of channels, a lane of traffic, means including a mixer for enabling the operative

channels to share the lane of traffic to the exclusion of idle channels, means for metering the traffic on one of said channels, and means including said mixer for actuating said last mentioned means.

40. A telegraph system comprising a plurality of channels, control means for said channels whereby the rate of transmission of characters on any channel depends upon whether more or fewer other channels are in operation, said control means including oscillating mechanical elements, and means operatively associated with said elements for metering the traffic on said channels.

41. An expanding channel system comprising a lane of traffic, a plurality of subchannels each including transmitting and receiving apparatus, means for dividing the transmitting time of said lane of traffic between operative ones of said subchannels and for cutting out subchannels when they have no signals to transmit and means for simultaneously cutting out all of the busy subchannels irrespective of the busy condition thereof.

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