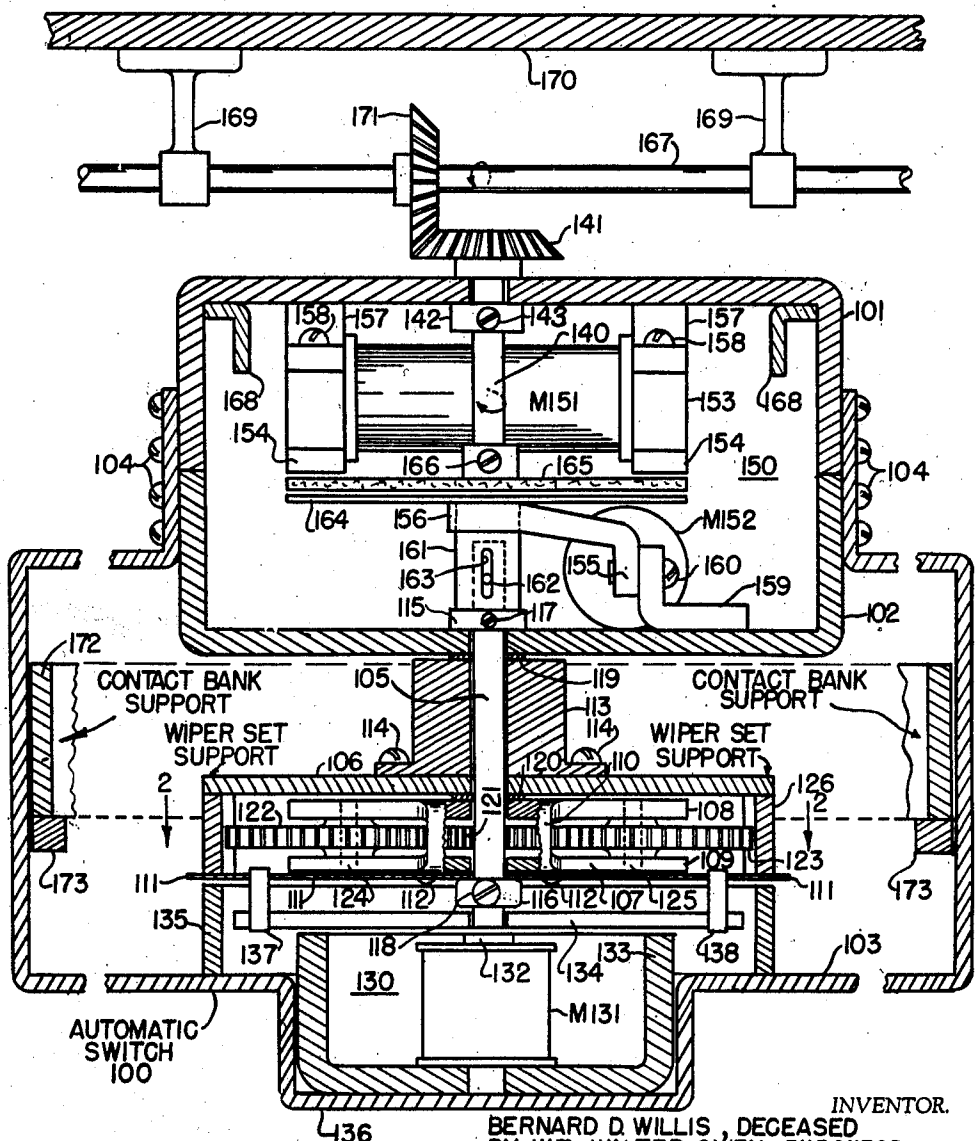
Feb. 1, 1944. B. D. WILLIS 2,340,445

AUTOMATIC SWITCH

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FIG. 1



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AUTOMATIC SWITCH

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FIG. 2

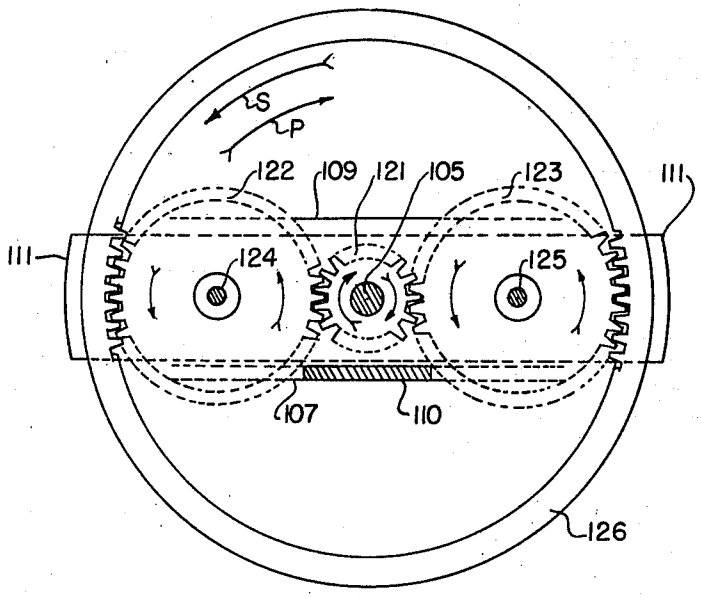
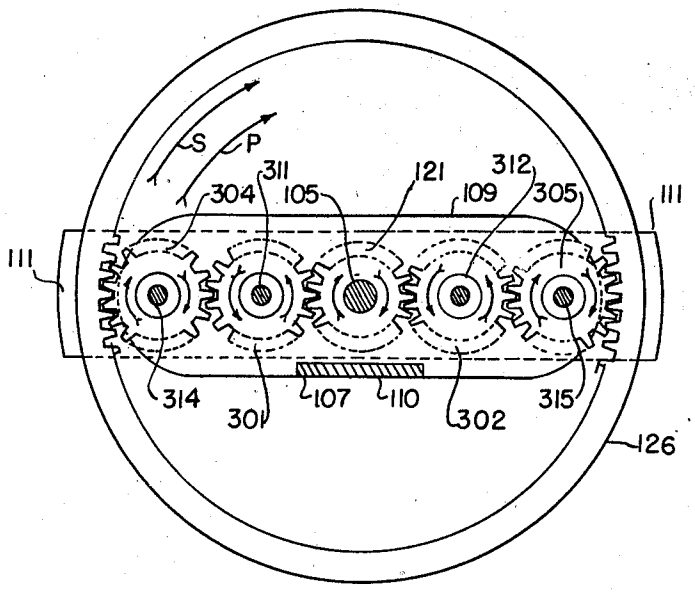


