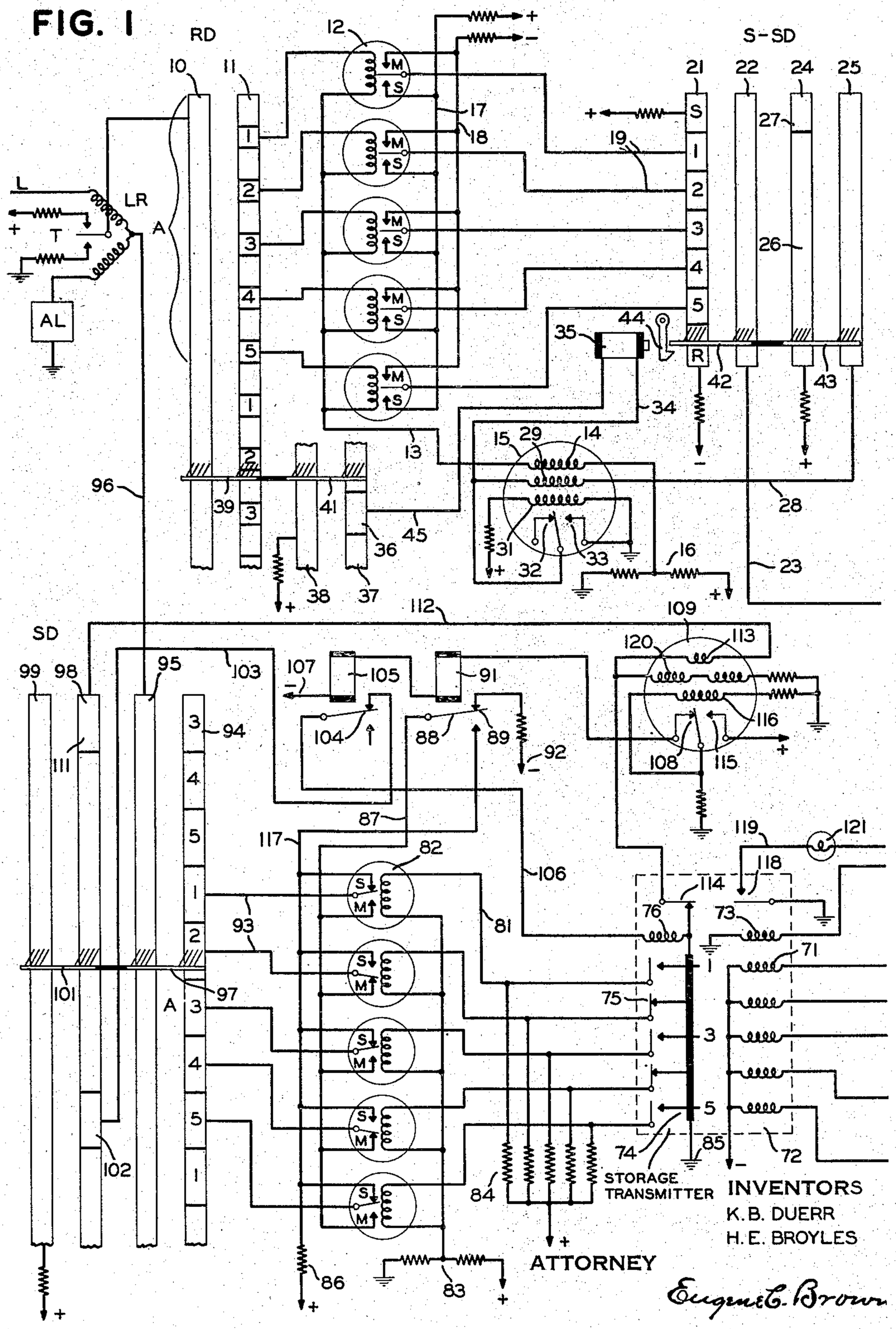
Oct. 4, 1932. K. B. DUERR ET AL 1,880,906

MULTIPLEX EXTENDED CHANNEL SYSTEM

Filed July 9, 1931 3 Sheets-Sheet 1

FIG. 1



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MULTIPLEX EXTENDED CHANNEL SYSTEM

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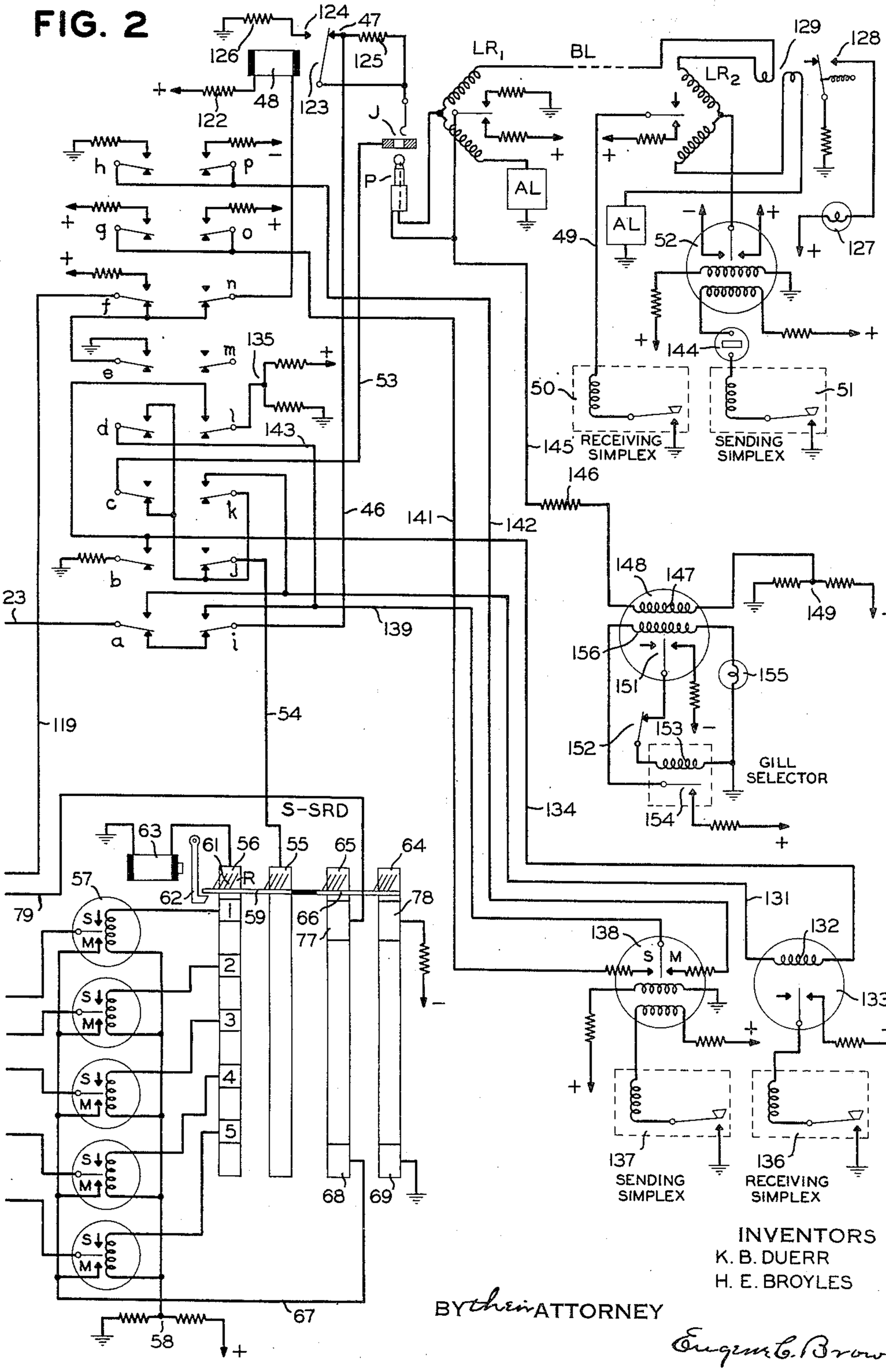
FIG. 2



