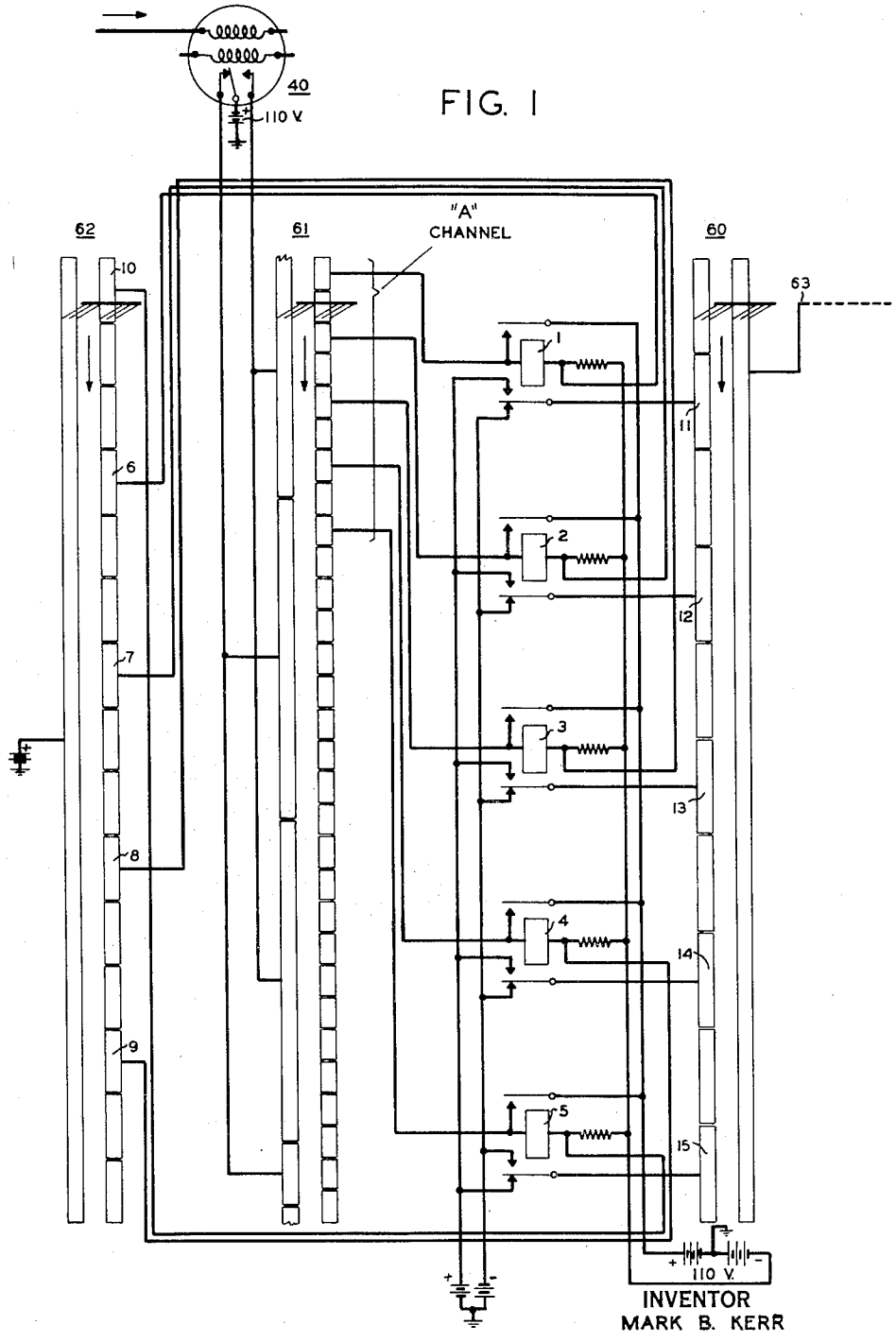
Dec. 12, 1933. M. B. KERR 1,939,396

TELEGRAPH SYSTEM

Filed Sept. 23, 1932 4 Sheets-Sheet 1

FIG. 1



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Dec. 12, 1933. M. B. KERR 1,939,396