FIG. 3



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AUTOMATIC SWITCH

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FIG. 4

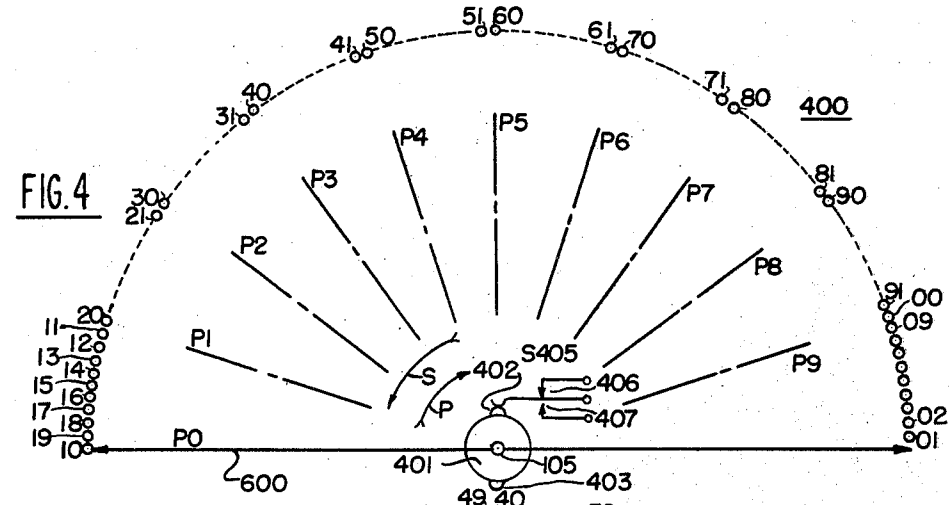
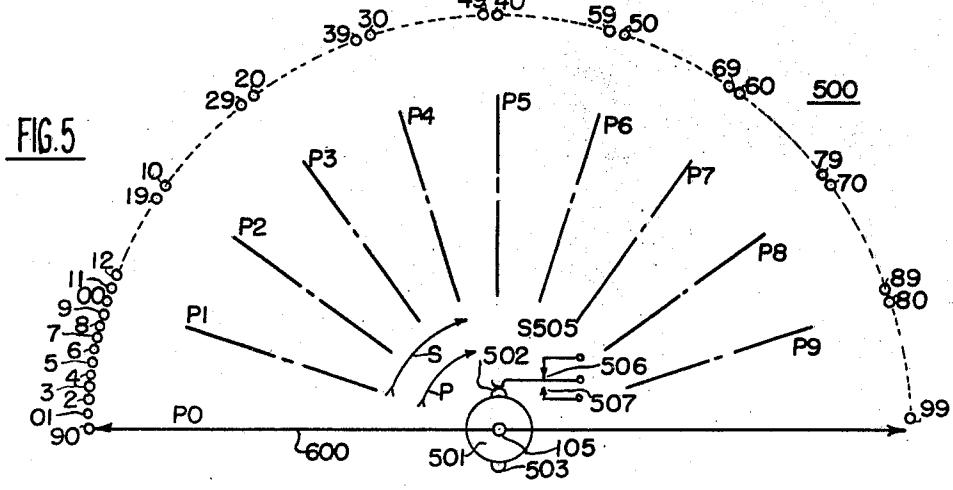


FIG. 5



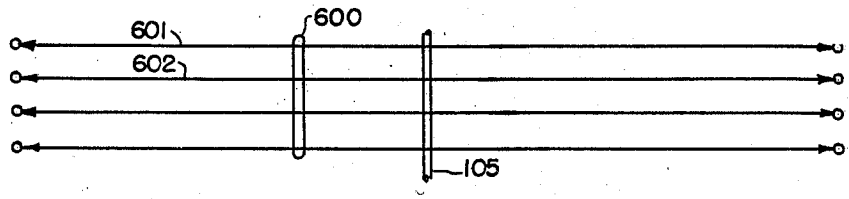


FIG. 6

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AUTOMATIC SWITCH

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FIG. 7

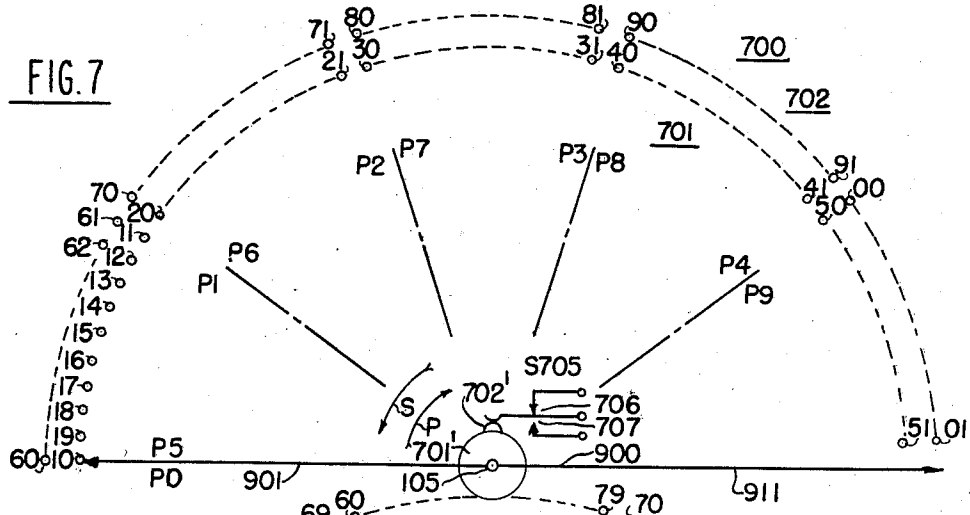


FIG. 8

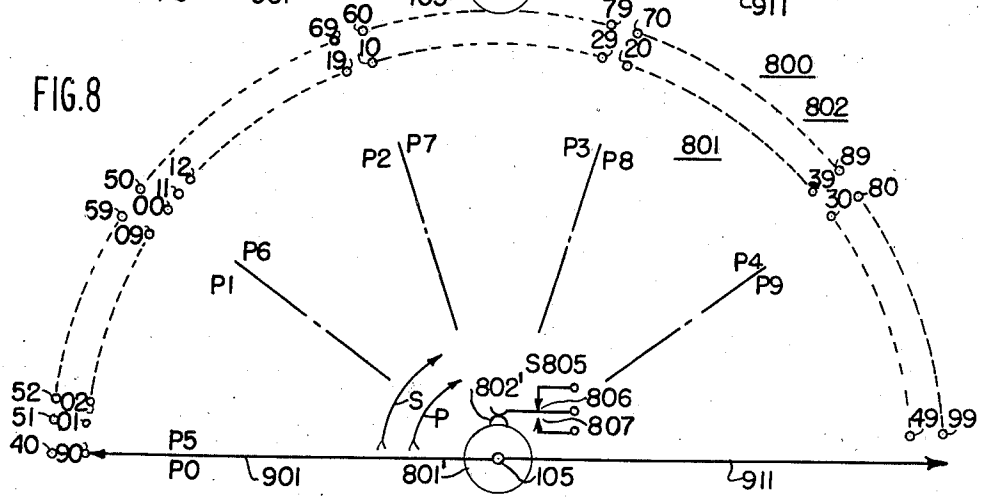
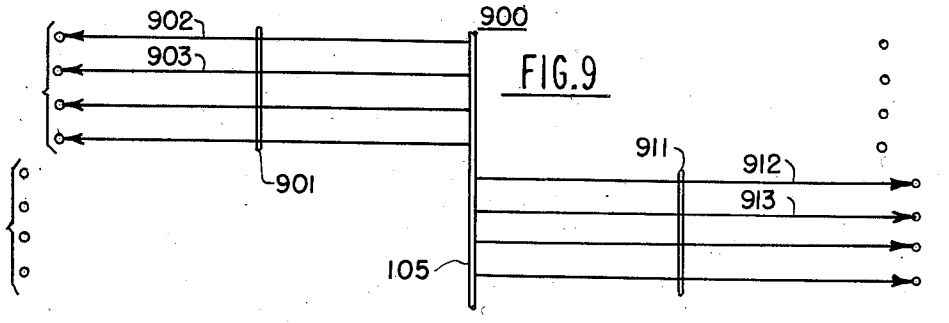


