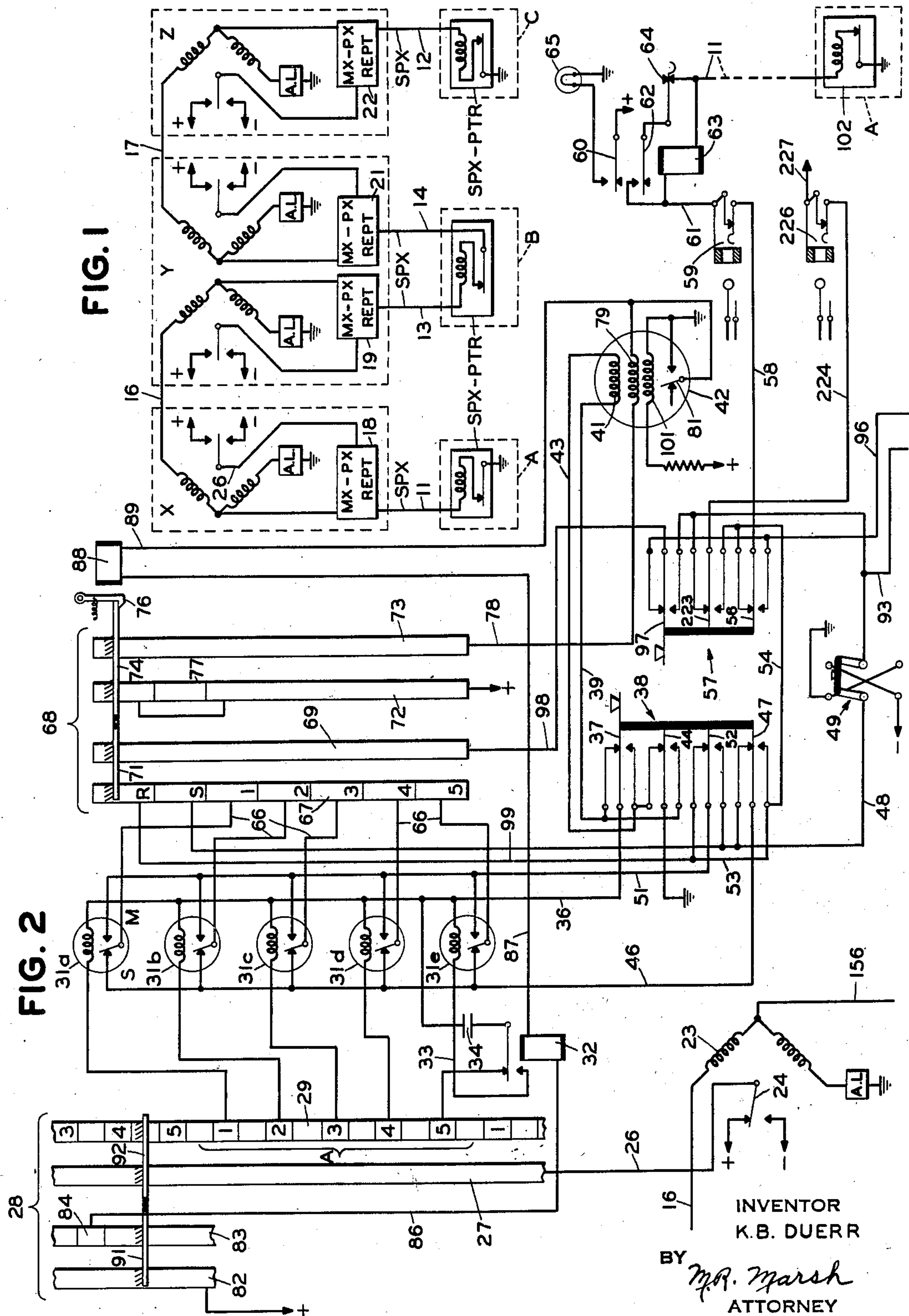


2,199,284

2 Sheets-Sheet 1



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K. B. DUERR

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MULTIPLEX-SIMPLEX EXTENDED CHANNEL SYSTEM

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2 Sheets-Sheet 2

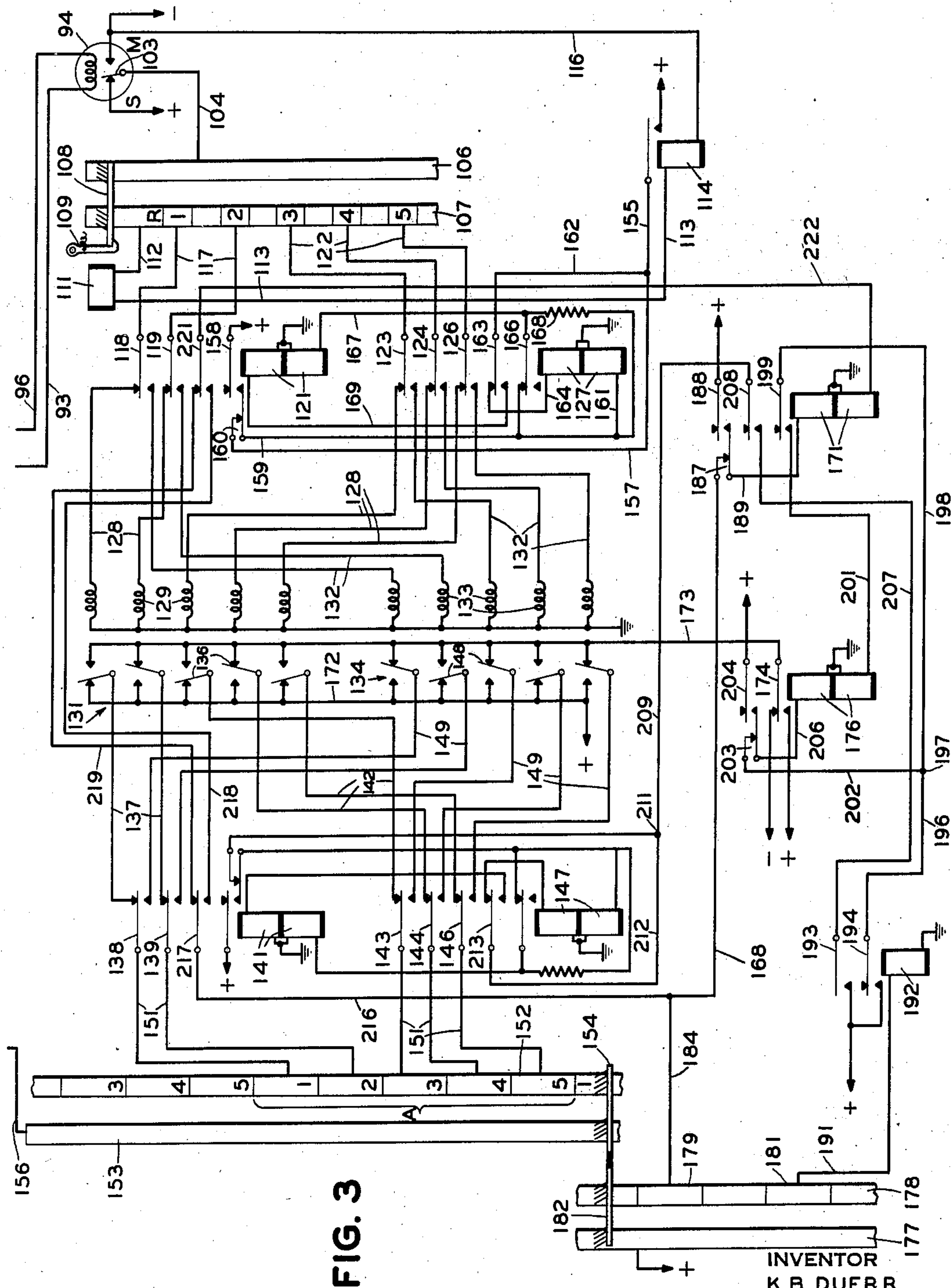


FIG. 3

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MULTIPLEX-SIMPLEX EXTENDED CHANNEL SYSTEM

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6 Claims. (Cl. 178—2)

This invention relates primarily to multiplex extended channel systems and more particularly to means whereby one or more channels of a multiplex circuit extending to or continuing from a start-stop or simplex operated telegraph system may be further extended to or continued from one or more other channels of another multiplex circuit extending to or continuing from other start-stop or simplex operated telegraph systems.

Oftentimes in telegraph practise it is very desirable to be able to interconnect a plurality of telegraph branch offices or subscribers stations, hereinafter considered to be the equivalent of a branch office, in series with one another or by what is known in the art as being connected in a "way wire" circuit. As is well known, in a "way wire" circuit the stations or branch offices associated therewith are connected in series and each branch office is able to communicate with each of the others, the signals transmitted from any one of the branch offices being received at every one of the others. Because the volume of business from or to a branch office is somewhat limited and is usually not sufficient to warrant the establishment of a direct multiplex circuit, the branch offices are usually connected with associated central or main offices by start-stop or simplex operated equipment. The branch offices desired to be connected in a "way wire" circuit are likely to be associated with different central offices, such as for example, where a single subscriber may have a plurality of remotely disposed plants and/or offices and desire that each be able to communicate directly with each of the others and have all the communications recorded at each station. Where the branch offices desired to be connected in a "way wire" circuit are associated with only two main offices, it is entirely feasible and practical to connect all the branch offices associated with each main office in series by a simplex operated circuit and directly connect the two simplex operated circuits, one with the other, by extending or continuing a channel of a multiplex circuit extending between the two main offices. The channel of a multiplex circuit may well be employed between the main offices, since only a part of the line time of a circuit is required, whereas if the main offices were connected by a simplex operated circuit, the whole line time of the circuit would be occupied. Where it was desired to connect branch offices associated with more than two main offices, retransmission of the messages at one or more of the main offices was required or a simplex circuit had to be employed throughout the whole circuit. Obviously,

the first method had the disadvantage of poor economy while the second method did not make as efficient use of circuits between main offices as would be possible if such circuits employed a channel of a multiplex.