TELEGRAPH SYSTEM

Filed Sept. 23, 1932 4 Sheets-Sheet 2

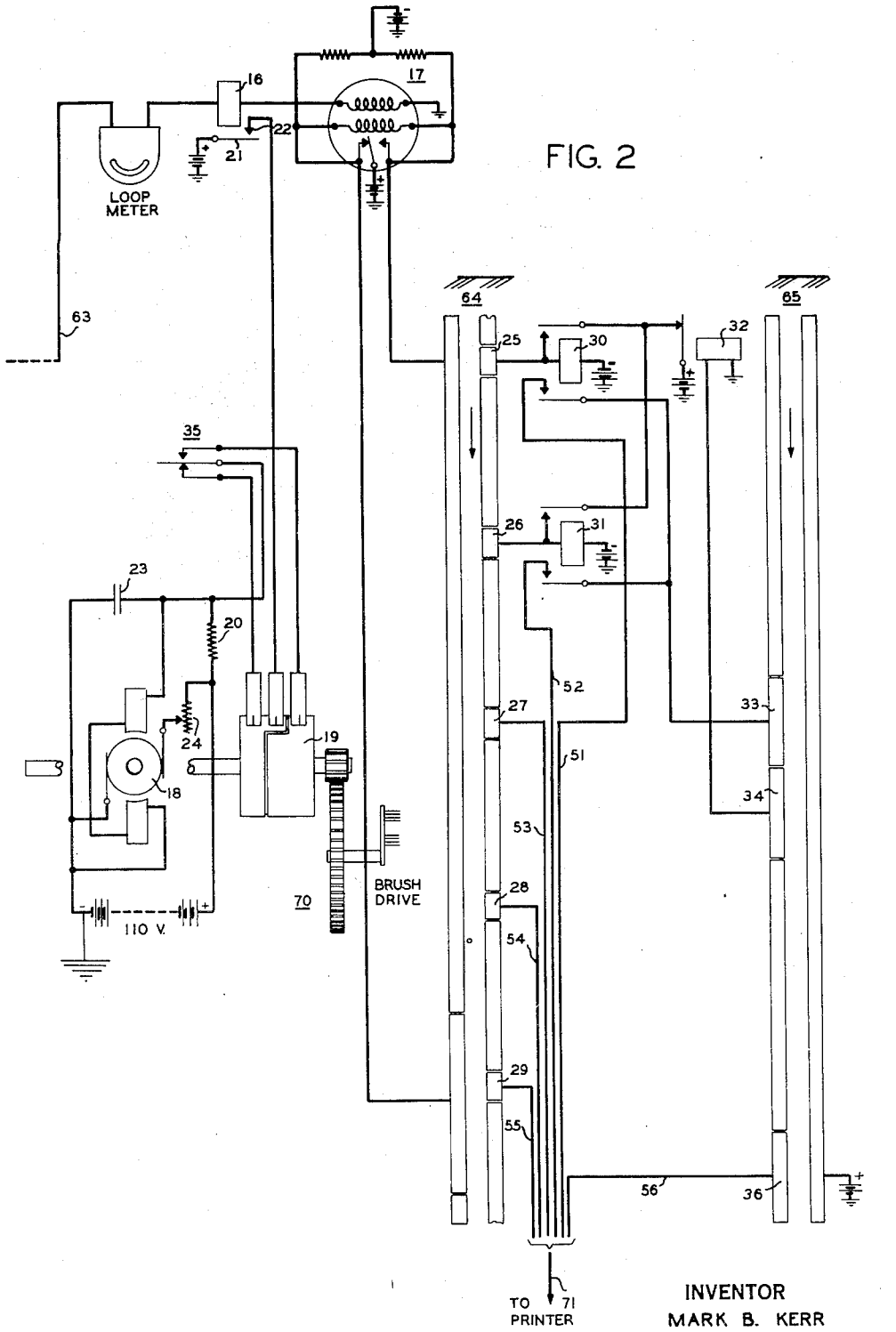


FIG. 2

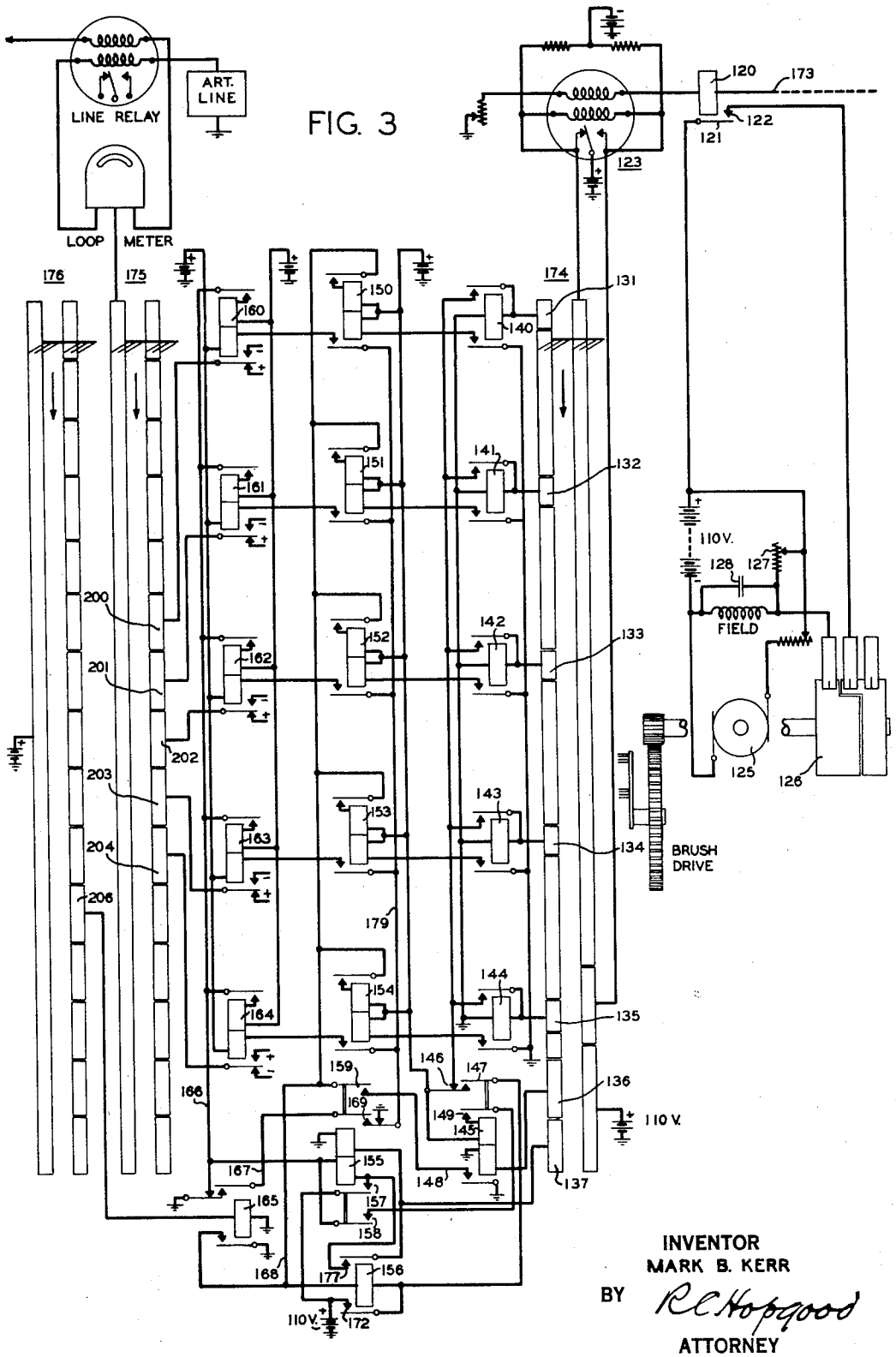
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TELEGRAPH SYSTEM

Filed Sept. 23, 1932 4 Sheets-Sheet 3

FIG. 3



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Dec. 12, 1933. M. B. KERR 1,939,396