FIG. 9



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AUTOMATIC SWITCH

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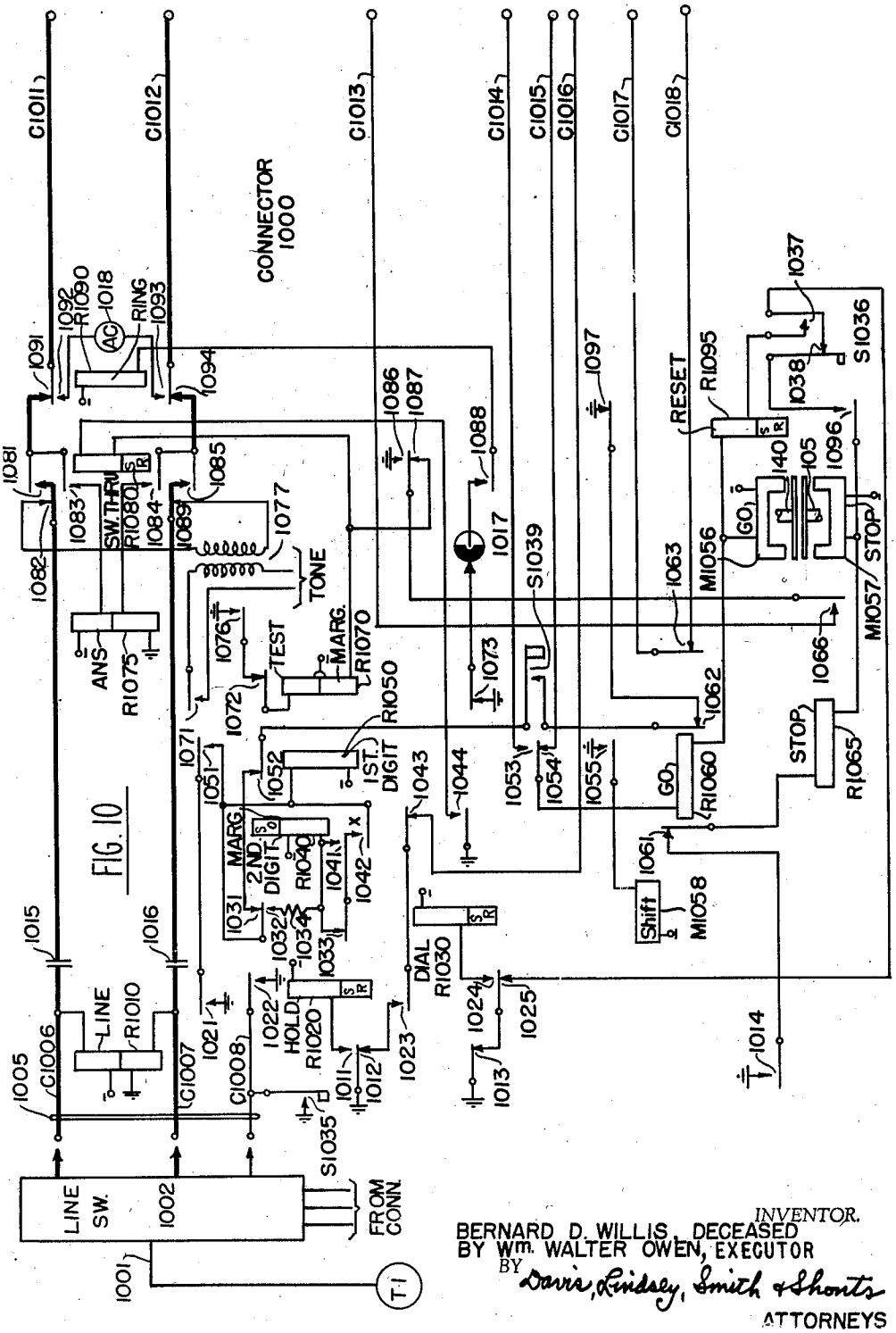


FIG. 10

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AUTOMATIC SWITCH

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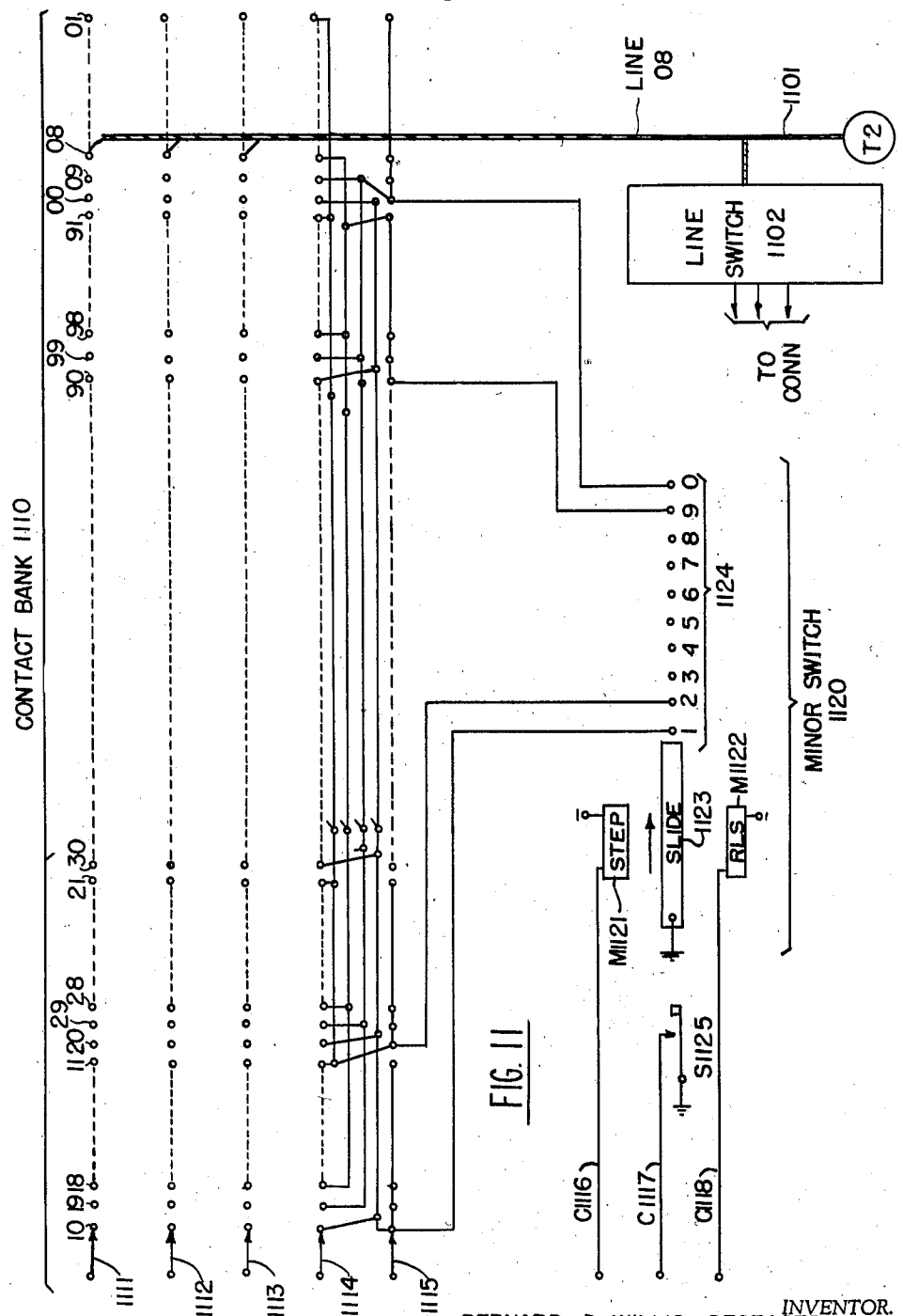