It is therefore one of the main objects of this invention to provide a means whereby predetermined sections of a "way wire" circuit may be operated in conjunction with multiplex equipment and other sections of the circuit may be operated in conjunction with simplex equipment.

More specifically, it is an object of this invention to provide a multiplex extended channel system with simplex operated "drop" facilities at various points throughout the multiplex channel.

These and various other objects and advantages of the invention will be apparent as the detailed description of the invention proceeds, taken in conjunction with the accompanying drawings in which:

Fig. 1 schematically illustrates the arrangement and main circuits for three branch offices and three main offices connected and operating in accordance with the invention;

Fig. 2 is a diagram illustrating the circuit arrangement of the receiving section of a repeater located at one of the main offices; and

Fig. 3 is a diagram illustrating the circuit arrangement of the sending section of a repeater located at one of the main offices.

Referring first to Fig. 1, the operation of the invention will hereinafter be described as embodying three branch offices or subscribers stations A, B and C, associated with three different main or central offices X, Y and Z respectively. It should be kept in mind, however, and will be more apparent as the description proceeds, that the invention is not by any means limited to the interconnecting of but three branch and three main offices, as the number could be greatly increased, the description of the operation of three being thought sufficient to properly disclose the invention. The only limiting factor as to the number of branch offices capable of being interconnected in accordance with this invention and still function properly is determined by the volume of business likely to be handled between the stations. The branch offices A and C are shown for the purpose of illustration connected to their associated main offices X and Z, respectively, by simplex operated tie lines 11 and 12, respectively. The branch office B is shown connected to its associated main office Y by a loop circuit comprising the two simplex operated circuits 13 and 14. Main office Y is shown connected to the main

offices X and Z by channels of multiplex circuits 16 and 17, respectively. As the signals transmitted from and to the branch offices A, B and C are of the start-stop or simplex variety and the signals transmitted between the main offices are of the multiplex variety, it is necessary to employ means for converting each type of signals to the other. To accomplish this, what is known in the art as multiplex-simplex channel repeaters are employed, designated in Fig. 1 as MX-PX REPT. One repeater 18 is employed at main office X, two repeaters 19 and 21 are provided at main office Y and one repeater 22 is used at main office Z. The necessity of employing two repeaters at main office Y will be apparent hereinafter. These repeaters, although somewhat similar in operation and function to others such as those disclosed in a patent to Noxon No. 2,014,908, dated September 17, 1935, have certain new and distinct features which will be apparent in the following description thereof. The detailed operation of one of these repeaters, such as the one 18 at main office X will now be given. The other repeaters 19, 21 and 22 operate in exactly the same manner as the one to be described, with the exceptions hereinafter pointed out.