TELEGRAPH SYSTEM

Filed Sept. 23, 1932 4 Sheets-Sheet 4

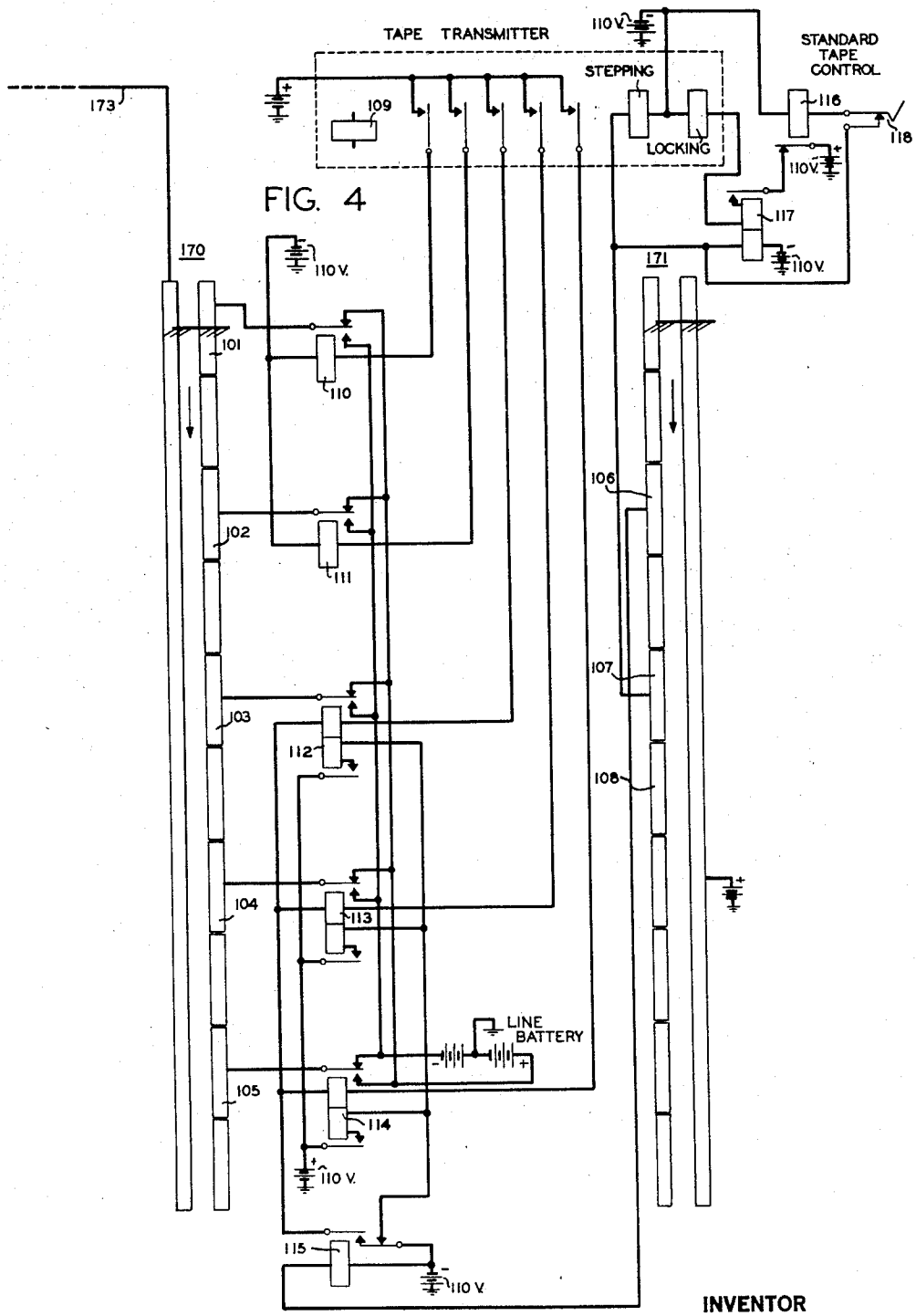


FIG. 4

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UNITED STATES PATENT OFFICE

1,939,396

TELEGRAPH SYSTEM

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Application September 23, 1932
Serial No. 634,455

9 Claims. (Cl. 178—53)

This invention relates to multiplex printing telegraph systems, and more particularly to a system for extending one or more of the channels of a multiplex printing telegraph system over a single circuit to a subscriber's station. It also discloses apparatus adapted to receive signals from a subscriber's station and insert the same into a multiplex system having a plurality of other channels therein.

It is an object of this invention to provide apparatus for eliminating the necessity of tuning fork speed control and correction devices in branch lines associated with continuously rotating distributors.

Another object is to provide an efficient and simple single channel extension system for use in connection with multiplex circuits.

Other objects will become apparent to those versed in the art, upon consulting the following description together with the accompanying drawings.

In the drawings:

Figs. 1 and 2 show a multiplex receiving distributor in developed view and the extension or drop channel line extending therefrom to the subscriber's station; and

Figs. 3 and 4 show a subscriber's station, adapted to transmit a message and insert the transmitted message into a multiplex system.

Since continuously rotating distributors are disclosed in this embodiment of the invention, it will be found that tape transmission and/or tape perforation may be preferably used in connection with this system.

The circuit, by means of which synchronism on the branch lines is maintained without requiring tuning fork speed control and phase correction, is shown on the accompanying figures. Referring to Fig. 1, it is seen that the sending distributor 60 for the extension line 63 has ten segments of equal length, of which five alternate segments are left unconnected. The other five segments 11 to 15 are connected to the contacts of storing relays 1 to 5 upon which the signals received over one channel, say A, of the multiplex receiver are stored. As the brushes pass over these half length sending segments, a series of impulses of half unit length and of varying polarity are transmitted over the extension line to the branch station. At the branch station, the extension line 63 passes through the windings of a neutral relay 16 and polar relay 17 in series. The neutral relay 16 responds to all the impulses, irrespective of polarity, and the polar relay 17 responds only to changes in polarity. An auxiliary locking circuit is provided for the latter, so that it will remain on the contact to which it was moved until an impulse of the reverse polarity is received. The locking current, of course, must be adjusted to be less than the line current, so that the relay will always respond to line impulses of reverse polarity.

Returning to the neutral relay 16, it is seen that the contacts of this relay are connected through a commutator 19 to the field circuit of an ordinary D. C. shunt motor 18 of sufficient power to drive the branch station signal channel distributor brushes. The commutator, which is securely fastened to the motor shaft, consists of two equal length segments. Three brushes are placed against the surface of the commutator in such positions that, as the commutator rotates, the middle brush is connected alternately to the two side brushes. The motor field control circuit may be connected to either side brush without, in any way, affecting the stability or efficacy of the control. To shift from one side to the other merely shifts the phase of the control from one half of each revolution of the motor armature to the other half. Whenever the neutral relay closes its front contact 22 during the same time that the commutator closes the circuit to the field of the motor, the resistance 20, in series with the field, may be adapted to be shunted, in a well known manner, by a low resistance, so that the field current momentarily increases and the motor 18 has a tendency to slow down. Whenever the relay operates during the time the motor field control circuit is open at the commutator 19, the speed will, of course, be unaffected. Assuming now that the relay is operating at a given rate, the motor will adjust its speed until the commutator is closing the field control circuit in step with the relay operations, and one impulse per revolution will be impressed on the field. The motor will further adjust its phase and that of the commutator, relative to the relay operations, until the duration of each impulse impressed on the field will be exactly sufficient to hold the motor at the proper speed. If the impulses become too short the motor will speed up, and if they become too long the motor will slow down. The control circuit then becomes a synchronous governor on the motor and establishes both speed and phase control. By connecting a condenser 23 in parallel with the motor field, the short impulses of current impressed through the control circuit can be flattened out to a certain extent so as to produce a steadier torque on the motor, and, at the same time, to reduce the

amount of phase shift necessary in the commutator to produce an effective control over the range of possible resistance adjustments.