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MULTIPLEX EXTENDED CHANNEL SYSTEM

Filed July 9, 1931 3 Sheets-Sheet 3

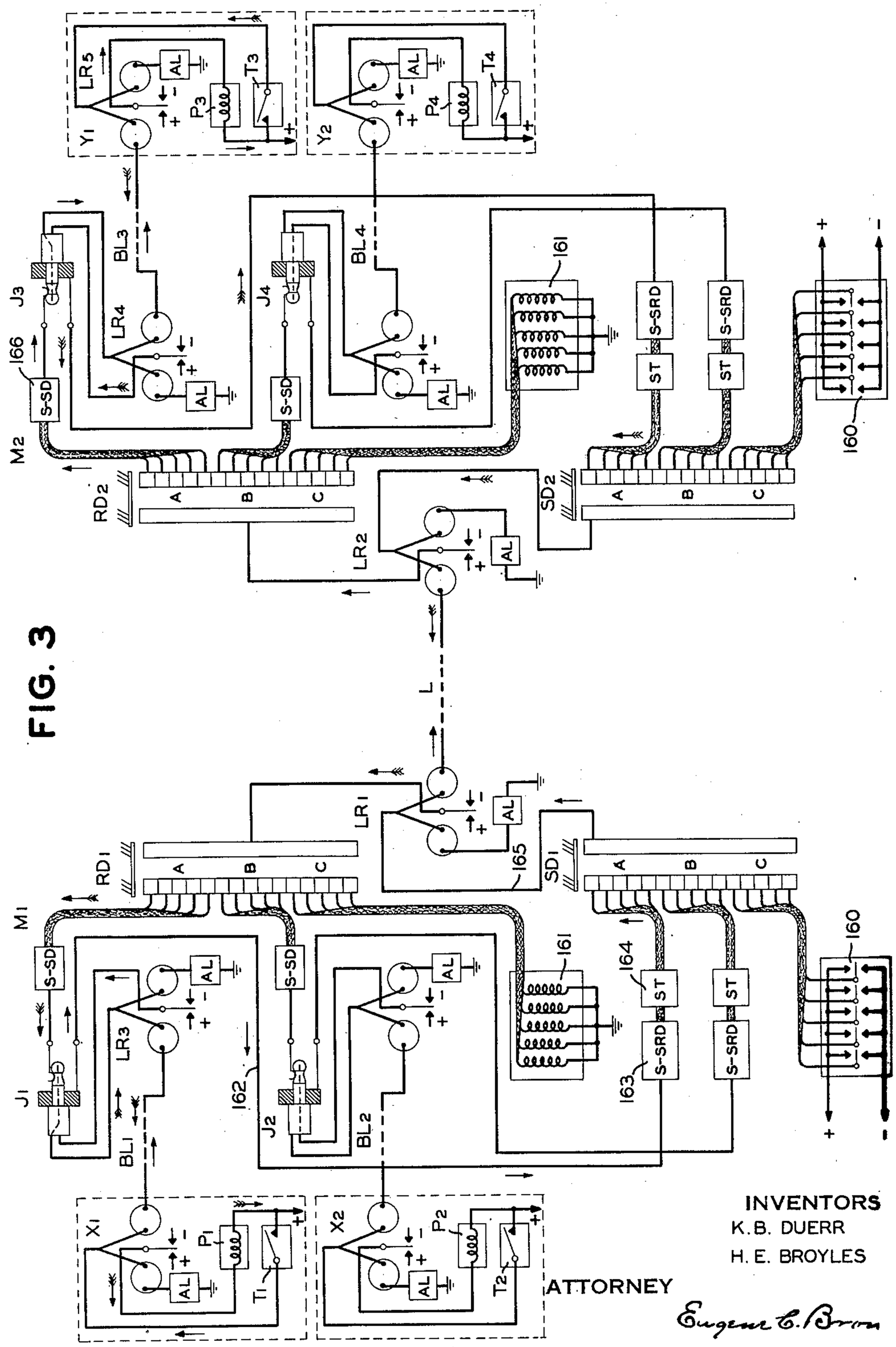

FIG. 3

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UNITED STATES PATENT OFFICE

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MULTIPLEX EXTENDED CHANNEL SYSTEM

Application filed July 9, 1931. Serial No. 549,762.