FIG. 11

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AUTOMATIC SWITCH

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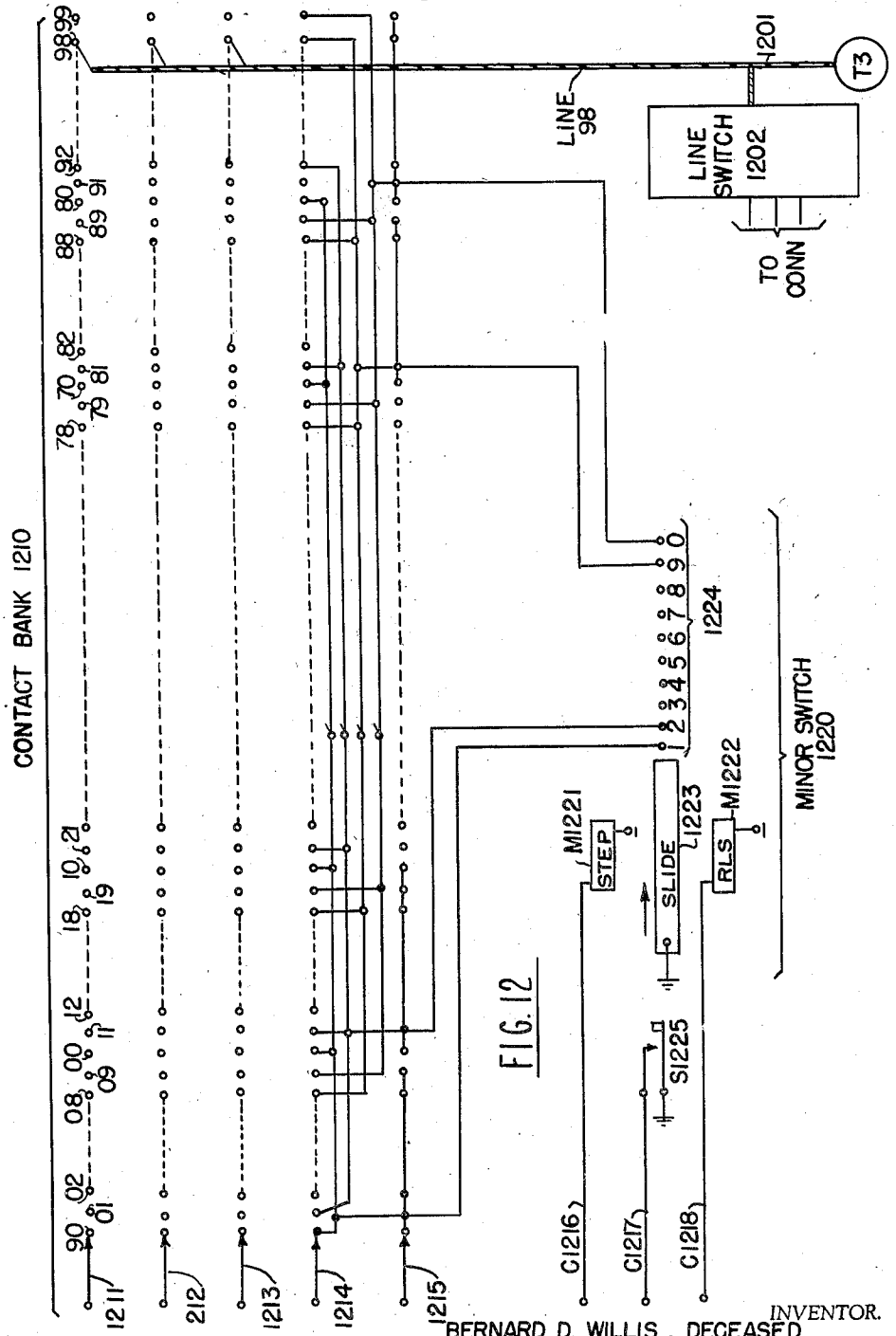