Referring now to the multiplex end of the extension, the sending extension rings 60, attached to the receiving multiplex distributor, always transmit five impulses per revolution, together with five intervening open current intervals of the same duration as the signalling impulses. The neutral relay 16 at the branch station, therefore, will operate during each half signal unit interval and the motor will make a half revolution during the same time. In other words, the motor will complete a full revolution during each successive signal unit impulse. By gearing the motor to the receiving distributor brushes, say, through a five to one reduction 70, the branch station receiving brushes will rotate at exactly the same speed as the multiplex distributor.

This same synchronous control circuit would also function with a series D. C. motor. In this case, the commutator and control circuit would be connected as a shunt around the resistance in series with the motor. The closure of the contact through the commutator would then tend to increase the speed of the motor, and, when the proper phase relation between the operations of the relay and the closures through the commutator is reached, the motor will be held at the synchronous speed. Again, the condenser performs the function of decreasing the phase shift necessary to control the motor speed, as well as tending to flatten out the impulses sent through the motor by the control circuit.

Synchronism having been established between the extension sending distributor at the multiplex terminal and the receiving distributor at the branch station, it is a simple matter to arrange the circuit for recording the characters transmitted over the extension. The polarized relay 17, connected in the line, operates in accordance with the polarity of the signals received over the extension 63. These signals are distributed in the normal way through the five segments 25 to 29 of the receiving distributor 64. Because of the short amount of time available between the reception of the fifth impulse and the beginning of a new signal, a partial overlap has been introduced to allow sufficient time for the printer to perform its function before it is required to set up a new selection. The first and second impulses received, therefore, do not pass directly into the printer but operate storing relays 30, 31. When the receiving brush has reached the third segment 27, a local brush, rotating in synchronism with the receiving brush, passes over a segment 33 of rings 65, which permits any selection set up on the first two relays to be transferred to the printer 71. Immediately after the selection has been transferred, the storing relays are released by the operation of a clear-out relay 32 and are ready for a new selection. After the reception of the fifth impulse, the local sixth pulse from segment 36 starts the printing function in the normal way. Thus, it is seen that the overlap circuit provided in this case permits an overlap of approximately two-fifths of a revolution of the distributor for performing the printing function. If a printer which is designed with a complete overlap in its selecting mechanism is used in this system, no auxiliary overlap circuit would be necessary, and the relays shown on the drawngs may be eliminated.

Returning now to the multiplex end of the extension circuit, it is to be noted that the drop channel or extension sending distributor 60 may be directly connected to the multiplex receiving distributor of the multiplex line, or it may be independently and synchronously driven therefrom, and that the code combinations received over the multiplex line are set up on storing relays 1 to 5 before being retransmitted into the extension line 63.

It will be noted that the circuit is so designed that the storing relays 1 to 5 will operate in accordance with the code combinations received from the A channel segments of the multiplex distributor 61, and that the last signal will be sent over the extension before the first impulse of the next combination is received. The phase relation of the brushes passing over the sending segments 60 associated with the extension must be adjusted to hold this relation, if rings 60 are independently driven. It will be noted, further, that each of the storing relays 1 to 5, in turn, is shunted down by an impulse generated by local segments 6 to 10 associated with the multiplex distributor 62, immediately after the corresponding element of the signals has been sent out over the extension 63. The circuits at the extension station have been described above. Motor 18 is adapted to drive the extension receiving distributor 64 through a 5:1 reduction gear. The sending distributor 170 (Fig. 4) may also be driven by this same motor, but preferably through a slightly larger gear, say 76:15 reduction or slightly greater than 5:1.

In order to facilitate the complete understanding of the system, a combination of signal elements such as make up the letter Y will be transmitted over the multiplex system and retransmitted over the extension line to the subscriber's station. The letter Y comprises mark, space, mark, space, mark impulses.

When the letter Y is received over the multiplex receiving circuit, relays 1, 3 and 5 will be operated and locked through obvious circuits including rings 61. As soon as the sending brush associated with the extension circuit has passed off of segment 11, an impulse from segment 6 of the multiplex receiving local rings 62 shunts down relay 1. As soon as the sending brush has passed over segment 13, relay 3 will be shunted down by an impulse sent through segment 8, and, finally, relay 5 will be shunted down by an impulse sent through segment 10 just before the extension sending brush reaches segment 11 again.

Assuming that all the distributors are operating in synchronism and that the branch station receiving segments are oriented, by means well known in the art, to pick up the middle of each signal element, then, as the brushes rotate, an impulse will be received and locked up on relay 30, through an obvious circuit including segment 25, at the drop channel subscriber's station. The other impulses will go directly to the printer magnets and printer 71 over circuits including segments 27 and 29. Then segment 36 of rings 65 will start the printer operating.

Synchronism between the subscriber's extension distributor and the multiplex distributor may be attained by the use of the well known differential gear principle, or by switching the phasing key 35 from the upper position, as shown on the drawings, to the lower position, the control circuit through the commutator 19 being switched to opposite segments so that the motor will tend to shift its phase 180° backward (or forward) relative to the incoming signals. This will shift the receiving brushes at the branch station half

the angular displacement between two segments of rings 64. By shifting the phasing key upward again, it will shift another half segment. By repeating this operation several times, the brushes of the distributor may be retarded or advanced any desired amount in multiples of half segment displacements, until the correct phase relation is reached.