This invention relates to a multiplex extended channel system and comprises means whereby one or more channels of a multiplex circuit may be extended to or continued from a start-stop telegraph system, which for instance, may connect the multiplex terminal with a branch office, or subscriber's station.

There is, at the present time, a tendency towards the creation of telegraph exchange systems in which individual subscribers are equipped with printing telegraph sending or receiving apparatus of the ordinary start-stop type. Such systems as heretofore developed, either require intermediate handling of the messages at a central telegraph office or an individual wire connection between the two subscribers over a trunk circuit which may be completed either automatically or by attendants at the terminals of the trunk line, as in ordinary telephone service. This latter system is open to the objection that ordinarily only one way communication is possible at a time and the message carrying capacity of the trunk line is not efficiently utilized.

Also there is often a limited amount of business between a branch telegraph office connected to one central office and a branch office connected to another central office which is insufficient to warrant the establishment of a direct multiplex circuit between such branch offices. In such cases, the messages received at the main office from the various branch offices are retransmitted to the second main office over multiplex circuits and at the second main office they are distributed by telephone, pneumatic tubes or branch lines to the branch office for which the message was intended. This involves the handling of such messages a number of times with consequent delay, increased cost and possibility of error.

In many instances there is a sufficient volume of business between branch offices to fill one channel of a multiplex circuit, at least for a portion of the day.

It is one of the objects of the present invention, in such cases, to provide a system whereby the business originating at one branch office or subscriber's station may be repeated directly therefrom, over one channel of a multiplex circuit extending between main stations, and thence directly to the branch office for which the message is ultimately intended, without intermediate handling.

Another object is to provide two-way or duplex operation over the extended channel between the simplex or branch office and the multiplex terminal.

Another object is to permit one-way or two-way communication between the branch office and either main office or between the main offices, over one channel of the multiplex circuit, through simplex transmitting and receiving equipment.

A still further object is to enable the operator at a branch office to call the main office and for the main office to indicate to the simplex operators either at the branch offices or at the main offices, the condition of the repeating equipment.

Other and more general objects are to convert start-stop signals into multiplex signals and vice versa, to maintain proper phase relation between the start-stop and multiplex equipment and to allow for difference in the rate of operation of the simplex and multiplex apparatus.

Other objects and advantages of the invention will appear as the detailed description of the invention proceeds.

The present invention, broadly speaking, comprises apparatus at a main station whereby signals received over one channel of a multiplex circuit may be repeated by means of a start-stop distributor, over a duplexed line to a branch office or subscriber's station and whereby the start-stop signals received from the branch office or subscriber's station operate a storage transmitter, which repeats the signals over one channel of a multiplex system.

Switching mechanism is provided whereby the signals received from the branch office may be recorded on simplex apparatus at the main office or repeated over the multiplex channel; whereby signals originating in a simplex transmitter at the main office may be transmitted either to the associated branch office or directly over the multiplex

circuit; and whereby signals received over the multiplex circuit may be recorded on simplex printers at the main office or repeated directly to the branch office.

Appropriate signals warn the simplex operators either at the main station or at the branch station, in case the signal storage device approaches its storage limit and another signal device serves to call the attendant at the main office whenever the branch office desires to transmit.

In order that these and other features of the invention will be more fully understood, reference will be had to the accompanying drawings in which;

Figures 1 and 2, together illustrate diagrammatically the equipment and circuit arrangement at one main station and a branch station, assembled in accordance with the present invention, and

Figure 3 illustrates schematically the station and principal circuit arrangements for a completely duplexed subscriber telegraph exchange system.

The incoming main line L, which connects the main station with a distant main station is terminated in a line relay LR, which is shown duplexed. The marking and spacing contacts of the relay LR are connected, respectively, to ground and to positive battery and the tongue T is connected to the solid ring 10 of a receiving multiplex distributor RD.

The multiplex distributor may provide for any desired number of channels, usually three or four. One channel only is shown complete, which for convenience may be termed the A channel, this channel being utilized for messages which are to be extended directly to the branch office or to be received upon the simplex apparatus at the main office. The other channels of the multiplex distributor ordinarily termed B, C and D channels may be operated in connection with regular multiplex equipment or with other extended channel equipment, as desired.

The segmented receiving ring 11 is provided with five segments for each channel, the segments for the A channel being connected individually to one terminal of the windings of a series of polarized relays 12. The opposite terminals of each of the windings of the relays 12 are connected, by a conductor 13 to the operating winding 14 of a polarized relay 15 and thence to the midpoint of a potentiometer 16, the opposite ends of which are connected to ground and to positive battery respectively.

The spacing and marking contacts, S and M, of each of the polar relays 12 are provided with positive and negative battery, through the bus bars 17 and 18 respectively and the tongue of each of these relays is connected by an individual conductor 19 to segments numbered 1 to 5 of the segmented ring 21 of a start-stop distributor S—SD. The ring 21 is also provided with a rest segment R connected to negative or marking battery and a start segment S connected to positive or spacing battery. The solid transmitting ring 22 of the start-stop distributor is connected by a conductor 23 to the outgoing line which extends to the branch station as will presently appear.

The start-stop distributor is provided with local rings 24 and 25, the former having a live segment 26 connected to a source of positive potential and a dead segment 27 corresponding to the start segment S of ring 21. The solid local ring 25 is connected by a conductor 28 to the locking winding 29 of relay 15 and thence to the tongue of the relay. The relay is also provided with a biasing winding 31 which tends to maintain the tongue on its insulated or left hand contact 32. The windings 14 and 29 are arranged, when a marking signal is received, to position the tongue of the relay on its right hand or grounded contact 33. The tongue of the relay is also connected, by means of conductor 34, to the winding of the start magnet 35 of the start-stop distributor, the opposite terminal of which is connected through a conductor 45 to a segment 36 on one of the local rings 37 of the multiplex receiving distributor RD. The opposite local ring 38 is provided with positive potential.