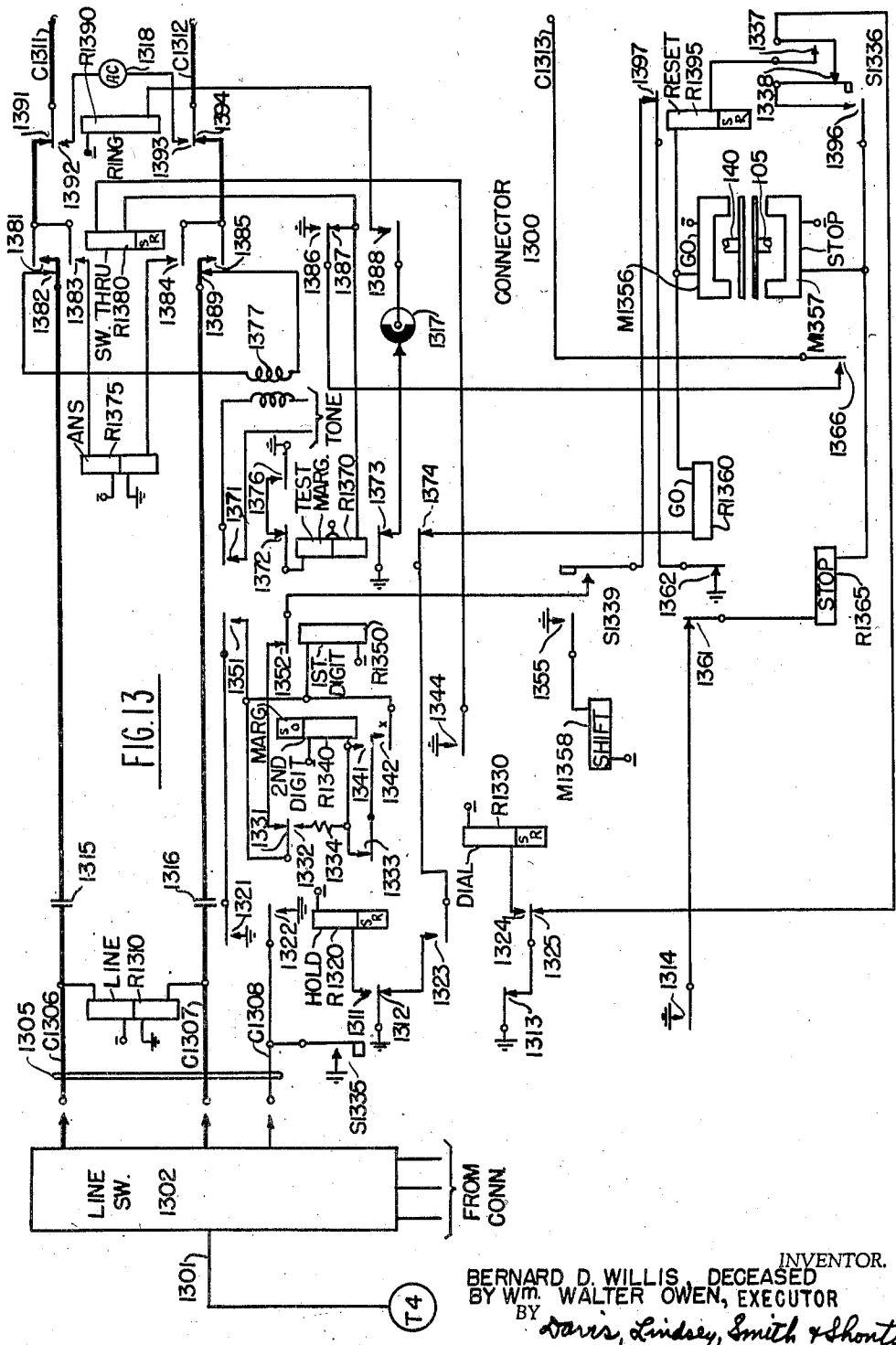
FIG. 12

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AUTOMATIC SWITCH

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AUTOMATIC SWITCH

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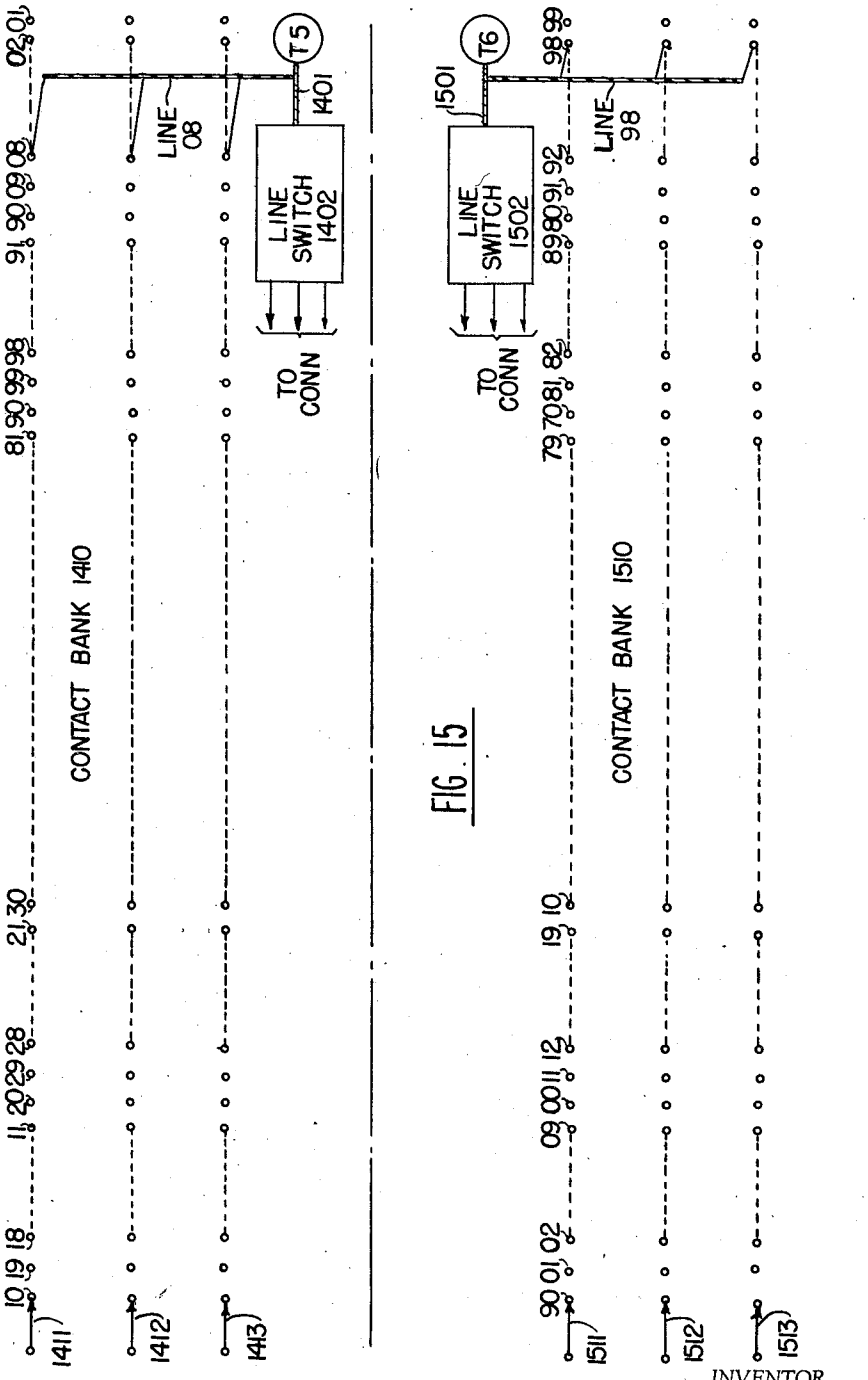


FIG. 14

FIG. 15

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Patented Feb. 1, 1944

2,340,445

UNITED STATES PATENT OFFICE

2,340,445

AUTOMATIC SWITCH

Bernard D. Willis, deceased, late of Oak Park, Ill., by Wm. Walter Owen, executor, Elgin, Ill., assignor to Automatic Electric Laboratories, Inc., a corporation of Delaware

Application April 13, 1942, Serial No. 438,695

14 Claims. (Cl. 179—27.51)

The present invention relates to switching systems and more particularly to automatic switches for telephone systems of the character of that disclosed in the copending application of Bernard D. Willis, Serial No. 377,835, filed February 7, 1941.

While the automatic switches utilized in the telephone system disclosed in the Willis application mentioned are entirely satisfactory in operation, they are of more complicated construction and arrangement than is desirable.

Accordingly one of the principal objects of the present invention is to provide an improved automatic switch of the character noted which is of relatively simple and compact construction and arrangement.

Another object of the invention is to provide an improved automatic switch including a contact controlling member having both primary and secondary movements along an associated single row of contacts.

A further object of the invention is to provide an improved automatic switch of the primary-secondary motion type, wherein the speeds at which the respective primary and secondary motions thereof take place are so correlated that the switch selects one group of contacts from the associated contact bank per unit time interval during the primary motion thereof and then selects one contact from the previously selected group of contacts per unit time interval during the secondary motion thereof.

A still further object of the invention is to provide an improved automatic switch of the primary-secondary rotation type, wherein the primary and secondary rotations thereof take place uniformly at different speeds along a single annular path.

In general, the objects set forth above are attained in accordance with the present invention by providing an automatic switch comprising a contact bank including a plurality of groups of contacts arranged in a row, each of the groups including N contacts, and a contact controlling member mounted for both primary and secondary movements along the row of contacts. Also the switch comprises means for imparting primary movement to the member at a substantially uniform speed NS, whereby the member selects from the contact bank one group of contacts per unit time interval during the primary movement thereof, and means for imparting secondary movement to the member at a substantially uniform speed S, whereby the member selects from the previously selected group of contacts one contact per unit time interval during the secondary movement thereof. More particularly, the groups of contacts in the contact bank are arranged in an annular row and the contact controlling member is mounted for both primary and secondary rotations along the annular row of contacts. Also primary rotation is imparted to the member at a substantially uniform speed $N\theta$ and secondary rotation is imparted to the member at a substantially uniform speed θ.

Further features of the invention pertain to the particular arrangement of the mechanical elements of the automatic switch, whereby the above-outlined and additional operating features are attained.

The invention, both as to its organization and method of operation, together with further objects and advantages thereof, will best be understood by reference to the following specification taken in connection with the accompanying drawings, in which Figure 1 is a side elevational view, partly in section, of an automatic switch embodying the present invention; Fig. 2 is a sectional view, taken along the line 2—2 in Fig. 1, of the gear train incorporated in the automatic switch shown in Fig. 1; Fig. 3 is a sectional view, similar to Fig. 2, of a modified form of the gear train, which is adapted to be incorporated in the automatic switch shown in Fig. 1; Fig. 4 is a diagrammatic illustration of one form of the contact bank of the automatic switch, which is utilized when the gear train shown in Fig. 2 is incorporated therein; Fig. 5 is a diagrammatic illustration of a modified form of the contact bank of the automatic switch, which is utilized when the gear train shown in Fig. 3 is incorporated therein; Fig. 6 is a diagrammatic illustration of one form of the wiper set of the automatic switch, which is utilized when either of the contact banks shown in Figs. 4 and 5 is employed; Fig. 7 is a diagrammatic illustration of another modified form of the contact bank of the automatic switch, which is utilized when the gear train shown in Fig. 2 is incorporated therein; Fig. 8 is a diagrammatic illustration of a further modified form of the contact bank of the automatic switch, which is utilized when the gear train shown in Fig. 3 is incorporated therein; Fig. 9 is a diagrammatic illustration of a modified form of the wiper set of the automatic switch, which is utilized when either of the contact banks shown in Figs. 7 and 8 is employed; Figs. 10 and 11, taken together, illustrate diagrammatically one form of a telephone system embodying the present invention and compris-

ing an automatic switch incorporating the gear train shown in Fig. 2 and utilizing either of the contact banks shown in Figs. 4 and 7; Figs. 10 and 12, taken together, illustrate diagrammatically a modified form of the telephone system and comprising an automatic switch incorporating the gear train shown in Fig. 3 and utilizing either of the contact banks shown in Figs. 5 and 8; Figs. 13 and 14, taken together, illustrate diagrammatically another modified form of the telephone system and comprising an automatic switch incorporating the gear train shown in Fig. 2 and utilizing either of the contact banks shown in Figs. 4 and 7; and Figs. 13 and 15, taken together, illustrate diagrammatically a further modified form of the telephone system and comprising an automatic switch incorporating the gear train shown in Fig. 3 and utilizing either of the contact banks shown in Figs. 5 and 8.