Coming now to the transmission of signals from the branch station over the extension to the multiplex terminal to be repeated into one of the channels of the multiplex circuit, the circuit elements required in this system are shown in Figs. 3 and 4. The same motor which drives the brushes of the receiving distributor may also be used to drive the brushes of the sending distributor, and the same gear ratio, 1:5 reduction, may also be used. The sending brushes at the branch station may, therefore, rotate at the same speed as the receiving brushes and, consequently, at the same speed as the receiving brushes of the multiplex terminal distributor, as previously described. It will be noted that the arrangement of the segments of the sending distributor at the branch station is the same as the arrangement of the segments of the extension sending distributor located at the multiplex end of the extension which sends the impulses, as received from the multiplex, out to the branch station, as previously described. The branch station sending distributor, therefore, sends out impulses of half unit length separated by zero current intervals of the same duration. At the receiving end of the extension loop at the multiplex terminal, these impulses are used to control the synchronism of the single channel receiving distributor and to set up the code combinations as received from the branch station, to be repeated into one of the channels of the multiplex sending distributor. The method of controlling the synchronism of the single channel receiving distributor is identical with the method previously described by which the synchronism of the branch station distributor is controlled. A motor, synchronously operated with said multiplex receiving distributor, may also be used to drive rings 60 through a 5:1 gear reduction and rings 174 through a 76:15 reduction gear. Then motor 125, relay 120, etc. will be unnecessary.

It is the general practice, in the operation of multiplex circuits, to provide separate distributors for receiving and sending. The receiving brushes are controlled by the usual correcting circuit from the signals received from the distant end of the multiplex line. The brushes of the sending distributor, however, will not be subject to this control, so they will rotate at a speed which is independent of the speed of the receiving multiplex distributor. Now, the signal channel extension distributors are held in synchronism with the receiving multiplex distributors, so that the brushes of the single channel receiving distributor at the multiplex terminal which receives the signals from the branch station may rotate at the same speed as the receiving brushes of the multiplex terminal distributor. Thus, there is bound to be slight difference in speed between the brushes of the signal channel distributor, which receives the signals from the extension, and the brushes of the sending distributor, through which the signals must be repeated over the multiplex line. As a result of this difference in speed there will be a constantly shifting phase between the receiving brushes of the channel extension and the sending brushes of the multiplex distributor, necessitating a signal storing circuit which provides a complete overlap, as shown in Fig. 2.

Referring to the branch station, it is noted that the sending distributor (Fig. 4) consists of a set of sending distributor segments 170 and a set of local segments 171. As has been explained above, the brushes that travel over both the sending and the sending local segments may be driven through a 5:1 reduction gear from the same motor that drives the brushes of the receiving distributor, shown in Fig. 2. A step-by-step transmitter 109 is used in this embodiment. In order to operate such a transmitter with a single channel sending distributor of this type, an overlap must be provided to allow time for the transmitter to complete its stepping operation. Five relays, 110 to 114, are provided between the transmitter 109 and the sending distributor segments 170, which perform the function of storing the code combinations set up by the transmitter while the transmitter is stepping the tape ahead to a new selection. It will be noted that relays 110 and 111 operate direct from the corresponding contacts of the transmitter and have no locking circuits. Relays 112, 113 and 114, on the other hand, are provided with locking circuits and are not directly connected to corresponding contacts of the transmitter. The operation of the circuit is as follows:

Assume that the brushes of the branch office distributor are just beginning to travel over segment 101. Assume, also, that at the same instant the code combination corresponding to the letter Y is in the tape directly over the transmitter pins so that the first, third and fifth contacts are closed. Relay 110 will, therefore, be operated and the transmitting line battery of marking polarity will be connected to segment 101. At this time, however, the operating circuits of relay 112, connected to the third contact of the transmitter, and relay 114, connected to the fifth contact of the transmitter, are open at the contact of relay 115. The sending brushes, continuing in their rotation, pass over segment 101, sending out a marking impulse to the receiving circuit at the multiplex end of the loop, and then pass over the open segment between segments 101 and 102 to allow the neutral relay 120 at the receiving end to release. During this time, the brushes associated with the local transmitting segments 171 are also rotating at the same speed as the sending brushes, so that they may pass on to segment 106 at the same time that the sending brushes pass on to segment 102. In this position, the sending brushes send a spacing impulse over the extension loop, since relay 111 is unoperated, and the local brushes connect battery to the winding of relay 115 and cause the latter to be operated. The contacts of relay 115 are arranged to make before break, so that the operating circuits of relays 112, 113 and 114 are closed to negative local battery before the locking circuits of these same relays are opened. The closure of the operating circuits of these three relays, by the operation of relay 115, permits relays 112 and 114 to operate through the corresponding closed contacts of the transmitter. Relay 113 does not operate on this combination because the fourth contact of the transmitter is open. As soon as the local brushes pass off of segment 106, relay 115 releases, closing the locking circuits for relays 112 and 114 before opening the operating circuits of these relays so that they remain locked up, irrespective of any change that may take place in the combination set up in the transmitter. The send-

ing brush then passes on to segment 103, sending out a marking impulse to the extension line, and the local brush passes on to segment 107 to operate the stepping magnet of the transmitter. As this magnet takes a considerable amount of time to operate, the impulse sent into its winding from the local segments may be lengthened by strapping segments 107 and 108 together. The operation of the stepping magnet opens all contacts in the transmitter 109, as it steps the tape ahead, so that relay 110, previously operated, is now released. As soon as the tape comes to rest with a new combination over the pins, the contacts corresponding to the new set of holes in the tape are closed, and, if this combination contains either or both the first and second impulses, either or both of relays 110 and 111 will now be operated. The sending brush at this time, however, will be passing over the remaining fourth and fifth segments of the sending ring, so that the change in combination on relays 110 and 111 will have no effect on the outgoing signal. The local brush during this time performs no function in connection with this circuit, and the combination previously set up on relays 112 and 114 will remain locked until the brushes get around to segment 106 again. The re-operation of relay 115 at this point releases the old combination set up on relays 112 and 114 and allows the new combination to be set up on these relays.

Turning, now, to the receiving end of the extension loop, let us follow the operations that take place in repeating the code combinations set up at the branch station and transmitted over the extension loop by the branch station distributor, as just described. All impulses, whether marking or spacing, operate the neutral relay 120, as previously described in connection with the receiving distributor at the branch station. The function of this relay, as before, is to control the synchronism of the motor which drives the brushes of the receiving distributor. This motor may drive the brushes of the distributor through a 5:1 reduction gear. The polar relay 123 discriminates between the polarities of the incoming signals and distributes them through the receiving rings to a set of five storing relays, 140 to 144 inclusive. It will be noted that, synchronism having been established similarly, as above described, in the extension circuit, this circuit is so arranged that the relays are affected only by impulses of marking polarity received over the extension loop 173.