Referring now to Fig. 2, which shows primarily the receiving part of the repeater at main office X, the multiplex line 16 is connected to a line relay 23, which is shown duplexed. The marking and spacing contacts of the line relay 23 are connected respectively to negative and to positive battery, and the tongue 24 of the relay is connected by a conductor 26 to the solid ring 27 of a receiving multiplex distributor, indicated in general at 28.

The multiplex distributor 28 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 being considered as the channel utilized for messages to be extended directly to the branch office A, or to be received therefrom. The other channels of the multiplex may be operated in connection with regular multiplex equipment or with other extended channel equipment, as desired.

The segmented receiving ring 29 of the distributor 28 has the segments thereof arranged in groups of five each, the number of groups depending on the number of channels in the multiplex circuit and being equal thereto. Only the complete group of segments of the A channel are shown and the first four of these segments are connected individually to one terminal of the windings of the first four relays 31a to 31d of a series of five polarized relays 31a to 31e. The fifth segment of the A channel is connected to the break contact of an overlap relay 32. The make contact of the relay 32 is connected by a conductor 33 to a terminal of the winding of the polarized relay 31e. The tongue of the overlap relay 32 is connected through a condenser 34 to a conductor 36. The conductor 36 connects the opposite terminals of the windings of the relays 31a to 31e and one side of the condenser to a tongue 37 of a manually operable switch, indicated in general by reference numeral 38. The tongues of the switch 38 will be considered to be in contact with their upper stops and therefore the circuit from conductor 36 continues through the tongue 37 and upper stop, over a conductor 39, through an operating winding 41 of a polarized, so called, cut-off relay 42, over a conductor

43, through the upper stop and tongue 44 of switch 38 to ground.

The spacing contacts S of each of the polar relays 31a to 31e are connected by a conductor 46 through the tongue 47 and upper stop of switch 38, over a conductor 48 and thence to the middle left hand contact of a reversing switch 49. The handle of the reversing switch 49 is normally closed on its upper contacts and therefore the spacing contacts of the relays 31a to 31e are normally connected to ground at the switch 49. The marking contacts M of the relays 31a to 31e are connected, over a conductor 51, through the tongue 52 and upper stop of switch 38, over conductors 53 and 54, through the upper stop and tongue 56 of a manually operable switch, indicated in general by reference numeral 57, the tongues of which are normally engaged with their upper stops, thence over a conductor 58, through a jack 59, over a conductor 61, through the winding of a relay 63, and thence to a branch office tie line, such as the tie line 11 of branch office A. The relay 63 is normally in its operated condition, as hereinafter described, and therefore maintains a possible shunt circuit, comprising the tongue 62 of the relay and a normally closed key 64, in an open condition. Where the branch office, such as A, Fig. 1, is at the end of the way wire circuit and is the only branch office associated with the main office, the tie line such as 11 usually extends through the simplex printer thereat and to the ground. The arrangement of the tie line at a branch office such as B will be hereinafter pointed out.

The tongues of the relays 31a to 31e, Fig. 2, are connected by individual conductors, such as 66, to segments numbered 1 to 5 of a segmented ring 67 of a start-stop distributor of the type well known in the art and indicated in general by reference numeral 68. The segmented ring 67 is also provided with a rest segment R and a start segment S. A solid ring 69 is associated with the segmented ring 67 and both are adapted to be traversed by a brush 71. The start-stop distributor 68 has two other rings 72 and 73 traversed by a brush 74. Both brushes 71 and 74 are adapted to rotate together and are normally held at rest by means of a latch 76, with the brush 71 on the rest segment R. The ring 72 has a dead or open segment 77 corresponding to the start segment S of ring 67. The rest of the ring 72 is connected to positive potential and the co-operating ring 73 is connected by a conductor 78 through a winding 79 of the relay 42 and thence to the tongue 81 thereof.

The multiplex receiving distributor has in addition to the heretofore mentioned receiving rings 27 and 29, two local rings 82 and 83, the former of which is connected to positive potential. The ring 83 has a segment 84 which is connected by a conductor 86 through the coil of the overlap relay 32, over a conductor 87, through the windings of the start-stop distributor start magnet 88 and thence over a conductor 89 to the tongue of the cut-off relay 42. The local rings 82 and 83 and the receiving rings 27 and 29 are traversed by brushes 91 and 92, respectively, rotating together. The brushes 91 and 92 rotate continuously and are kept in synchronism with incoming line signals by means well known in the art.

When the A channel of the multiplex is idle or no permutation signals are being received thereover, spacing battery only is received over this channel which, in this case, holds the tongue 24 of the line relay 23 on its positive or spacing

contact. Therefore, during such conditions as the brush 92 traverses segments 1 to 5 of the ring 29 associated with the A channel, spacing battery is applied through the winding of the relays 31a to 31d and over the circuit hereinbefore described through the winding 41 of the cut-off relay 42 to ground. Spacing battery flowing from left to right through the operating winding 41 of the relay 42 holds the tongue 81 thereof to the left. As described, the winding of the relay 31e is not connected directly to the fifth segment of ring 29 and the manner in which the fifth impulse of a code group is transferred from the fifth segment to relay 31e will now be described. As the brush 92 contacts the fifth segment of the ring 29, the condenser 34 is charged with a polarity corresponding to the polarity of the ring 27 at this time. When the overlap relay 32 is energized by means hereinafter described, the tongue thereof makes contact with its make-stop and allows the condenser 34 to discharge through the coil of relay 31e and operating it in accordance with the charge on the condenser. The effect of over-lap relay 32 is to cause the transfer from the fifth segment to the coil of the relay 31e to occur an appreciable length of time after the brush 92 contacts this segment.