The receiving rings 10 and 11 of the multiplex distributor are traversed by brushes 39 and the local rings 37 and 38 are traversed by brushes 41. The transmitting rings 21 and 22 of the start-stop distributor are traversed by brushes 42 and the local rings 24 and 25 are traversed by brushes 43. The brushes of the multiplex distributor rotate continuously in synchronism with the incoming signals, as is well understood by those versed in the art, and crosses the segments of channel A once during each revolution. The brushes 42 and 43 of the start-stop distributor are normally held at rest upon the rest segment R by means of a latch 44.

When the A channel is idle, spacing battery only is received over this channel, and in such case, as the brush 39 passes over the segments of the A channel, spacing battery from the relay LR is applied to the windings of the relays 12 and to the winding 14 of the relay 15, thereby maintaining the tongue of the latter relay upon its insulated contact 32. Consequently, the circuit for the start magnet 35, of the distributor S—SD, is not completed and the brushes 42 and 43 are held stationary. At this time, continuous marking battery is applied to the conductor 23 from the rest segment R, for transmission over the branch circuit.

When intelligence signals are transmitted over the A channel, at least one of the selecting impulses will be of marking character

and will operate the relay 15 to its right hand or grounded contact 33. When this occurs, the tongue is locked in its shifted position by battery supplied from the live segment 26 of ring 24, brush 43, ring 25, conductor 28, locking winding 29 and the tongue and contact 33 of the relay to ground. At the same time, the marking signals are set-up on the segments of the ring 21 by the relay group 12. After the brush 39 of the multiplex distributor RD passes off of the segments of channel A, that is, after the received signals have been set-up on the segments of the start-stop distributor, the brush 41 engages local segment 36 completing a circuit for the start magnet 35 from battery at the local segment 38, brush 41, segment 36, conductor 45, start magnet 35, conductor 34 and the tongue and contact 33 of relay 15, to ground. Consequently, the brushes 42 and 43 are released and pass on to the start segment S and the dead segment 27 respectively.

As the brush 43 passes onto the dead segment 27 the circuit for the locking winding 29 of relay 15 is interrupted and the relay is restored to its insulated contact by the biasing winding 31, in readiness for the next signal group. As the brush 42 traverses, the segments S and 1 to 5, a start signal and five intelligence signals are repeated over the conductor 23. The brush comes to rest on the rest segment R at the end of the revolution.

Referring now to Figure 2, the circuit from the conductor 23 may be traced through the tongue and lower contact of a switch (*a*) of a switching group, lower contact and tongue of switch (*i*), conductor 46 to the right hand contact 47 of a neutral relay 48; thence by the tongue of the relay 48 to the tip contact of a jack J and plug P to the apex of the line relay LR1 which is shown duplexed, thence over the branch line BL to the receiving line relay LR2. The tongue of the relay LR2 is connected by conductor 49 to a receiving simplex printer, diagrammatically illustrated at 50, upon which the signals repeated by the start-stop distributor S—SD are received at the branch station.

The purpose of the group of switches (*a*) to (*p*) is to enable communication to be established either (1) between the branch office and the main multiplex line L, to the distant station or (2) between the branch station and the main station or (3) between the main station and the distant main station over the duplex circuit. The group of switches (*a*) to (*h*) are operated together, as are the switches (*i*) to (*p*). For through communication from the branch station to the main line L, both groups of switches are against their lower contacts, as shown.

The communication in the opposite direction, that is between the branch station and the distant main station over the line L, will now be described. Signals originating at the simplex transmitter diagrammatically shown at 51 at the branch station are repeated by a sending relay 52 directly to the apex of the line relay LR2 and thence over the branch BL to the line relay LR1 at the main station.

The relay LR1 has one of its contacts grounded and its opposite contact connected to positive battery. The tongue of the relay is connected through the sleeve contacts of the plug and jack, by conductor 53 to the tongue of switch *c*, the circuit being continued from the lower contact of switch *c*, lower contact and tongue of switch *j*, and conductor 54 to the solid ring 55 of the start-stop receiving distributor S—SRD.

The ring 56 of this distributor has its segments, numbered 1 to 5, connected individually to one terminal of the windings of a group of polarized relays 57, the opposite terminals of the relay windings being connected to the mid-point of a potentiometer 58, the opposite ends of which are connected to ground and to positive battery respectively. The brush 59 of the rings 55 and 56 is normally held upon segment 61 by a latch 62. Segment 61 is connected through the winding of the start magnet 63 to ground.

When the sending simplex 51 at the branch station is idle, continuous marking battery is applied to the line BL, which maintains the tongue of the line relay LR1 on its upper or grounded contact. Consequently the start magnet 63 is unenergized. When signals are transmitted through the transmitter 51, the first or start impulse is of spacing character causing the tongue of relay LR1 to move to its positive contact, thereby energizing the start magnet 63 to release the brush 59. The brush 59 passes over the segments 1 to 5 in synchronism with the transmitted intelligence impulses and serves to operate the relays 57 either to their marking or spacing contacts in accordance with the signal combination received. At the end of the revolution the brush 59 again comes to rest on segment 61. The distributor S—SRD is also provided with local rings 64 and 65, traversed by a brush 66.

The upper or spacing contacts of the relay group 57 are insulated and the lower or marking contacts are connected by a common conductor 67 to one segment 68 of ring 65, the corresponding segment 69 of ring 64 being grounded. The tongues of the relays 57 are connected individually to the setting-up magnets 71 of a storage transmitter 72 which may be of the type shown in patent to Wheeler & Dirkes, No. 1,576,167 granted March 9, 1926.

Briefly the storing transmitter comprises a drum having a multitude of rows of radially extending pins which may be moved inward or outward with respect to the surface of the drum. Each row of pins corresponds to one group of intelligence signals and the setting thereof corresponds to the code com-

bination. As each code combination is set up on the pins of the drum the setting-up arm is stepped ahead, by means of a magnet diagrammatically represented at 73, in position to receive the next signal group. After the pins have been set-up they are engaged by a traveling transmitting arm which serves to repeat the combinations to a transmitting distributor. The transmitting arm and the setting-up mechanism operate independently and at different speeds. The transmitting pins are diagrammatically represented at 74 and the contacts of the transmitting arm at 75. After each code combination is transmitted the transmitting arm is stepped forward by a magnet 76 in position to transmit the succeeding signal group.