In the case assumed above, where the combination set up in the transmitter at the branch station corresponds to the letter Y in which the first, third and fifth impulses are marking, it will be seen that, with synchronism established between sending brushes at the branch station and the receiving brushes at the multiplex end of the extension, relays 140, 142 and 144 will be operated. These relays will lock up through an obvious circuit including contact 146 of relay 145 to positive battery. By their operation they also close obvious circuits leading through the operating circuits of relay 150, 152 and 154, so that the latter will operate immediately following the operation of the former relays. It is seen, therefore, that each successive signal combination received over the extension loop will immediately be set up and stored in relays 150 to 154 inclusive, irrespective of the phase relation between the receiving brushes and rings 174 and the multiplex sending brushes and rings 175. From this point on, the transfer of the code combinations is placed under the joint control of the extension receiving and multiplex sending distributors by the control relays 145 and 155, operating through obvious circuits including segments 136 and 137, respectively.

The receiving brush associated with the extension requires almost a complete revolution to receive a signal combination, while the sending brush of the multiplex distributor requires only a portion of a revolution to send a complete signal combination. If the multiplex circuit is equipped for three channel operation, the sending brush requires only one-third of a revolution to send out a complete signal combination on any one channel. During the remaining two-thirds of its revolution it is sending out signal combinations on the other two channels. As far as the particular channel in which we are interested is concerned, we must arrange the circuit so that each individual impulse received from the extension will not interfere with the combination set up on the final set of storing relays, the contacts of which are directly connected to the segments of the channel associated with the multiplex, until after the multiplex sending brush has passed over the sending segments corresponding to the five sending segments of that channel. In other words, if the sending brush of the multiplex distributor reaches segment 200 just as the extension brush is passing over segment 131 to receive the first impulse of a code combination, the impulse so received and stored on relay 140 is not transferred over directly to relay 160 but must wait until the multiplex sending brush has passed off of segment 204 before allowing the selection to be transferred to storing relays 160—164 inclusive. Even if the extension receiving brush passes over segment 131 before the multiplex sending brush reaches segment 200, that selection is not transferred over to relay 160 because a previous selection may still be stored in relays 160—164, and the sending brush may reach segment 204 before the extension brush reaches segment 135. The only time that the selections received and stored on relays 140 to 144 may be transferred directly to relays 160 to 164, inclusive, is when the phase relation between the receiving and sending brushes is such that the former will have passed over segment 135 before the latter reaches segment 204. For all other phase relationships, the selections received and stored on relays 140 to 144 must be held on relays 150 to 154, inclusive, until the sending brush has completely sent out the previous selection.

Relay 155, operating in conjunction with relay 165, determines when the received selections can be transferred to the final set of storing relays 160 to 164 inclusive. It is seen that relay 155 operates from local segment 137 associated with the extension receiving distributor and that relay 165 operates from local segment 206 in the multiplex sending local rings 176. The phase relationships of these two local signals is such that relay 155 operates just prior to the beginning of the reception of a new signal combination and relay 165 operates just after the sending brush on rings 175 has completed sending out a code combination. The operation of relay 155 removes the ground from the common circuit through which the code combinations are transferred from relays 150 to 154, inclusive, over to relays 160 to 164, inclusive. The operation of relay 155, therefore, prevents a selection from being transferred over to the last group of stor-

ing relays. Since relay 155 locks itself up through contact 157 to the back contact 166 of relay 165, it will remain locked until relay 165 operates, whereupon it will release and connect ground again to lead 179, permitting the transfer of the selections over to relays 160 to 164.

As pointed out above, the proper operation of the circuit is based upon the assumption that the multiplex sending brushes, e. g., for rings 176, 175, rotate at an equal or slightly greater speed than the extension receiving distributor brushes, e. g., for ring 174. In the assumed case, where the multiplex sending and receiving distributors are driven by the same tuning fork and receiving brushes are held in synchronism by means of a mechanical corrector which periodically steps the receiving brushes backward in phase, the speed of the extension distributor motors and brushes will be less than the speed of the multiplex sending brushes by the amount of the mechanical correction. Under normal operating conditions the multiplex receiving brush will be corrected backward from 50 to 100 degrees a minute. This will cause the brushes of the extension distributors to fall behind the multiplex sending brushes by the same amount. This is equivalent to a slow, gradual phase shift between the extension receiving distributor brushes and the multiplex sending brushes, by which the latter are gradually moving ahead of the former.

In order to explain more clearly how the overlap circuit operates under these conditions, let us assume that at a given instant in the cycle of operations the multiplex sending brushes reach segment 200 at the same instant that the extension receiving brushes have just passed off of segment 135. At this time a complete code combination has been set up on relays 140 to 144, transferred over to relays 150 to 154, and the operation of some or all of the latter has caused the corresponding relays in the group 160 to 164 to be operated. It is seen, in this case, that relay 155 had been operated by the passage of the extension receiving brushes over segment 137 in the revolution prior to the reception of the present code combination, but relay 155 had been released by the operation of relay 165 immediately after the previous code combination had been sent out over the multiplex. According to the assumed phase relationship, relay 165 operates at about the same time that the extension receiving brushes are passing over segment 132, to receive the second impulse of the present code combination. The release of relay 155 at this time permits the transfer of the selection that may have been set up on relays 150, 151, or both, over to relays 160, 161, or both, as well as closing the circuits to permit the transfer of the subsequent selections in the order in which they are received directly from relays 142, 143 and 144 over to 162, 163 and 164. Assuming that this code combination corresponds to the letter Y, which will cause the operation of relays 140, 142 and 144, it is seen that relay 150 will operate by the closure of the contact on relay 140 before relay 155 releases. This selection is, therefore, stored on relay 150 until relay 155 releases. As soon as ground is established by the operation of relay 165 over lead 167 and contact 169, relay 160 will operate. Also, during the interval that relay 165 is operated, the locking circuit for relays 160 to 164, inclusive, is opened, so that any relays previously locked up will now be released. Since switching contact 169 is arranged to make before break, there will be no break in the ground established on lead 179 by the release of relay 155. Proceeding, now, with the selection corresponding to the letter Y as received from the extension, relays 141 and 151 not being operated on this combination, relay 161 remains unoperated. When the extension receiving brush reaches segment 133, relays 142, 152 and 162 operate in sequence. Extension receiving brush proceeds on to segment 134, but relays 143, 153 and 163 remain unoperated. The extension receiving brush then passes over segment 135, operating relays 144, 154 and 164 in sequence. During this time the multiplex sending brush has been passing over the segments of other channels. Just after the extension brushes pass off of segment 135, operating the last mentioned relays, the multiplex sending brush reaches segment 200 and starts sending out the code combination set up in relays 160, 162 and 164. Before it is finished sending this combination, however, the extension receiving brushes pass over segment 136, operating relay 145. This closes contact 147 and opens contact 146 in make before break combination. The circuit from contact 147 to relay 156 performs no function at this time. The opening of contact 146 releases relays 140, 142 and 144 as well as relays 150, 152 and 154, respectively. Relays 160, 162 and 164 remain operated, as they are locked up through lead 166 at the contact of relay 165. The extension receiving brush then reaches segment 137, releasing relay 145 and operating relay 155. The latter remains locked up under control of contact 166. The extension receiving brush then passes to segment 131 again, to start the reception of a new code combination, and the multiplex sending brush continues to send out the remaining impulses of the code combination set up on relays 160 to 164. The first two impulses of the new code combination are not permitted to affect the last group of storing relays, as previously described, until the sending brush has finished sending out the previous combination and relay 165 operates to clear out the previously operated relays in the group 160 to 164. In this manner, the cycle repeats itself and each combination received from the extension is sent out over the multiplex in proper order and sequence.