Referring now more particularly to Figs. 1 and 2 of the drawings there is illustrated an automatic switch 100 embodying the present invention, which comprises an upper supporting channel 101, a lower supporting channel 102 and a substantially U-shaped supporting bracket 103, the flanges of the supporting channels 101 and 102 being directed toward each other and secured together in place between the outer ends of the legs of the supporting bracket 103 by a plurality of screws 104. Also the switch 100 comprises an operating shaft 105 suitably journaled in a bearing provided in the bottom wall of the lower supporting channel 102, a carriage 106, a gear bracket 107 and a gear train supported by the gear bracket 107 and interposed between the operating shaft 105 and the carriage 106. More particularly, the carriage 106 is in the form of a disk disposed above the gear bracket 107 and surrounding the operating shaft 105; while the gear bracket 107 surrounds the operating shaft 105 and is of substantially U-shape, including upper and lower plates 108 and 109 and a connecting strap 110. Also a flexible friction plate 111 surrounds the operating shaft 105 and is rigidly secured to the lower plate 109 of the gear bracket 107 by a number of rivets 112. Further a collar 113 surrounds the operating shaft 105 and is rigidly secured to the upper surface of the carriage 106 by a number of screws 114. The carriage 106 and the supported collar 113, as well as the gear bracket 107 and the supported friction plate 111, are held in assembled relation upon the operating shaft 105 by an arrangement comprising two collars 115 and 116 respectively carried adjacent the upper and lower ends of the operating shaft 105. More particularly, the collar 115 is secured to the upper end of the operating shaft 105 by a set screw 117 and bears upon the adjacent upper surface of the bottom wall of the lower supporting channel 102; while the collar 116 is secured to the lower end of the operating shaft 105 by a set screw 118 and bears upon the adjacent lower surface of the friction plate 111. The collar 113 is spaced from the lower surface of the bottom wall of the lower supporting channel 102 by a washer 119 surrounding the operating shaft 105; while the carriage 106 and the upper plate 108 of the gear bracket 107 are arranged in spaced relation by a washer 120 surrounding the operating shaft 105.

It is noted that the gear train interposed between the operating shaft 105 and the carriage 106 comprises a drive gear 121 rigidly secured to the operating shaft 105 and arranged between the upper and lower plates 108 and 109 of the gear bracket 107, two transmission pinions 122 and 123 rotatably mounted on two pins 124 and 125 extending between the upper and lower plates 108 and 109 of the gear bracket 107 and a ring gear 126 rigidly secured to the lower surface of the carriage 106 adjacent the peripheral edge thereof. The teeth on the drive gear 121 mesh the teeth on the transmission pinions 122 and 123 disposed on opposite sides thereof; while the teeth on the transmission pinions 122 and 123 mesh the internal teeth on the ring gear 126. Finally it is noted that the opposite ends of the flexible friction plate 111 engage the lower surface of the ring gear 126 in order normally to lock the ring gear 126 and consequently the carriage 106 directly to the operating shaft 105.

Also the switch 100 comprises shift mechanism 130 for controlling the gear train and consequently the speed of rotation of the carriage 106. The shift mechanism 130 comprises a shift magnet M131, provided with a core 132, a cup-shaped field element 133 and a movable armature 134. Also the shift mechanism 130 includes a friction ring 135. The shift magnet M131, the core 132 and the field element 133 comprise a unit which is suitably secured in a centrally disposed U-shaped bend 136 formed in the supporting bracket 103; while the armature 134 surrounds the operating shaft 105 and is secured to the flexible friction plate 111 adjacent the outer ends thereof by two clips 137 and 138. The friction ring 135 is suitably secured to the supporting bracket 103 in surrounding relation with respect to the armature 134 and is arranged below the outer ends of the friction plate 111 in spaced relation with respect thereto. At this point it is noted that the outer ends of the friction plate 111 normally engage the lower surface of the ring gear 126, but are adapted to engage the upper surface of the friction ring 135 when the friction plate 111 is flexed due to movement of the armature 134 in a downward direction, in a manner more fully explained hereinafter.

Further the switch 100 comprises a stub shaft 140 suitably journaled in a bearing provided in the top wall of the upper supporting channel 101 and arranged in alignment with the operating shaft 105. The upper end of the stub shaft 140 carries a bevel gear 141 which bears against the upper surface of the top wall of the upper supporting channel 101. A collar 142 is secured to the stub shaft 140 by a set screw 143 and bears against the lower surface of the top wall of the upper supporting channel 101.

Further the switch 100 comprises clutch mechanism 150 including a go magnet M151 and a stop magnet M152. The go magnet M151 includes a core 153 carrying two spaced-apart field elements 154 on the opposite ends thereof; while the stop magnet M152 includes a core 155 carrying two spaced-apart field elements 156 on the opposite ends thereof. The core 153 is secured to two nonmagnetic brackets 157 by two screws 158, which brackets 157 are suitably secured to the top wall of the upper supporting channel 101. Similarly, the core 155 is secured to two nonmagnetic brackets 159 by two screws 160, which brackets 159 are suitably secured to the bottom wall of the lower supporting channel 102. The upper end of the operating shaft 105 carries a tubular collar 161 slidably mounted thereon, a pin 162 being fixed to the operating shaft 105 and arranged in a longitudinally extending slot 163 formed in the tubular collar 161. The lower end of the tubular collar 161 is normally supported

upon the collar 115 and the upper end thereof carries an annular flange 164 formed of magnetic material. A drive plate 165 is secured to the lower end of the stub shaft 140 by a set screw 166 and arranged above and in spaced relation with the annular flange 164.

The switch 100 is supported as a whole in cooperating relation with a drive shaft 167 upon two external supports 168 engaging the lower surface of the top wall and the adjacent flanges of the upper supporting channel 101. It is noted that the drive shaft 167 is common to a plurality of switches of the character of the switch 100 and is suitably journaled in a number of bearing brackets 169 carried by an external support 170. More particularly, the drive shaft 167 carries a bevel gear 171 which is arranged to mesh the bevel gear 141 carried on the upper end of the stub shaft 140 when the switch 100 is supported in place upon the external supports 168, in the manner noted above. Also the switch 100 is supported in cooperating relation with respect to a contact bank support 172 which carries a contact bank, not shown, the contact bank support 172 being disposed between the legs of the supporting bracket 103 and carried by two external supports 173. The external supports 173 and the contact bank support 172 engage the legs of the supporting bracket 103, thereby positively to position the switch 100. Further it is noted that the carriage 106 supports a wiper set, not shown, which cooperates with the contact bank carried by the contact bank support 172.

When the switch 100 is completely released the shift magnet M131 is deenergized, whereby the flexible friction plate 111 is biased, due to its inherent resiliency, into engagement with the lower surface of the ring gear 126 in order to lock the ring gear 126 and consequently the carriage 106 directly to the operating shaft 105, as previously noted. Also, at this time, the wiper set carried by the carriage 106 occupies its normal position with respect to the contact bank carried by the contact bank support 172, in a manner more fully explained hereinafter. Furthermore, the go magnet M151 and the stop magnet M152 are normally deenergized, whereby the tubular collar 161 occupies its normal position engaging the collar 115 and the annular flange 164 carried by the tubular collar 161 disengages the associated drive plate 165. Finally the drive shaft 167 is rotated at a constant speed in the clockwise direction, as viewed toward the right, in order to drive the stub shaft 140 at a constant speed in the clockwise direction, as viewed from the top. Hence, at this time, the stub shaft 140 and the drive plate 165 carried thereby are rotated in the clockwise direction above the annular flange 164 carried by the tubular collar 161.

In order to operate the switch 100, thereby to cause the wiper set carried by the carriage 106 to select a particular group of contact sets in the associated contact bank, the go magnet M151 is first energized and retained energized for a corresponding given time interval, depending upon the speed of rotation of the stub shaft 140, this given time interval comprising one or more unit time intervals, as explained more fully hereinafter; and, at the conclusion of this given time interval, the go magnet M151 is deenergized and the stop magnet M152 is energized. When the go magnet M151 is thus energized the field elements 154 thereof attract the annular flange 164, thereby to cause the annular flange 164 to move upwardly into frictional engagement with the drive plate 165, the pin and slot connection 162—163 between the operating shaft 105 and the tubular collar 161 accommodating this movement of the tubular collar 161 and the annular flange 164 carried thereby. When the annular flange 164 is thus moved by the go magnet M151 into frictional engagement with the drive plate 165 the operating shaft 105 is clutched to the stub shaft 140 and is rotated in the clockwise direction.