In the position shown in Figure 1 the pins 74 are set up with numbers 1, 3 and 5 in spacing position and 2 and 4 in marking position.

It will be noted that, as the brush 59 sweeps over the segments 1 to 5, the code combination is not immediately transferred to the pins through the setting up magnet 71, only the tongues of the relays 57 being set at this time. After the last impulse of the group has been received, that is, the No. 5 impulse, brush 66 engages segments 68 and 69 of the local rings to apply ground to the tongues of the relays of group 57 which are in their marking position, thereby energizing the corresponding setting-up magnets of the storage transmitter to set the corresponding pins, At the beginning of each revolution of the brushes 59 and 66, the latter brush passes on to a live segment 77 completing a circuit from negative battery through segment 78, brush 66, segment 77 and conductor 79, to the stepping magnet 73, by which the setting-up arm is advanced into position before the row of pins on which the next code combination is to be recorded.

At the transmitting side of the storage transmitter, the transmitting contacts 75 are connected by individual conductors 81, to one terminal of the windings of a second group of polarized relays 82. The opposite terminals of the windings of relays 82 are connected to the mid-point of a potentiometer 83 the opposite ends of which are connected to ground and to positive battery respectively. Positive battery is also applied to each of the conductors 81 through a series of resistances 84. The transmitting pins 74, when selected, are grounded at 85. Consequently as the transmitting arm moves into contact with a row of pins, the relays of group 82 corresponding to pins which are retracted, that is the pins 1, 3 and 5 in the illustration, are moved to their spacing side by battery supplied through the resistances 84 and those relays associated with pins which have been moved outwardly to engage the contacts 75 are moved to their marking side by battery from the potentiometer 83, through the windings of the relays and to ground at 85.

The upper or spacing contacts of the relays 82 are connected directly to a source of positive potential at 86 and the lower or marking contacts are connected by a conductor 87 through the tongue 88 and front contact 89 of a relay 91 to negative battery at 92. Consequently, with the relay 91 energized, the potential applied to the tongues of the relays 82 corresponds to the signal combination set-up on the pins of the storage transmitter.

The tongues of the relays 82 are individually connected by conductors 93 to the segments 1 to 5 of one channel of the transmitting ring 94 of the multiplex sending distributor SD. The solid ring 95 of distributor SD is connected to the apex of the line relay LR by means of a conductor 96. The rings 94 and 95 are traversed by a brush 97.

The distributor SD is also provided with local rings 98 and 99 traversed by brushes 101.

The brush 97 as it passes over segments 1 to 5 of the A sending channel transmits the signals previously set up on the segments of the A channel directly over the outgoing line L. As the brush 97 engages the last segment 5 of this group the brush 101 engages a segment 102 of ring 98, thereby completing a circuit from positive battery through the solid ring 99, brush 101, segment 102, conductor 103, front contact 104 and tongue of a neutral relay 105, and conductor 106 to the winding of the stepping magnet 76 of the transmitting arm and thence to ground at 85. The energization of the magnet 76 does not immediately step the transmitting arm ahead but advances the stepping pawl of the mechanism so that as the brush 101 passes off of segment 102, the transmitting arm is advanced into the next position, thereby setting up a new combination on the segments of channel A.

The neutral relays 105 and 91 are normally energized from a source of potential 107, by a circuit traced through the windings of the relays in series, left hand contact 108 of an auto-stop relay 109 and to ground through the tongue of the relay. The tongue of the relay is normally positioned on the contact 108 each time the brush 101 revolves, by a circuit completed from the solid ring 99, brush 101, segment 111 of ring 98, conductor 112, winding 113, thence by normally closed auto-stop contact 114 to ground at 85. The relay 109 is locked on its contact 108 throughout the remainder of the revolution by locking winding 116, under normal conditions. However, in case the transmitting arm gains on the setting-up arm due to the transmission of the signals over the multiplex circuit at a faster rate than they are received over the simplex circuit, the auto-stop contact 114 is

opened. This ordinarily occurs when the number of characters stored in the transmitter is reduced to about two.

The opening of contact 114 stops the transmission over the multiplex circuit until additional received signals cause the contact 114 to again close. For this purpose the relay 109 is provided with a second winding 120 opposing the winding 113 and having substantially four times the number of turns. With the auto-stop contact 114 closed both ends of the winding 120 are grounded and it is rendered ineffective.

However, in case contact 114 is opened by substantial exhaustion of the stored characters in the transmitter, a circuit for the winding 120 is completed, as the brush 101 engages its local segment 111, this circuit being traced over the wire 112, winding 113 and winding 120 to ground. The winding 120 overpowers the winding 113 moving the tongue of the relay to its righthand contact 115 and thereby applying locking battery to the locking winding 116 of the relay. At the same time the circuit for the neutral relays 105 and 91 is broken at contact 108 and the tongues of these relays drop to their back contacts. As the tongue of relay 105 drops to its back contact the circuit of the stepping magnet 76 is interrupted thereby preventing the transmitting arm from advancing further around the drum of the transmitter and as the tongue 88 of relay 81 drops to its back contact, positive or spacing battery from the source 86, is applied through the conductor 117, back contact of relay 91, tongue 88 and conductor 87 to the lower or marking contacts of the relays 82.

It will be noted, therefore, that positive or spacing battery is applied to both contacts of the relays at this time so that in whatever position they may be set spacing battery is applied to the sending segments of the A channel, of the distributor SD. This condition continues until the number of characters in the storage transmitter increases sufficiciently to permit the auto-stop contact 114 to close, whereupon ground is again applied to both terminals of the winding 120 and consequently when brushes 101 again pass onto segment 111, the tongue of the relay is returned to its contact 108, again energizing neutral relays 105 and 91, and locking winding 116 and permitting the transmission to continue in its normal manner.