As the normal shift in phase takes place, which causes the multiplex sending brushes to move slowly and gradually ahead of the extension receiving brushes, the time will soon be reached when the multiplex brushes will reach segment 200 before the extension receiving brushes reach segment 135. This, however, will not cause any change in the cycle of operations previously described. The phase shift continues and, finally, the relation is reached when relay 165 operates before the extension receiving brush passes off segment 137. In this case, relay 155 will not release immediately following the operation of relay 165. This will not change the cycle of operations, however, unless relay 165 operates prior to relay 155, which will take place when the multiplex brushes associated with 175, 176 have advanced in phase sufficiently so that the local brush reaches segment 206 before the extension brushes associated with 174 reach segment 137. Inasmuch as segments 137 and 206 are substantially the same length, the operation of relay 165 before relay 155 will insure that relay 165 releases before 155. As soon as this condition exists, relay 155 will not release because ground will be established on lead 166 to re-estab-

lish the locking circuit for relay 155 through contact 157 before the latter contact opens. The cycle of operations now changes. The next code combination received from the extension is received on the first group of relays 140 to 144 and transferred to relays 150 to 154, but goes no further. All of the last group of relays 160 to 164, previously operated, were released by the operation of 165, so that no code combination is set up on these relays the next time the multiplex brushes reach segment 200 and a blank or idle signal is sent out over the multiplex circuit. The extension receiving brushes, after distributing the code combination to relays 140 to 144, now reach segment 136 at about the same time that the multiplex sending brushes are passing over segment 204. Relay 145 operates, releasing the combination set up on relays 140 to 144, but now establishes a locking circuit for relays 150 to 154 through lead 148 and contact 159 on relay 155. Also, the closure of contact 147 connects battery to the winding of relay 156, and, since the ground on lead 148 passing through contact 159 is also connected to lead 168, relay 156 operates. A locking circuit for relay 145 is also established through contacts 149 and 158 to ground at the back contact of relay 165. Relay 145, therefore, does not release when the extension receiving brushes pass from segment 136 to 137 but remains locked up under control of relay 165. It is seen, then, that relays 140 to 144 have been cleared out, but relays 150 to 154 are held locked by relay 145, and relay 156 establishes an auxiliary locking circuit for relay 155 through contact 177 to prevent its releasing. Before the extension receiving brushes pass on to segment 137, relay 165 operates. Ground is now established on lead 167 to transfer the code combination held stored on the group of relays 150 to 154 over to relays 160 to 164, places an auxiliary ground on lead 168 to prevent relay 156 and relays 150 to 154, inclusive, from releasing, removes the ground from lead 166 to release relay 145. Thus, during the transfer of the code combination from the group of relays 150 to 154 to relays 160 to 164, which takes place during the time that relay 165 is operated, relay 156 is held locked through its own contact 172 to battery, and it, in turn, maintains the locking circuit for relay 155 through contact 177. As soon as relay 165 releases after the multiplex local brushes pass off of segment 206, ground is removed from lead 167 just after the locking circuit for the group of relays 160 to 164 and 155 has been re-established. The release of relay 165 also removes ground from lead 168, allowing relay 156 to release. Relay 155, however, remains locked, both because its locking circuit is re-established through lead 166 and because the extension brushes are still on segment 137. The extension brushes continue with their rotation and begin the reception of another code combination from the branch station, and the selection set up on the group of relays 160 to 164 remains intact until another operation of relay 165 clears them out and, at the same time, transfers the new code combination from the intermediary of relays 150 to 154. During this time, relay 155 remains continually locked and relays 145 and 156 operate and release once per revolution, as previously described, under joint control of relay 165 and segment 136 of the extension receiving distributor.

As the phase relation between the two distributors continues to shift, the relation is finally reached where relay 165 operates before the extension receiving brushes leave segment 136. If the extension brushes pass on to segment 136 sufficiently ahead of the operation of relay 165 to permit the operation of relay 156, closing contact 177 before ground is removed from lead 166, relay 155 will not release and the cycle will continue in the same order. It will be noted, however, that with this relationship the extension brushes will pass off of segment 136 before relay 165 releases, so that the locking circuit for relay 145 will not be established in time to prevent the latter from releasing. Finally, the relation is reached when relay 165 and relay 145 will operate at substantially the same time. In that case, relay 156 will not have time to operate and establish the auxiliary locking circuit for relay 155 through contact 177 before the regular locking circuit through lead 166 is broken and relay 155 will release. Relay 156 will eventually pull up but will not re-establish the auxiliary locking circuit for relay 155, because the latter is broken at contact 157. This will not interfere with the transfer of the selection to the final group of relays, however, for direct ground is re-established on lead 179. Also, the locking circuit for relay 145 is now open, so that the latter will not remain locked up after the release of relay 165. Immediately after the extension receiving brushes pass off of segment 136 on to 137, relay 155 operates again and repeats the cycle, relay 156 releasing immediately following the release of 165. As the multiplex brushes continue to advance in phase, the operation of relay 165 occurs earlier and earlier, relative to the passage of the extension receiving brushes over segment 136, so that the time interval during which relay 155 is released continues to increase. It is seen that, as this shift in phase continues, the same relation as described under the conditions assumed at first prevails, with part of the selection held stored on relays 150 and 154 until the operation of relay 165 releases relay 155 to permit the direct transfer of the incoming selections from the group of relays 140 to 144 to the final group of relays 160 to 164.