The operation of the cut-off relay 42 will now be described first in connection with a code of signals comprising only spacing impulses and then in connection with a code group comprising both spacing and marking impulses. When spacing impulses are received over conductor 39 at the winding 41 of the cut-off relay 42, the tongue 81 remains on its left hand insulated spacing contact. Therefore, when the brush 91 subsequently contacts the segment 84 of the local ring 83, the over-lap relay 32 and the start magnet 88 will not be energized as the circuits there- to are open at the tongue 81 of the cut-off relay. When a marking impulse is received on the solid ring 27, as one of the impulses of a code group, it is continued by the brush 92, as described, through the winding 41 of the cut-off relay 42. This impulse being negative causes the tongue 81 to move to its marking or right hand contact. Thereupon a locking circuit is established from positive battery at the local ring 72 of the start-stop distributor 68, through brush 74 and ring 73, over conductor 78, through the coil 79 of the relay 42 and thence through the tongue 81 thereof to ground, and as this locking circuit is more effective than any subsequent spacing impulses that may happen to be received on the winding 41 from the ring 29 of the multiplex, the tongue will remain for the time being on its marking contact. Now when the local brush 91 contacts segment 84, a circuit will be completed through the over-lap relay 32 and start magnet 88 to ground, causing them to be energized. The over-lap relay 32 being energized causes the relay 31e to be operated in accordance with its respective signal impulse and the energization of the start magnet 88 causes the release of the brushes 71 and 74 of the start-stop distributor 68. If only the fifth impulse of a code group happened to be marking, the charge of the condenser would be sufficient to cause the winding 41 of the relay 42 to operate the tongue 81 thereof to its marking contact which renders the start magnet 88 and over-lap relay 32 operative as heretofore described.

When the brush 71 of the start-stop distributor is on the rest segment R of the ring 67, a rest impulse is transmitted over the associated branch

office tie line such as 11. As in general practice for start-stop equipment this rest impulse is a closed line condition or one during which current is transmitted. The circuit for this rest impulse is from negative potential at the reversing switch 49 over a conductor 93, through the winding of a neutral relay 94, Fig. 3, over a conductor 96, Fig. 2, through the upper stop and tongue 97 of switch 57, over a conductor 98, through the solid ring 69, over the brush 71, the rest segment R, a conductor 99, and conductors 53 and 54, through the upper stop and tongue 56 of switch 57 and thence by conductor 58, jack 59, conductor 61, through relay 63 and tie line 11 to branch office A, where the circuit is grounded. When the brush 71 passes off the rest segment R and is contacting the start segment S, a start impulse is transmitted. The start impulse is an interval during which no current is being transmitted or an open line condition and while the brush is on the start segment S, it will be noted from a study of the circuits that the line circuit will be open at this time, the closed line circuit heretofore described being opened at the start segment S. As the brush 71 successively contacts segments numbered 1 to 5 of the ring 67, the tongues of the relay 31a to 31e are successively connected to battery on the solid ring 69. It will be remembered that the spacing contacts S of the relays 31a to 31e are connected to ground at the reversing switch 49 and the marking contacts M are connected to the tongue 52 of switch 38 which in turn by means of its upper stop extends to the line 11. Therefore, impulses of current or no current will be transmitted to the line 11, depending on the position of the tongues of the relays 31a to 31e, as the brush 71 contacts segments numbered 1 to 5 of ring 67. It will be noted that during the whole revolution of the brush 71 a steady current is maintained through the line relay 94, Fig. 3, and therefore it will be held on its right or marking side.

While the brush 71 is on the start segment S, the brush 74 is on the dead segment 77 of ring 72. Therefore, during this time the locking circuit through the winding 79 of the cut-off relay 42 is opened which allows a small biasing current flowing through a winding 101 of the cut-off relay 42 to move the tongue 81 thereof to the left onto its insulated contact. The tongue 81 will remain on its left contact until moved to its right contact by a marking impulse flowing through the winding 41 in response to a marking impulse received over the multiplex channel, as hereinbefore described.

The start-stop distributor brushes 71 and 74 rotate at a slightly higher speed of rotation than the multiplex distributor brushes 91 and 92, and therefore are brought to rest after each revolution thereof ready to be released in conjunction with the impulse from the local segment 84 of the multiplex distributor as previously described.

Thus the multiplex signals received over a multiplex channel, such as 16, are converted into signals of the start-stop variety and are transmitted over a tie line, such as 11, to the branch office station A. Each of the other multiplex-simplex repeaters operate in substantially the same manner to repeat signals to their associated branch office.

The transmission of signals from one of the branch office stations, such as branch office A, will now be described. To transmit the signals from a branch office, which signals are of the

start-stop variety, over a multiplex channel, the start-stop signals must be converted into multiplex signals. This is accomplished by the sending part of a multiplex-simplex repeater and

5 comprises in general the receiving face plate of a start-stop distributor, two relay storing banks, a multiplex sending ring and a plurality of control and transfer relays. As well understood, transmitting by means of start-stop equipment

10 consists primarily of opening and closing the line circuit in a predetermined timed relationship for each character signal transmitted. In the arrangement, such as at branch office A, the line circuit is grounded at the branch office and has

15 potential applied thereto at the associated main office, and referring to Figs. 2 and 3, when no signals are being transmitted to or from the branch office, the above mentioned circuit is from ground at the branch office, through the simplex receiving-transmitting machine 102 thereat,

20 over the line 11, through the winding of relay 63, conductor 61, jack 59, conductor 58, the tongue 56 and upper stop of switch 57, conductors 54, 53 and 99, the rest segment R of ring 67, the brush 71 and the solid ring 69, conductor 98, the tongue 97 and upper stop of switch 57,

25 conductor 96, through the winding of the line relay 94 and thence over conductor 93 to battery at the reversing switch 49. This circuit holds the tongue 103 of the line relay 94 on its right hand or marking contact and when a signal is transmitted from a branch office the start impulse, which is an open line condition, allows the tongue of the relay 94 to move to its left

30 hand or spacing contact. The spacing and marking contacts of the line relay 94 are connected to positive and negative potential respectively. The tongue 103 is connected by a conductor 104 to the solid ring 106 of the receiving face plate of the start-stop distributor. Associated with the solid ring 106 is a segmented ring 107 comprising a rest segment R and five segments numbered 1 to 5 separated by dead segments. A brush 108 normally at rest on the rest segment successively bridges the segments with the solid ring

40 106 as it rotates and is normally held in its rest position by a latch 109 adapted to be operated by a start magnet 111. The rest segment R is connected by a conductor 112 through the winding of the start magnet 111, over a conductor 113,

50 through the winding of a so-called receiving sixth pulse relay 114 and thence by a conductor 116 to the marking contact of the line relay 94. The first and second of the numbered segments, 1 and 2 of the ring 107, are connected by individual

55 conductors 117 to the tongues 118 and 119, respectively, of a differentially wound receiving transfer relay 121, hereinafter referred to as the first receiving transfer relay. The third, fourth and fifth numbered segments of the ring 107 are connected by individual conductors 122 to the tongues 123, 124 and 126 respectively by a differentially wound receiving transfer relay 127, hereinafter referred to as the second receiving

60 transfer relay. The break contacts associated with the tongues 118, 119, 123, 124 and 126 of relays 121 and 127 are connected by individual conductors 128 to respective individual windings 129 of a first relay bank, indicated in general by reference numeral 131, and the make contacts are connected by individual conductors 132 to respective individual windings 133 of a second relay bank, indicated in general by reference numeral 134. The other ends of the windings

70 129 and 133 are grounded.