In case the simplex signals transmitted from the branch station are received at a faster rate than they are retransmitted over the multiplex circuit, the storage transmitter will ulimately reach the limit of its storage capacity. In such case it is necessary to signal the simplex operator at the branch station so that he may discontinue transmission until the number of characters in the storage transmitter has been substantially reduced. For this purpose a stop-warning contact 118 is provided in the storage transmitter which closes whenever the setting-up arm approaches within a definite number of characters of full storage capacity, usually within about fifteen characters. One contact of the switch 118 is grounded and the other is connected by a conductor 119 through a signal lamp 121 to the tongue of the switch (*f*) of the switching group, thence through the lower contact of switch (*f*) and lower contact and tongue of switch (*n*) to one terminal of the relay 48, the opposite terminal of which is connected to a souce of potential through a resistance 122. When this circuit is completed by closing of contact 118, the light 121 glows dimly thus indicating to the attendant at the main station that the storage transmitter is reaching the limit of its capacity. At the same time the relay 48 draws is tongue 123 to the front contact 124 thereby connecting the resistance 125 in series with the line BL and thus reducing the current transmitted over the line from the start-stop distributor S—SD. In order to maintain the balance of the duplex circuit an additional resistance 126 is connected between the apex of the duplex line and the ground.

The reduction in current over the line BL serves to operate a signal lamp 127 at the branch station to warn the operator to discontinue the transmission. The circuit of this lamp is normally held open at the contact 128 of a relay 129 in the line circuit. The normal current over the line holds the tongue of the relay away from the contact 128 but upon reduction of the line current by the insertion of the resistance 125 at the opposite end, causes relay 129 to release its tongue so as to complete the circuit to the lamp 127. The lamp 127 continues to operate until the number of characters in the storage transmitter 72 decreases sufficiently to open the contact 118 and thereby deenergize relay 48 to shunt out the resistance 125. When this occurs the current over the line BL increases again sufficiently to operate the relay 129 and interrupt the circuit of the lamp 127. Thereupon the sending operator may again resume transmission.

It will be noted, with the system so far described, that two-way communication may be had between the branch station partly over the simplex circuit BL and partly over the multiplex circuit L. Proper phase relation is maintained between the receiving distributor RD and the start-stop distibutor S—SD under the control of the local ring of the receiving distributor, it being only necessary that the start-stop distributor brush operate at a sufficient speed to complete its revolution before the succeeding signal group is received over channel A of the multiplex circuit.

In a multiplex circuit the practice is to employ a spacing battery on idle channels whereas in the start-stop or simplex system it is necessary to transmit marking battery over the line when the transmitter is idle. The relay 15 permits continuous marking battery to be applied to the simplex line when continuous spacing signals are being received over the A channel of the multiplex circuit. As previously described, when all spacing signals are received over the multiplex circuit, corresponding to an idle channel condition, the circuit to the starting magnet 35 of the start-stop distributor is held open at the contacts of relay 15 so as to maintain the brush 42 continuously on the rest segment R in position to transmit steady marking battery over the branch line BL.

Simultaneously with the repetition of signals from the line L to the line BL, simplex signals may be transmitted in the opposite direction, that is from the branch station to the main station, at any desired rate, and repeated over the line L through one channel of the multiplex circuit at the normal rate of operation thereof, the storing transmitter allowing for differences in the rate of transmission of the simplex and multiplex signals. If the repetition of these signals over the multiplex line is interrupted, the neutral relay 91 serves to cause spacing battery to be applied to the A channel of the multiplex circuit regardless of the combination which may be set up at the time in the pins of the storage transmitter.

If it is desired to carry on simplex operation directly between the branch station and the main station, the tongues of the switch group (*i*) to (*p*) are moved to their upper contacts, the switches of group (*a*) to (*h*) being retained in their lower position as shown. In this case the start-stop receiving distributor S—SRD is removed from connection with the contacts of the relay LR1 at the lower contact of switch (*j*) and the receiving distributor S—SD is removed from the apex of the line BL at the lower contact of switch (*i*). At the same time the circuit from the transmitting relay 52 at the branch station is completed over the line BL and repeated by the relay LR1 over the conductor 53, tongue and lower contact of switch (*c*), tongue and upper contact of switch (*k*) and conductor 131 to one terminal of the winding 132 of a polarized receiving relay 133, the circuit being continued through the conductor 134, to the upper contact and tongue of switch (*l*) to the potentiometer 135. Signals received from the branch station over the above circuit are repeated by the relay 133 to the receiving simplex printer 136.

Simultaneously therewith, signals may be transmitted from the simplex transmitter 137 at the main station, to the receiving simplex 50 at the branch station. The signals originating at the transmitter 137 are repeated by the polarized relay 138, the tongue of which is connected by a conductor 139 through the upper contact and tongue of switch (*i*), conductor 46, contact 47, and tongue 123 to the apex of the branch line BL. The spacing contact S of relay 138 is connected by a conductor 141 to positive line battery through the tongue and upper contact of switch (*o*) and the marking contact (*m*) of the relay 138 is connected by conductor 142 to negative line battery through the tongue and upper contact of switch (*p*).

If it is desired to communicate from the multiplex terminal to the opposite terminal of the multiplex line over the simplex apparatus 136 and 137, the tongues of the switch group (*a*) to (*h*) are moved to their upper contacts, the tongues of switch group (*i*) to (*p*) being retained against their lower contacts. In this position of the switch, the line BL is interrupted at the lower contact of switch (*a*) and the tongue of the relay LR1 is disconnected at the contacts of switch (*c*). At the same time the circuit from the start-stop distributor S—SD is continued from the conductor 23 through the tongue and upper contact of switch (*a*) and conductor 131 to the winding of relay 133 and thence by conductor 134 to the upper contact and tongue of switch (*b*) to ground. Signals received over channel A of the multiplex circuit are, therefore, repeated directly to the receiving simplex machine 136.

Signals originating at the transmitting apparatus 137 are repeated from the tongue of the relay 138 over conductor 139, wire 143, tongue and upper contact of switch (*d*) thence by the lower contact and tongue of switch (*j*) and conductor 54 to the solid ring 55 and the start-stop receiving distributor S—SRD from which the signals are repeated to the storage transmitter and thence to the transmitting multiplex distributor.