Numerous variations of the above system are possible and are not without the scope of this invention. Thus, the synchronizing apparatus shown in Fig. 3 is not necessary if the sending and receiving extension rings at the multiplex terminal are driven in synchronism with the receiving multiplex distributor by well known means, say, through a 5:1 and a 76:15 gear reduction, respectively. With this modification a 76:15 gear reduction may be used in connection with the transmitting rings of the branch station sending distributor.

In the above description, it is to be noted that the multiplex receiving distributor and multiplex sending distributor are synchronously driven under the control of means well known in the art and may be kept in synchronism either by signals received over the multiplex line or by tuning fork apparatus at the multiplex station. These methods of control are well known to those familiar with the related art.

What is claimed is:

1. In a telegraph system, a main line, a single channel extension circuit, a first and continuously rotating multiplex distributor in said main line, a second and continuously rotating single channel distributor in said extension circuit, a group of storage relays associated with each of said distributors and energized by impulses transmitted over said extension line, means for main-

taining said distributors in synchronism, characterized in this, that means is provided for locking the energized storage relays in operated condition, and that additional means, conditioned for operation upon further rotation of said distributors, is provided for releasing the operated storage relays after said distributors have rotated a predetermined distance subsequent to the completion of transmission of signal impulses over said extension line.

2. In a telegraph system, a subscriber's station having continuously rotating synchronous distributors, a main line terminating at a main station having a multiplex continuously rotating synchronous distributor, a single channel extension line connecting said stations, and means at the main station controlled by signals received over the main line for transmitting over the extension line signals each composed of a negative or a positive impulse and a zero current interval, means responsive to each impulse transmitted over said line, for maintaining the distributors at said stations in synchronism.

3. In a signalling system, a main line, a single channel extension circuit, a multiplex distributor in said main line, a first pair of continuously rotating distributors one at each terminal of said extension circuit, means for re-transmitting impulses from said multiplex distributor and over said extension circuit through said first pair of distributors, a second pair of continuously rotating distributors one at each terminal of said extension circuit, means for re-transmitting impulses from said extension circuit and over said main line through said second pair of distributors, and means for maintaining said first and second pair of distributors in synchronism with signal impulses received over said main line characterized by the provision of means for rotating said second pair of distributors at a slower speed than said first pair of distributors.

4. In a telegraph system, a multiplexed main line over which negative and positive signal impulses are transmitted, a synchronous multiplex distributor at one terminal of the line, a single channel extension line from said main line terminal to a branch station, send and receive continuously rotated synchronous distributors for each end of the extension line, means at said terminal controlled by signals received over the main line on the multiplex distributor for causing the extension distributor thereat to transmit over the extension line signals each composed of a negative or a positive impulse and a zero current interval, means at the branch station responsive to the polarity of said signals to determine a character indication, and means at the branch station responsive to each signal impulse to maintain the branch station receiving distributor in synchronism with the extension transmitting distributor at the said terminal.

5. In a telegraph system, a multiplexed main line over which negative and positive signal impulses are transmitted, a synchronous multiplex distributor at one terminal of the line, a single channel extension line from said main line terminal to a branch station, send and receive continuously rotated synchronous distributors for each end of the extension line, means at said terminal controlled by signals received over the main line on the multiplex distributor for causing the extension distributor thereat to transmit over the extension line signals each composed of a negative or a positive impulse and a zero current interval, a polar relay at the branch station responsive to the signals to determine a character indication, and a non-polar relay responsive to each signal impulse to maintain the branch station receiving distributor in synchronism with the transmitting distributor at the multiplex terminal.

6. In a telegraph system, a multiplexed main line over which negative and positive signals are transmitted, a synchronous multiplex distributor at one terminal of the line, a single channel extension line from said main line terminal to a branch station, transmitting and receiving continuously rotated synchronous distributors for each end of the extension line, means at the main line terminal and including the transmitting distributor thereat for converting the signals received over the main line into signals each composed of a negative or a positive impulse and a zero current interval, and transmitting said converted signals over said extension line, means at the branch station responsive to each signal impulse, driving means at the branch station for the receiving distributor thereat, and a control circuit for said driving means closed once during each response of said responsive means for a period dependent upon the phase relation between the driving means and the received signal impulse to maintain the branch station receiving distributor in synchronism with the transmitting distributor at the multiplex terminal.

7. In a telegraph system, a multiplexed main line over which negative and positive signal impulses are transmitted, a synchronous multiplex distributor at one terminal of the line, a single channel extension line from said main line terminal to a branch station, send and receive continuously rotated synchronous distributors for each end of the extension line, means at said terminal controlled by signals received over the main line on the multiplex distributor for causing the extension distributor thereat to transmit over the extension line signals each composed of a negative or a positive impulse and a zero current interval, a polar relay at the branch station responsive to the signals to determine a character indication, a non-polar relay responsive to each signal impulse to maintain the branch station receiving distributor in synchronism with the transmitting distributor at the multiplex terminal, a motor for driving the branch station receiving distributor, a commutator driven by the motor and co-operating with a non-polar relay upon each energization to increase the current flow through the field windings of the motor for a period dependent upon the phase relation between the commutator and the received signal impulse.

8. In a telegraph system, a multiplexed main line over which negative and positive signals are transmitted, a synchronous multiplex distributor at one terminal of the line, a single channel extension line from said main line terminal to a branch station, transmitting and receiving continuously rotated synchronous distributors for each end of the extension line, means at the main line terminal and including the transmitting distributor thereat for converting the signals received over the main line into signals each composed of a negative or a positive impulse and a zero current interval, and transmitting said converted signals over said extension line, means at the branch station responsive to each signal impulse, driving means at the branch station for the receiving distributor thereat, a control circuit for said driving means closed once during each response of said responsive means for a period dependent

upon the phase relation between the driving means and the received signal impulse to maintain the branch station receiving distributor in synchronism with the transmitting distributor at the multiplex terminal, a motor for driving the branch station receiving distributor, a commutator driven by the motor having two segments, a brush continuously engaging each segment and a third brush for alternately engaging one segment during one-half revolution and the other segment during the other half revolution of the commutator, a control circuit for the motor including the field winding thereof, the third brush, one of the commutator segments and the brush in continuous engagement therewith closed once during each revolution of the commutator for a period dependent upon the phase relation between the commutator and the received signal impulse.

9. In a telegraph system, according to claim 8, characterized by the provision of means including a switch in the control circuit for shifting the phase of the control from one to the other half revolution of the commutator.

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