Individually associated with each of the coils 129 of the relay bank 131 and adapted to be operated in accordance with the polarity of the current flowing therethrough are a set of five

5 tongues 136. The first and second of these tongues 136, from the top, are connected by individual conductors 137 to the break contacts associated with the tongues 138 and 139 respectively of a differentially wound sending transfer relay 141. The third, fourth and fifth of the

10 tongues 136 are connected by individual conductors 142 to the break contacts associated with the tongues 143, 144 and 146 respectively of a second differentially wound sending transfer relay 147. The sending transfer relays 141 and

15 147 will be hereinafter referred to as the first and second sending transfer relays respectively. A set of five tongues 148 individually associated with the coils 133 of the second relay bank 134 are connected by individual conductors 149 to

20 the make contacts associated with the tongues 138, 139, 143, 144 and 146 of the first and second sending transfer relays 141 and 147, the tongues 138, 139, 143, 144 and 146 being connected by individual conductors 151 to segments numbered

25 1 to 5 of the segmented multiplex sending ring 152. Associated with the segmented ring 152 is the solid multiplex sending ring 153 and the segments are successively bridged to the solid ring by a brush 154, continuously traversing the

30 rings. The solid ring is connected by a conductor 156 to the apex of the line relay 23. Thus, as the brush 154 contacts the segments 1 to 5 of the ring 152, impulses corresponding to the potential on these segments at the time of contact will be transmitted to a channel of the

35 multiplex circuit, such as 16.

The detailed operation of the manner in which a character signal is transmitted from a simplex printer to a multiplex channel will now be described. Assume that the two receiving transfer

40 relays 121 and 127 are deenergized as shown and that the start impulse preceding a code combination to be transmitted from branch office A causes, by the circuit hereinbefore described, the tongue 103 of the line relay 94 to move to its spacing contact. This effects the energization of the start magnet and the receiving sixth pulse relay 114. The following variable impulses of this code combination, comprising open and

50 closed line conditions, cause the line relay 94 to operate in accordance therewith which in turn applies positive and negative potential to the solid ring 106, positive potential being applied for open line conditions and negative potential for closed line conditions. The energization of the start magnet 111 causes the release of the brush 108 which rotates in synchronism with the signals received on the solid ring 106 from the line relay 94 so as to connect the segments numbered 1 to

60 5 of the segmented ring 107 with the solid ring during the reception of the variable impulses 1 to 5 respectively of the signal code combination. As the sixth pulse relay is energized battery at its make contact is connected through the tongue

65 over conductors 155 and 157, through the make-before-break contact 160, associated with the tongue 158 of the first receiving transfer relay 121, over conductors 159 and 161 and through the lower winding of the second receiving transfer relay 127 to ground. Battery is also connected from the tongue of the sixth pulse relay 114 over conductors 155 and 162, through the tongue

70 163 and break contact of relay 127 and thence over a conductor 164 through the upper winding of

75

relay 127 to ground, thus neutralizing the effect of the current in the lower winding so that the relay 127 will remain unoperated. A third circuit is completed from the tongue of the sixth pulse relay 114 over conductors 155, 157, contact 160, conductor 159, through the break contact and tongue 166 of relay 127 and thence over a conductor 167, through the lower winding of the first receiving transfer relay 121 to ground. This causes the operation of relay 121 which locks itself up by a circuit from battery at the tongue 158 thereof, through the lower terminal of contact 160 and thence over the last described circuit through the lower winding of the relay 121 to ground. As the tongue 158 of the relay 121 operates to open the make-before-break contact 160, battery from the tongue and make contact of the sixth pulse relay 114 is removed from the lower winding of the transfer relay 127 and replaced by battery from the tongue 158 of relay 121. Thus the circuits from segments 1 and 2 of ring 107 to the first two coils 129 of relay bank 131 are transferred to the first two coils 133 of relay bank 134. Now when the brush 108 passes off the rest segment R, the circuit to the sixth pulse relay 114 and the start magnet 111 will be opened causing them to return to their unoperated positions. The start magnet 111 being deenergized allows the latch 109 to return to its normal position in the path of the brush 108 and will stop the same after the current revolution thereof. The deenergization of the sixth pulse relay 114 opens the second described circuit from battery at the make contact thereof through the upper winding of the transfer relay 127, however, the circuit from the tongue 158 of relay 121 is maintained through the lower winding of relay 127 and this circuit will thereupon cause this relay to operate. As relay 127 operates it remains locked up as long as relay 121 remains operated by the above described locking circuit through its lower winding. The locking circuit for relay 121, with relay 127 operated, is maintained through a resistance 168 shunted around the break contact and tongue 166 of relay 127. Also, as relay 127 operates the individual circuits from the third, fourth and fifth segments of ring 107 to the third, fourth and fifth coils 129 of the relay bank 131 are transferred to the third, fourth and fifth coils 133 of the relay bank 134. Thus for the described energization and deenergization of the sixth pulse relay 114 the individual circuits from the five numbered segments 1 to 5 of the ring 107 are transferred from respective coils of relay bank 131 to respective coils of relay bank 134, and as the brush 108 successively contacts these segments the tongues 148 of this bank 134 will be operated in accordance with the operation of the tongue of the line relay 94. As described above, the line relay 94 transforms the make and break signals received from a branch office into positive and negative combinations and applies them to the solid ring 106, and the brush 108 rotating in synchronism with these signals distributes them to their proper segments. The tongues 148 of relay bank 134 will therefore be successively operated in accordance with the signal transmitted from the branch office, moving to their left hand and right hand contacts in response to positive and negative potential respectively through their associated coils 133. As the rest impulse is a closed line condition, the line relay 94 will be operated to its marking contact during the reception of this impulse. Now when the brush

108 completes its revolution, the circuit to the start magnet 111 will be open and the brush 108 stopped in its normal rest position.