At this time the operating shaft 105 is directly locked to the ring gear 126 and consequently to the carriage 106 by the resilient friction plate 111, whereby the carriage 106 is rotated in the clockwise direction with the operating shaft 105 at the same speed. During this rotation of the operating shaft 105 the gear bracket 107 is rotated therewith, whereby the transmission pinions 122 and 123 remain stationary upon the associated pins 124 and 125, but are revolved about the operating shaft 105 with the gear bracket 107. As the carriage 106 is thus rotated in the clockwise direction the wiper set supported thereby is moved continuously with respect to the groups of contact sets in the associated contact bank, whereby the different groups of contact sets are progressively selected by the wiper set. More particularly, the speed of rotation of the operating shaft 105 is so related, with respect to the position of the groups of contact sets in the contact bank associated with the wiper set carried by the carriage 106, that the wiper set selects one group of contact sets in the associated contact bank during each unit time interval. Thus, at the conclusion of the first, second etc. unit time intervals, the wiper set has selected the corresponding first, second etc. groups of contact sets in the associated contact bank.

At the conclusion of the given time interval the go magnet M151 is deenergized and the stop magnet M152 is energized, as previously noted, whereupon the field elements 156 of the stop magnet M152 attract the annular flange 164 causing the tubular collar 161 and the annular flange 164 carried thereby to be moved downwardly, the pin and slot connection 162—163 between the operating shaft 105 and the tubular collar 161 facilitating this movement. At this time the stop magnet M152 is retained energized, thereby to retain the annular flange 164 out of engagement with the drive plate 165 and in locked engagement with the field elements 156. As long as the stop magnet M152 is retained energized, the annular flange 164 is retained in locked engagement with respect to the field elements 156, thereby to prevent movement of the carriage 106 and consequently the wiper set carried thereby.

At the conclusion of the rotary movement of the carriage 106 in the clockwise direction, which motion constitutes the primary motion of the switch 100, as explained above, the shift magnet M131 is energized. When the shift magnet M131 is thus energized the armature 134 is attracted by the cup-shaped field element 133 and is moved downwardly, whereby the straps 137 and 138 connecting the armature 134 to the flexible friction plate 111 flex the outer ends of the friction plate 111 downwardly out of engagement with the lower surface of the ring gear 126 and into engagement with the upper surface of the friction ring 135. When the armature 134 is thus operated in order to flex the friction plate 111, as explained above, the ring gear 126 and con-

sequently the carriage 106 are unlocked from the operating shaft 105; and the friction plate 111 and consequently the gear bracket 107 are locked to the stationary friction ring 135.

After the switch 100 has been operated in the manner described above, thereby to cause the wiper set carried by the carriage 106 to select one of the groups of contact sets in the associated contact bank carried by the contact bank support 172, the switch 100 is operated further in order to cause the wiper set to select a particular contact set in the previously selected group of contact sets in the associated contact bank. In order to accomplish this end, the stop magnet M152 is first deenergized and then the go magnet M151 is energized and retained energized for a corresponding given time interval, depending upon the speed of rotation of the stub shaft 140, this given time interval comprising one or more unit time intervals, as explained more fully hereinafter; and at the conclusion of this given time interval the go magnet M151 is deenergized and the stop magnet M152 is energized. When the stop magnet M152 is thus deenergized the field elements 156 release the annular flange 164; and when the go magnet M151 is thus energized the field elements 154 attract the annular flange 164, thereby again to clutch the annular flange 164 to the drive plate 165, in the manner previously explained; whereby the operating shaft 105 is again rotated in the clockwise direction with the stub shaft 140. The rotation of the operating shaft 105 in the clockwise direction effects rotation of the drive gear 121 in the clockwise direction, whereby the transmission pinions 122 and 123 are rotated in the counterclockwise direction about the pins 124 and 125 extending between the upper and lower plates 108 and 109 of the gear bracket 107 due to the fact that the gear bracket 107 is locked by the friction plate 111 to the stationary friction ring 135 against rotation in the clockwise direction. The rotation of the transmission pinions 122 and 123 in the counterclockwise direction about the pins 124 and 125 effects rotation of the ring gear 126 in the counterclockwise direction, whereby the carriage 106 is driven continuously in the counterclockwise direction during the given time interval mentioned.

As the carriage 106 is thus rotated in the counterclockwise direction the wiper set carried thereby successively engages the individual contact sets in the previously selected group of contact sets in the associated contact bank. The gear train interposed between the operating shaft 105 and the carriage 106 has a transmission ratio, as determined by the number of teeth disposed about the periphery of the drive gear 121 and the number of teeth disposed about the interior of the ring gear 126, of 10:1; whereby the operating shaft 105 is rotated in the clockwise direction ten times as fast as the rotation of the carriage 106 in the counterclockwise direction when the gear train is effective. At the conclusion of any given number of unit time intervals the wiper set engages a corresponding individual contact set in the previously selected group of contact sets in the associated contact bank. Thus at the conclusion of the first, second etc. unit time intervals the wiper set engages the corresponding first, second etc. individual contact sets in the previously selected group of contact sets in the associated contact bank.

At the conclusion of the given time interval the go magnet M151 is deenergized and the stop magnet M152 is again energized, as previously noted; whereupon the field elements 154 release the annular flange 164 and the field elements 156 attract the annular flange 164 in order to cause the annular flange 164 to be locked to the field elements 156, in the manner previously explained.

At this time the wiper set carried by the carriage 106 has selected a particular group of contact sets in the associated contact bank corresponding to the first time interval mentioned and a particular individual contact set in the previously selected group of contact sets in the associated contact bank corresponding to the second time interval mentioned, thereby to establish a connection to the particular selected individual contact set. At the conclusion of the rotary movement of the carriage 106 in the counter-clockwise direction, which motion constitutes the secondary motion of the switch 100, as explained above, the shift magnet M131 and the stop magnet M152 are retained energized.

In view of the foregoing explanation of the mode of operation of the switch 100 first to select a particular group of contact sets and then to select a particular individual contact set in the previously selected group of contact sets in the associated contact bank, it will be understood that the carriage 106 is first rotated in the clockwise direction, the primary movement of the switch 100, at a speed of 10S; then the carriage 106 is rotated in the counterclockwise direction, the secondary movement of the switch 100, at a speed of 1S. Accordingly the switch 100 operates during the primary movement of the carriage 106 to select one group of contact sets per unit time interval and then operates during the secondary movement of the carriage 106 to select one contact set from the previously selected group of contact sets per unit time interval.

In order completely to release the switch 100 the shift magnet M131 and the stop magnet M152 are first deenergized and the go magnet M151 is energized. When the shift magnet M131 is thus deenergized the armature 134 is released by the cup-shaped field element 133, whereby the friction plate 111 moves the armature 134 upwardly out of engagement with the cup-shaped field element 133 due to its own resiliency. Furthermore, the outer ends of the resilient friction plate 111 are moved upwardly out of engagement with the stationary friction ring 135 and into engagement with the ring gear 126, whereby the ring gear 126 and consequently the carriage 106 are again locked to the operating shaft 105 directly, as previously explained. When the stop magnet M152 is thus deenergized the field elements 156 release the annular flange 164; and when the go magnet M151 is thus energized the field elements 154 attract the annular flange 164, whereby the annular flange 164 is moved upwardly into engagement with the drive plate 165, in the manner previously explained. At this time the operating shaft 105 is again clutched to the stub shaft 140 and is rotated in the clockwise direction, whereby the carriage 106 and the wiper set carried thereby are rotated in the clockwise direction at the speed of 10S, in the manner previously explained. Finally when the wiper set carried by the carriage 106 is returned to its normal position the go magnet M151 is deenergized and the stop magnet M152 is energized. When the go magnet M151 is thus deenergized the field elements 154 release the annular flange 164; and when the stop magnet M152 is thus energized the field elements 156 attract the annular flange

164, whereby the annular flange 164 is moved downwardly into locked engagement with the field elements 156, in the manner previously explained. At this time the operating shaft 105 is again declutched from the stub shaft 140. Ultimately the stop magnet M152 is deenergized; however, the annular flange 164 remains in engagement with the field elements 156 due to the action of gravity in view of the fact that the go magnet M151 is not energized at this time. At this time the switch 100 is completely released and available for further use.