While the switches (*a*) to (*p*) are set for transmission between the main terminals of the multiplex circuit, the circuit for the stop warning signal lamp 121 associated with the storage transmitter is prepared through the tongue and upper contact of switch (*f*), to positive battery. Consequently, if the storage transmitter reaches the limit of its storage capacity so as to close the switch 118, the lamp 121 will be illuminated to warn the transmitting operator of this condition. The resistance of this circuit is made considerably less at this time than when the transmission is taking place from the branch station at which time, it will be recalled, the circuit for the lamp 121 was prepared through the tongue and lower contact of switch (*f*), lower contact and tongue of switch (*n*) and relay 48 to positive battery through the resistance 122. By

decreasing the resistance in the lamp circuit when transmission is taking place from the main station, the lamp is caused to glow more brilliantly, thus providing a more positive signal for the operator.

In order that the operator at the branch station will not attempt to transmit when the switches are set for transmission from the main station, the warning signal 127 at the branch office is operated by reducing the line current in the manner previously described. In this last case, however, the circuit for the magnet 48 is completed from ground through the upper contact and tongue of switch (*e*) and lower contact and tongue of switch (*n*).

It will be noted, therefore, when the apparatus is set for transmission between the main stations, that the circuit from the branch station is interrupted and a signal operated at the branch station to warn the operator of the condition so that he will not transmit messages to the wind.

Should the operator at the branch station desire to call the operator at the main station at any time he may do so through the automatic calling key 144. This key is connected in series with the sending keyboard 51 of the simplex printer. The particular type of key used is not important to the present invention but preferably is of the type adapted to transmit signals for operating a Gill selector at the main station. Ordinarily, such keys comprise a pair of make and break contacts operated by a toothed wheel driven through a gear train by means of a spring which is wound by turning the key in one direction to the extent of its movement. As the key moves in the opposite direction, upon release, the contacts are operated to cause a particular series of code impulses to be impressed on the line.

At the main station a leak path is taken from the tongue of the line relay LR1 over a conductor 145, resistance 146, winding 147 of a relay 148, and potentiometer 149, to ground or to battery. The relay, through its tongue 151, repeats the signals through the manual switch 152, to the magnet 153 of a Gill selector. The Gill selector may be of the type shown in Gill Patent 1,004,566 granted October 3, 1911. It operates when the predetermined code signal has been received by it, to close its contact 154 and complete a circuit to signal lamp 155 through the locking winding 156 of relay 148. The lamp circuit remains energized until the attendant answers a call by opening the manual switch 152 whereupon the contact 154 of the Gill selector opens, interrupting the light circuit.

It is to be understood that the main station at the opposite end of the line L may also be similarly equipped with the extended channel and switching apparatus described, in which case it is possible, by proper positioning of the switch groups (*a*) to (*p*) to provide two-way communication directly between the branch offices associated with each main office; between either branch office and either main office and directly between the main offices.

Obviously suitable switching arrangements may also be provided at the main office whereby any branch line terminating at the office may be connected either automatically or manually through one channel of the multiplex system, thus providing an efficient exchange system whereby connections may be made between any branch offices associated with one main office and any branch offices associated with the other main office. It is also obvious that similarly extended channel apparatus may be provided for each channel of the multiplex system, thereby enabling the single multiplex line to be used for making a plurality of through connections between branch offices or subscribers' stations.

Referring now to Figure 3, we show a complete subscribers' exchange system in which each of two main or central telegraph offices M1 and M2 have a number of branch offices associated therewith. Branch offices or subscribers' stations X1 and X2 are shown connected to the main station M1 over the branch lines BL1 and BL2 respectively, and stations Y1 and Y2 are connected to central office M2 over the branch lines BL3 and BL4. As shown, station X1 is connected through channel A of the multiplex circuit directly to station Y1, and station X2 is connected to station Y2 over channel B. Channel C is operated in the usual manner through multiplex transmitting apparatus 160 and multiplex receiving printers 161. It is to be understood that the apparatus at each of the main stations associated with channel A for instance, is as shown in Figures 1 and 2, the circuit being simplified in Figure 3 for convenience of illustration.

It will be noted that the main line L and each of the branch lines BL1 and BL4 are duplexed so that communication may be had simultaneously in both directions between the connected branch stations or between the main stations. The circuit between stations X1 and Y1 will be traced. Signals originating at the simplex transmitter T at station X1 take the course shown by the plain arrows, and signals originating at station Y1 take the course indicated by the feathered arrows. Starting from station X1 these signals go out over the branch line BL1 to the windings of receiving relay LR3, from the tongue of which they are repeated through the sleeve contact and sleeve of the jack J1, thence by conductor 162 to the start-stop receiving distributor 163 and storage transmitter 164, to the A channel segments of the sending distributor SD1 and thence by con-

ductor 165 to the apex of the line relay LR1 and to the line L. The signals are repeated from the tongue of the line relay LR2 through the A channel segments of the receiving distributor RD2, start-stop distributor 166, tip contact and tip of the jack J3, to the apex of the line relay LR4, thence by the branch line BL3 to the line relay LR5 at station Y1. The signals are repeated by this latter relay directly to the receiving simplex printer P3. Simultaneously, signals originating at the transmitter T3 at station Y1 may be transmitted over a similar path to station X1 as shown by the feathered arrows.

It is obvious, of course, by changing the connections at jacks J1 to J4, that stations X1 or X2 may be connected with either of stations Y1 or Y2 or with any other station associated with the main offices. It will be noted therefore that a plurality of branch or subscriber circuits may be completed through the multiplex line L by employing the various channels of the multiplex system.

Many modifications and variations of the present system will occur to those skilled in the art without departing from the essential attributes of the invention and, therefore, we do not desire to be limited to the particular embodiment shown and described except as required by the limitations of the appended claims.

What we claim is:

1. In a telegraph system, a multiplex system terminating at a main station, a simplex system also terminating at said main station, means for transmitting corresponding marking and spacing conditions over said simplex system when marking and spacing conditions are received over said multiplex system, and means for applying marking conditions only to the simplex system when spacing conditions only are received over the multiplex system.

2. In a telegraph system, a multiplex system terminating at a main station, a simplex system extending from said main station to a distant station, a start-stop distributor at the main station for repeating marking and spacing signal conditions over the simplex system as marking and spacing signal conditions are received over one channel of the multiplex system, said distributor also serving to supply marking conditions only to the simplex system when said multiplex channel is idle and thereby transmitting spacing conditions only.