The manner in which the circuits from the numbered segments of ring 107 are transferred back to the coils 129 of relay bank 131 will now be described in connection with the next received character code group. The start impulse of the following group which may occur immediately or after a prolonged rest period, causes the release of the brush 108 and the energization of the sixth pulse relay 114 in exactly the same manner as previously described in conjunction with the preceding group. It should be kept in mind, however, that the receiving transfer relays 121 and 127 are at this time operated and locked in their operated positions by current through their lower windings. Now as the sixth pulse relay 114 is operated, battery is applied through its make contact and tongue over conductors 155 and 162, through the tongue 163 and make stop of relay 127 and thence over a conductor 169 through the upper winding of relay 121 to ground. This circuit neutralizes the circuit in the lower winding and allows the relay 121 to return to its unoperated position. As tongue 158 of relay 121 returns to its unoperated position, it removes battery thereat from the circuit to the lower winding of relay 127 and substitutes therefor battery from the make contact and tongue of the sixth pulse relay 114 through the at this time closed make-before-break contact 160. Now when the sixth pulse relay 114 is subsequently deenergized, the circuit to the transfer relay 127 will be opened, allowing it to return to its unoperated position. Thus the circuits from the segments of the ring 107 are retransferred back to the associated coils 129 of relay bank 131 to their original assumed positions and from the above description it is evident that in a cycle of operation comprising two character signal codes and two revolutions of the brush 108, each of the two relay banks 131 and 134 are in turn connected to the segments of ring 107. This sequence of operation continues uninterruptedly during the entire period of operation or as long as signals are received on the line relay 94 alternately storing a signal in one relay bank and then in the other. It will be noted that in each complete transfer operation, the time of the transfer operation of the circuits from the first two segments of ring 107 precedes by a slight amount (i. e., the operating time of transfer relay 127 and the length of time relay 114 is operated) the time of the transfer operation of the circuits from the last three segments. The reason for this slight delay will be apparent hereinafter.

The manner in which the signals stored on the relay bank 131 and 134 are transmitted to the multiplex channel will now be described. This operation is accomplished by the two sending transfer relays 141 and 147 functioning in substantially the same manner as the two receiving transfer relays 121 and 127; however, these transfer operations are somewhat more involved due to the fact that the multiplex brush 154 is rotating continuously and that there is no direct phase relationship between the rotation of the multiplex brush and the signals transmitted from a branch office. This transmitting operation incorporates an auto-stop relay 171 which, as will presently appear, maintain the proper over-lap between the receiving start-stop distributor and the sending multiplex distributor.

Assume that the first character code combination from the branch office is stored in relay bank 134, as heretofore described, and that for the time being no other signals are to be received from said office. Therefore, in accordance with the above description the receiving transfer relays 121 and 127 will be locked up in their energized position. The relays of relay banks 131 and 134 are polarized and the tongues 136 and 148 thereof respectively remain as positioned by the last impulse through their respective coils 129 and 133, respectively. Thus the tongues of relay bank 134 will be set in accordance with the signals from the branch office. The left hand contacts of the tongues 136 and 148 of the relay banks 131 and 134 respectively are connected by a conductor 172 to positive potential and the right hand contacts are connected by a conductor 173 to a tongue 174 of a line battery relay 176. The make and break contacts associated with the tongue 174 are connected to positive and negative potential, respectively. The sending face plate of the multiplex comprises in addition to the two above mentioned main sending rings 152 and 153 two local sending rings 177 and 178. The ring 177 is solid and connected to positive potential while the ring 178 is segmented and has two local segments 179 and 181. A brush 182 rotating continuously with the brush 154 wipes over the multiplex face plate and traverses the local rings 177 and 178 while brush 154 contacts the main sending rings 152 and 153.

Let it be further assumed that the sending transfer relays 141 and 147, the line battery relay 176 and the auto-stop relay 171 are all in their unoperated or deenergized position and that some time after the first character code group is set up on relay bank 134, the multiplex sending brush 182 contacts the local segment 179. Thereupon a circuit is completed from battery at the solid ring 177, through the brush 182 and segment 179, over conductors 184 and 186, through the make-before-break contact 187, associated with a tongue 188 of the auto-stop relay 171, and thence over a conductor 189 through the upper winding of relay 171 to ground. This causes the relay 171 to operate which locks itself in an operated position by battery from the tongue 188 thereof through the lower half of contact 187, over conductor 189 and through the upper winding of the relay. Shortly thereafter the brush 182 contacts local segment 181, completing a circuit therefrom over a conductor 191 and through the winding of a sixth pulse sending relay 192 to ground, causing this relay to momentarily operate. The relay 192 has two tongues 193 and 194, the make contacts of which are connected to battery and as the tongue 194 operates, it connects battery over a conductor 196 to a point 197 where the current divides, half continuing from this point over a conductor 198, through the tongue 199 and make contact of relay 171, which is at this time energized, and thence over a conductor 201 through the lower winding of relay 176, the other half continuing from point 197 over a conductor 202, through a make-before-break contact 203 associated with a tongue 204 of relay 176 and thence over a conductor 206 through the upper winding of relay 176. As the upper and lower winding of relay 176 are opposed to one another, the relay will not operate.

As the tongue 193 of relay 192 operates, it connects battery therethrough over a conductor 207, through the make contact and tongue 208 of relay 171 and over a conductor 209 to a point 211.

Here the current divides and causes the sending transfer relays 141 and 147 to operate and lock themselves in an operated position in exactly the same manner as the receiving transfer relays 121 and 127 were operated and locked in an operated position by an impulse from the receiving sixth pulse relay 114 as hereinbefore described and a description of the detailed operation and locking of these relays 141 and 147 is thought to be superfluous herein.

As the relays 141 and 147 operate, the tongues 148 of the relay bank 134 are connected to associated segments of the ring 152 by the circuits hereinbefore described and some time thereafter the main sending brush 154 successively connects these segments to the solid ring 153. The code signals thereupon are transmitted over conductor 156 and through the multiplex line relay 23 to the multiplex circuit 16. Thus the first character signal from a branch office is transmitted to the multiplex channel.