3. In a telegraph system, a multiplex system terminating at a main station, a simplex system extending from said main station to a distant station, a start-stop distributor at the main station for repeating signals received over one channel of the multiplex system, to the simplex system, a start magnet for said distributor, a relay for preparing a circuit to said magnet in response to the first marking impulse of a code combination received over said multiplex channel, a locking circuit completed upon operation of the relay to lock the same during the reception of the remainder of the code combination, means for starting the distributor at the completion of the reception of said code combinations and means for interrupting the locking circuit before the reception of the succeeding code combination over said multiplex channel.

4. In a telegraph system, a multiplex system terminating at a main station, a simplex system extending from said main station to a distant station, a start-stop distributor at the main station for repeating signals received over one channel of the multiplex system, to the simplex system, a start magnet for said distributor, a relay for preparing a circuit to said magnet in response to the first marking impulse of a code combination received over said multiplex channel, a locking circuit including said distributor completed upon operation of the relay for locking the same during the reception of the remainder of the code combination, means for starting the distributor at the completion of the reception of said code combination, said distributor upon operating serving to interrupt said locking circuit.

5. In a telegraph system, a multiplex system terminating at a main station, a simplex system extending from said main station to a distant station, start-stop recording apparatus at said main and distant stations and means for selectively repeating signals received over one channel of said multiplex system to the recording apparatus at the main station or over said simplex circuit to the recording apparatus at the distant station, and means for preventing the operation of said start-stop recording apparatus when said multiplex channel is idle.

6. In a telegraph system, a multiplex system terminating at a main station, a simplex system extending from said main station to a distant station, means for transmitting signals at one rate over the simplex system, means for repeating said signals at a different rate over the multiplex system, and means for interrupting the transmission over one system when said system gains a predetermined amount over the other system.

7. In a telegraph system, a multiplex system terminating at a main station, a simplex system extending from said main station to a distant station, means for transmitting signals at one rate over said simplex system, means for repeating said signals at a different rate over said multiplex system, and means for interrupting the transmission over the multiplex system whenever said system gains a predetermined amount over the simplex system.

8. In a telegraph system, a multiplex system terminating at a main station, a simplex system extending from said main station to a distant station, means for transmitting signals over said simplex sysem, a storage device for storing said signals at the main station and repeating them at a different rate over the multiplex system and means for interrupting transmission from said storage device when the signals stored therein are reduced to a predetermined number.

9. In a telegraph system, a multiplex system terminating at a main station, a simplex system extending from said main station to a distant station, means for transmitting signals over said simplex system, a storage device for storing said signals at the main station and repeating them at a different rate over the multiplex system, and means for indicating to the distant station when the signals in the storage device exceed a predetermined number.

10. In a telegraph system, a multiplex system terminating at a main station, a simplex system extending from said main station to a distant station, means for transmitting signals over said simplex system, a storage device for storing said signals at the main station and repeating them at a different rate over the multiplex system, and means for indicating to the distant station, without interrupting the transmission of signals over said system, when the signals in the storage device exceed a predetermined number.

11. In a telegraph system, a multiplex system terminating at a main station, a simplex system extending from said main station to a distant station, means for transmitting signals over said simplex system, a storing device for storing said signals at the main station and repeating them at a different rate over the multiplex system, means for reducing the signal current over the simplex system when the signals in said storage device exceed a predetermined number and an indicator at the distant station responsive to said reduction in current.

12. In a telegraph system, a multiplex system terminating at a main station, a simplex system extending from said main station to a distant station, said simplex circuit being duplexed, a storage device at the main station for storing signals received over the simplex system and repeating them to the multiplex system at a different rate, means for reducing the signal current over said duplexed circuit without disturbing the balance thereof when the number of characters in the storage device exceeds a predetermined number and an indicator at the distant station responsive to said reduction in line current.

13. In a telegraph system, a multiplex system terminating at a main station, a simplex system extending from said main station to a distant station, means for transmitting signals over said simplex system, a storage device for storing said signals at the main station and repeating them at a different rate over the multiplex system, means for interrupting transmission from said storage device when the signals stored therein are reduced to a predetermined number, and means for applying steady potential of spacing character to the multiplex system when transmission from said storage device is interrupted.

14. In a telegraph system, a multiplex system terminating at a main station, a simplex system extending from said main station to a distant station, start-stop recording mechanism at the main station, means for transmitting signals from said distant station to the main station over the simplex system independently of control by said multiplex system and selective means for recording said signals on said start-stop recording mechanism at the main station or repeating the signals over the multiplex system.

15. In a telegraph system, a multiplex system terminating at a main station, a simplex system extending from said main station to a distant station, start-stop receiving and transmitting apparatus at said main station and means for enabling said apparatus to be employed for receiving and transmitting signals over the multiplex system or over said simplex system.

16. In a telegraph system, a multiplex system terminating at a main station, a simplex system including a single circuit extending from the main station to a distant station, and means for simultaneously transmitting signals in both directions over said circuit between said multiplex and simplex systems.

17. In a telegraph system, a plurality of main stations, a branch station associated with each main station, multiplex circuits extending between said main stations, a single simplex circuit extending between each branch station and its associated main station, and means for establishing two-way through transmission of signals between said branch stations, partially over said single simplex circuits and partially over one channel of said multiplex circuit.

18. In a telegraph system, a plurality of main stations, a branch station associated with each main station, multiplex circuits extending between said main stations, a simplex circuit extending between each branch station and its associated main station, and switch means permitting the reception and transmission of signals, by means of start-stop recording and transmitting apparatus, directly between said branch stations, between each branch station and either main station or between said main stations.

19. In a telegraph system, a plurality of main stations, a branch station associated with each main station, multiplex circuits ex-

tending between said main stations, a single simplex circuit extending between each branch station and its associated main station, and means for establishing through two-way transmission of signals between any of said branch stations associated with one main station and any branch station associated with the other main station.

In testimony whereof, we affix our signatures.

KARL B. DUERR.

HARMON E. BROYLES.