Now let it be assumed that the second character code signal was received by the start-stop receiving distributor and set up on the relay bank 131 and the brush 108 brought to rest for the time being as hereinbefore described during the transmitting of the first signal by the multiplex sending distributor, or any time before the brush 182 again contacted the local segment 179. For this condition the receiving transfer relays 121 and 127 will be deenergized and as it is assumed that the multiplex brushes 182 and 183 have completed but one revolution, the auto-stop relay 171 will still be energized. Therefore, when the brush 182 contacts local segment 179 the second time the conditions of none of the relays change as the circuits from this segment are open. However, as the brush 182 subsequently contacts local segment 181, the sixth pulse sending relay 192 is momentarily energized and applies potential to each of the tongues 193 and 194 thereof. The line battery relay 176 will not be energized by the movement of the tongue 194 as current will flow through both of the windings of the relay 176. As the tongue 193 operates, battery is applied therethrough over conductor 207, through the make contact and tongue 208 of the auto-stop relay 171 and over conductors 209 and 212 to the tongue 213 of relay 147. This impulse causes the sending transfer relays 141 and 147 to be returned to their unoperated positions in exactly the same manner as the second described impulse from the receiving sixth pulse relay 114 caused the receiving transfer relays 121 and 127 to be returned to their unoperated positions, and as the relays 141 and 147 return to normal, the tongues 136 of relay bank 131 are connected by the described circuits to the A channel segments of ring 152. Now when the multiplex sending brush 154 again contacts the A channel segments of ring 152, the character signal stored in relay bank 131 will be transmitted to the multiplex circuit. This sequence of transfer operations of the sending and receiving transfer relays 141 and 147, and 121 and 127 would continue indefinitely, alternately transmitting from one relay bank while the other was in the process of being set up, if the signal groups were received at a uniform rate and the multiplex brushes rotated in synchronism therewith. This condition would give a very satisfactory overlap, i. e., the angular lead of the brush 108 of the receiving start-stop distributor with respect to the brushes 182 and 154 of the multiplex sending distributor. However, this is not the

case as the start-stop signal groups are received at a non-uniform rate and the multiplex brushes rotate continuously at a speed slightly in excess of the possible maximum speed of transmission of the start-stop equipment. Therefore, when the start-stop signals are received at the normal rate and up to the maximum rate the over-lap is gradually reduced until both distributors are connected to the same relay bank, 131 or 134, during a large part of the time. During this condition the start-stop receiving brush 108 might be in the course of setting up a signal in the fifth coil of a relay bank such as 131 while the multiplex brush 154 was transmitting an impulse representative of the setting of the third tongue of the same relay bank. Obviously, a closer approach than this of the sending brush 154 to the receiving brush 108 or the decrease of the over-lap to this extent would be disastrous since an attempt would eventually be made to send a pulse from a tongue of a relay bank which had not yet operated or had time to settle on its contact. Therefore, when the overlap decreases to a predetermined minimum, a condition is set up which automatically restores the overlap to a maximum. This is accomplished by preventing the sending transfer relays 141 and 147 from performing their normal transfer operation on the following revolution of the multiplex brush while the receiving distributor proceeds to set up the next character signal on the other relay bank. During this revolution of the multiplex brushes an all spacing signal is sent to the A channel of the multiplex from the relay bank from which the previous signal had been transmitted. On the succeeding revolution of the multiplex brushes following the transmission of the all spacing signal, the sending transfer relays 141 and 147 operate and connect the multiplex segments with the relay bank and transmit the signal therein which was set up by the start-stop receiving distributor during the transmission of the all spacing signal by the multiplex, the receiving distributor at the time setting up a signal in the other relay bank. Thus the overlap is restored to a maximum and transmission proceeds in a normal manner until the brushes of the multiplex sending distributor have again nearly caught up with those of the start-stop receiving distributor, or reduced the overlap to the minimum at which time the process is repeated.

During normal operation of the repeater one relay bank such as 131 is being set up while transmission is taking place from the other 134, or vice versa. Therefore, while the sending transfer relays 141 and 147 are operated and unoperated the receiving transfer relays 121 and 127 will normally be unoperated and operated respectively. Also, as pointed out above the auto-stop relay 171 is normally maintained locked in its energized position and the line battery normally maintained in its deenergized position, the operation of the sending sixth pulse relay on subsequent revolutions making no change in their conditions as long as the overlap between the reception and transmission remains adequate.

Assume now that the position of the multiplex sending brushes 182 and 154 with respect to the slower start-stop receiving brush 108 changes to such an extent that while the multiplex local brush 182 is in contact with local segment 179, the tongue of the sending and receiving transfer relays 141 and 147, and 121 and 127 respectively are in the same corresponding positions. During

such a condition current will then flow from the segment 179, over conductors 184 and 216, through a tongue 217 and make or break contact of relay 141, over one of the conductors 218 or 219, respectively, through the make or break contact, respectively, and tongue 221 of relay 121 and thence over a conductor 222 through the lower winding of the auto-stop relay 171 to ground. As stated above, this relay 171 is normally energized by a locking circuit through its upper winding and therefore this circuit through the lower winding will neutralize the field created by the locking winding allowing the relay armatures to disengage their respective contacts. As the brush 182 subsequently contacts the segment 181 and causes the energization of the sixth pulse relay 192, battery from the tongue 193 thereof will not cause a change in the condition of the sending transfer relays 141 and 147 as the circuit thereto is open at the tongue 208 and make contact of the at this time deenergized auto-stop relay 171. However, battery will flow from the make contact and tongue 194 of relay 192 over conductors 196 and 202 through the make-before-break contact 203 and thence over conductor 206 and through the upper winding of the line battery relay 176 to ground. As the circuit from the same tongue 194 of relay 192 to the lower winding of relay 176 is open at the tongue 199 of relay 171, the current in the upper winding of relay 176 causes it to operate. This relay 176 is thereupon locked in its energized position by battery from its tongue 204, through the lower stop of contact 203 and over conductor 206 through the upper winding thereof to ground. The operation of the tongue 174 of the line battery relay 176 removes marking battery from the marking or right hand contacts of the two relay banks 131 and 134 and substitutes spacing battery therefor. Therefore, as the multiplex sending brush 154 subsequently contacts the segments 1 to 5, an all spacing signal will be sent from the relay bank that is at this time connected to the multiplex segments. The relay bank will be the same one from which the last permutation code signal was sent as the condition of the sending transfer relays 141 and 147 have not changed.

Since the receiving transfer circuit has not been interrupted, the receiving transfer relays 121 and 127 will have in the meantime been moved to a condition opposite to that of the sending transfer relays 141 and 147. Therefore, as local multiplex brush 182 contacts local segment 179 following the transmission of the all spacing signal a circuit will be completed from this segment over conductors 184 and 186, through the make-before-break contact 187 and thence over conductor 189 and through the upper winding of the auto-stop relay 171 to ground, causing this relay to become energized and lock itself as hereinbefore described. The circuit from the segment 179 to the lower winding of relay 171 will be open at the tongue 221 of relay 121. Now as the multiplex brush 182 contacts segment 181 to cause the operation of the sixth pulse sending relay 192, battery is connected to the tongue 194 thereof, over conductors 196 and 198 through the tongue 199 and make contact of relay 171 and over conductor 201 through the lower winding of relay 176 to ground. This circuit neutralizes the effect of the locking circuit in the upper winding and the relay thereupon returns to normal. At the same time an operating impulse for the sending transfer relays 141 and 147 is supplied

thereto from the tongue 193 of relay 192 to operate the same in the manner described and operation from this point proceeds in the normal manner until the overlap is again reduced to the minimum, whereupon the above described functions are repeated.

The above paragraphs cover the operation of the repeater on a "single" basis, i. e., the transmission to and from the branch office such as A or C over a single tie line. In order to send to and receive from a branch office such as A or C on a "duplex" basis, i. e., the transmission to and from a branch office over separate tie lines, the tongues of the switch 57 are moved to their lower stops. This operation, as is obvious, disconnects the conductor 58 from conductor 54 and by means of a tongue 223 of the switch 57 connects a conductor 224 to conductor 54. The conductor 224 is connected through a jack 228 to a branch office receiving tie line such as 227. As described the signals received over the multiplex channel pass over the conductor 54 and therefore the operation of the switch 57 extends these signals to the branch office by way of the branch office receiving tie line 227. The operation of the switch 57 as is obvious, also disconnects the line relay 94 from in series with the sending solid ring 69 of the start-stop sending distributor 68 and negative battery at the reversing switch 49 so that the signals from the branch office over a tie line 11 pass only through the line relay. Thus a branch office may be adapted to operate on a "duplex" basis.

If one section of the complete system such as the multiplex channel 17, should happen to fail, it would ordinarily render the whole system inoperative. At such a time, by operating the switch 57 of the associated repeater, such as 21 to its lower stops, the failed section of the system is isolated and operation may be continued over the rest of the system, such as between branch office stations A and B. The circuits for such operations are obvious from the above description.

The polarity of spacing and marking impulses on adjacent channels of a multiplex circuit are for obvious reasons sometimes reversed. Therefore, the polarized relays 31a to 31e will be oppositely operated when associated with different channels. To take care of this condition the switch 38 is provided and if the circuits there-through are traced, it will be apparent that its operation provides for the reversed polarity of the multiplex signals.

It will be noted in tracing the circuit from the branch office A that it is connected to battery at the reversing switch 49 of its associated repeater. At a main office such as Y which is associated with a branch office B by means of two tie lines 13 and 14, the switches 49 at the repeaters 19 and 21 must be thrown in opposite directions. The reason for this is that one end of the tie lines 13 and 14 must be grounded and by scrutinizing the circuits it can readily be seen that the operation of the reversing switch 49 merely reverses ground and battery on some of the circuits.

At times it may be desirable for the branch office operator at a station such as A to attract the attention of an attendant at the associated main office. To accomplish this the branch office operator opens the branch office tie line 11 by an approved method such as removing the printer plug from it associated jack for a few seconds and then again inserting it. This abnormal opening of the line circuit 11 allows the normally

energized slow-to-release relay 63 to become de-energized. The relay 63 is normally energized and is adjusted so that open line conditions of ordinary signals do not cause it to release. When the relay 63 is released as described above, the two tongues 60 and 62 thereof make contact with their associated break contacts. The tongue 62 shorts out the relay coil while the tongue 60 completes a circuit to a signal lamp 65. When the line circuit is again closed by replacing the plug the relay 63 remains deenergized until the attendant thereat operates the key 64 to open the shunt circuit through the tongue 62.

Jacks 59 and 226 are provided at each repeater so as to permit the attendants thereat to plug in a printer for monitoring purposes or so as to be able to communicate with any other station on the system.

It is obvious, of course, that various changes and modifications of the circuits shown and described herein may be made without departing from the spirit or essential attributes of the invention, and it is desired, therefore, that only such limitations shall be placed thereon as are imposed by the prior art or are specifically set forth in the appended claims.

What is claimed is:

1. In a telegraph system, a station, a plurality of multiplex circuits terminating at said station, start-stop recording means at said station, means for transferring marking and spacing signal conditions received over one of said multiplex circuits through said start-stop recording means and into another of said multiplex circuits, and means for recording said signal conditions on said start-stop recording means at said station.

2. In a telegraph system comprising a plurality of multiplex operated circuits, a plurality of simplex operated circuits, said simplex operated circuits being greater in number than said multiplex operated circuits, means for alternately connecting said simplex operated and said multiplex operated circuits in a continuous circuit, means for originating simplex signals at each of said simplex operated circuits and means for recording signals originating at any one of said simplex operated circuits at all of said simplex operated circuits.

3. In a telegraph system, a circuit comprising a plurality of multiplex operated sections and a plurality of simplex operated sections, transmitting and receiving means in each of said simplex operated sections and means comprising said multiplex operated sections for recording signals originating at the transmitting means in any one of said simplex operated sections on the receiving means in each of said simplex operated sections.

4. In a telegraph circuit comprising a plurality of multiplex operated sections separated by simplex operated sections, recording means in each of said simplex operated sections, means for extending signals from a multiplex operated section through a simplex operated section and the recording means thereat to operate the same in accordance therewith and means for further extending said signals into another of said multiplex operated sections.

5. In a telegraph circuit comprising a plurality of multiplex operated sections separated by simplex operated sections, means for extending telegraph signals from one multiplex operated section through a simplex operated section and into other multiplex operated sections, recording means in each of said simplex operated sections

and means for recording said signals on said recording means in each of said simplex operated sections.

5 6. In a telegraph circuit comprising a plurality of series multiplex circuits adapted to operate at substantially the same speed, simplex operated transmitting and receiving mechanisms at the ends of said circuit and at the junction points of said multiplex circuits adapted to receive signals

at a faster rate than the operating speed of said multiplex circuits and to transmit signals at a slower rate than the operating speed of said multiplex circuits, means for transmitting signals from any one of said simplex transmitting mechanisms at a time and means for recording 5 said signals on each of said simplex operated receiving mechanisms.

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