In view of the foregoing explanation of the release of the switch 100 it will be understood that the carriage 106 thereof is rotated in the clockwise direction back to its normal position at the speed of 10S due to the fact that the shift magnet M131 is deenergized at the beginning of the release period. Accordingly the carriage 106 of the switch 100 is rapidly returned, in the clockwise direction, to its normal position, in the manner explained above.

Referring now more particularly to Fig. 3 of the drawings, a modified form of the gear train, similar to the gear train shown in Fig. 2, is illustrated, which may be incorporated in the switch shown in Fig. 1. More particularly, this gear train comprises, in addition to the drive gear 121 and the ring gear 126, two sets of transmission pinions 301, 302 and 304, 305 interposed between the operating shaft 105 and the carriage 106. More specifically, the drive gear 121 is rigidly secured to the operating shaft 105 and the transmission pinions 301, 302, 303 and 304 are respectively rotatably mounted upon pins 311, 312, 314 and 315 extending between the upper and lower plates 108 and 109 of the gear bracket 107. The teeth on the drive gear 121 mesh the teeth on the transmission pinions 301 and 302 disposed on opposite sides thereof; the teeth on the transmission pinions 301 and 302 respectively mesh the teeth on the transmission pinions 304 and 305 disposed on opposite sides thereof; while the teeth on the transmission pinions 304 and 305 mesh the teeth disposed about the interior of the ring gear 126 at opposite sides thereof.

The gear train shown in Fig. 3 may be substituted directly for the gear train shown in Fig. 2 in the switch shown in Fig. 1, in an obvious manner, in order to produce a modified switch 100. Considering now the operation of the modified switch 100 it is noted that the primary movement of the carriage 106 in the clockwise direction is the same as that previously described in view of the fact that, during the primary movement of the switch, the operating shaft 105 is locked directly to the ring gear 126 and consequently to the carriage 106, in the manner previously explained. However, the secondary movement of the carriage 106 is modified due to the interposition of the two sets of transmission pinions 301, 302 and 304, 305 between the drive gear 121 and the ring gear 126. More particularly, when the armature 134 is operated in order to flex the outer ends of the friction plate 111 out of engagement with the ring gear 126 and into engagement with the stationary friction gear 135, the operating shaft 105 is operatively connected to the carriage 106 through the gear train, as previously explained. At this time, rotation of the operating shaft 105 in the clockwise direction effects rotation of the drive gear 121 in the clockwise direction, and the consequent rotation of the transmission pinions 301 and 302 in the counterclockwise direction about the pins 311 and 312. The rotation of the transmission pinions 301 and 302 in the counterclockwise direction about the pins 311 and 312 effects rotation of the transmission pinions 304 and 305 in the clockwise direction about the pins 314 and 315. Finally the rotation of the transmission pinions 304 and 305 in the clockwise direction about the pins 314 and 315 effects rotation of the ring gear 126 and consequently the carriage 106 in the clockwise direction. Accordingly, in the modified form of the switch 100, not only the primary movement of the carriage 106 but also the secondary movement thereof takes effect in the clockwise direction. Moreover, in the modified switch 100, the gear train interposed between the operating shaft 105 and the carriage 106 has a transmission ratio, as determined by the number of teeth disposed about the periphery of the drive gear 121 and the number of teeth disposed about the interior of the ring gear 126, of 10:1; whereby the operating shaft 105 is rotated in the clockwise direction ten times as fast as the rotation of the carriage 106 in the clockwise direction, when the gear train is effective.

Thus, at the conclusion of any given number of unit time intervals, the wiper set engages a corresponding individual contact set in the previously selected group of contact sets in the associated contact bank. Thus, at the conclusion of the first, second, etc., unit time intervals, the wiper set engages the corresponding first, second, etc., individual contact sets in the previously selected group of contact sets in the associated contact bank.

The subsequent operation of the modified switch 100 at the conclusion of the second time interval, as well as the ultimate release thereof, is the same as those previously explained. More particularly, incident to the release of the modified switch, the carriage 106 is rotated in the clockwise direction back into its normal position.

In view of the foregoing explanation of the mode of operation of the modified switch 100 to select first a particular group of contact sets anld then a particular individual contact set in the previously selected group of contact sets in the associated contact bank, it will be understood that the carriage 106 is first rotated in the clockwise direction, the primary movement of the modified switch 100 at a speed of 10S; then the carriage 106 is rotated in the clockwise direction, the secondary movement of the modified switch 100, at a speed of 1S. Accordingly the modified switch 100 operates during the primary movement of the carriage 106 to select one group of contact sets per unit time interval and then operates during the secondary movement of the carriage 106 to select one contact set from the previously selected group of contact sets per unit time interval. Also it will be understood that, during the release of the modified switch 100, the carriage 106 thereof is rotated in the clockwise direction back to its normal position, at the speed of 10S, due to the fact that the shift magnet M131 is deenergized at the beginning of the release period. Accordingly the carriage 106 of the modified switch 100 is rapidly returned in the clockwise direction to its normal position, in the manner explained above.

Referring now more particularly to Figs. 4 and 6 of the drawings, there are illustrated diagrammatically one form of the wiper set 600 and the associated contact bank 400 of the switch 100 which may be utilized when the gear train, shown in Fig. 2, is incorporated therein. More particu-

larly, the wiper set 600 is carried by the operating shaft 105 and comprises a number of wipers 601, 602, etc. of the double-ended type; while the contact bank 400 is of the 100-point type. More specifically, the contact bank 400 comprises ten groups of contact sets; each group of contact sets comprises ten individual contact sets; and each individual contact set comprises a number of contacts respectively associated with the wipers 601, 602, etc., of the wiper set 600.

In this form of the switch 100 the wiper set 600 is rotated continuously during the primary movement thereof in the clockwise direction, as indicated by the arrow P, from the normal position P0 successively through the positions P1, P2, etc., and P9 during the successive corresponding time intervals. Subsequently the wiper set 600 is rotated continuously during the secondary movement thereof in the counterclockwise direction, as indicated by the arrow S, from the operated position P1, P2, etc., back toward the adjacent position P0, P1, etc., during the corresponding time intervals.

From an examination of the contact bank 400 shown in Fig. 4, it will be understood that, in order to operate the switch 100 to select the contact sets 11, 12, etc., the wiper set 600 is first rotated in the clockwise direction during the primary movement thereof from the normal position P0 engaging the contact set 10 to the position P1 to engage the contact set 20, and is then rotated in the counterclockwise direction during the secondary movement thereof from the operated position P1 toward the adjacent position P0 to engage the contact sets 11, 12, etc. Similarly, in order to operate the switch 100 to select the contact sets 01, 02, etc., the wiper set 600 is first rotated in the clockwise direction during the primary movement thereof from the normal position P0 engaging the contact set 10 back to the position P0 to engage the contact set 10, and is then rotated in the counterclockwise direction during the secondary movement thereof from the operated position P0 toward the adjacent position P9 to engage the contact sets 01, 02, etc. Ultimately, when the switch 100 is released the wiper set 600 is rotated in the clockwise direction from the engaged contact set back to the normal position P0 to engage the contact set 10.

Also the operating shaft 105 operates off-normal switch control mechanism illustrated diagrammatically as a cam 401 carried by the operating shaft 105 and an associated set of switch springs S405. The cam 401 comprises two projections 402 and 403 corresponding to the two normal positions of the wiper set 600; while the set of switch springs S405 comprises a set of contacts 406 which is engaged when the wiper set 600 occupies either one of its normal positions and a set of contacts 407 which is engaged when the wiper set 600 occupies other than one of its normal positions. This off-normal switch control mechanism is utilized in the switch 100 for a purpose more fully explained hereinafter.

Referring now more particularly to Figs. 5 and 6 of the drawings, there are illustrated diagrammatically one form of the wiper set 600 and the associated contact bank 500 of the switch 100 which may be utilized when the gear train, shown in Fig. 3, is incorporated therein. More particularly, the wiper set 600 is carried by the operating shaft 105 and comprises a number of wipers 601, 602, etc., of the double-ended type, as previously noted; while the contact bank 500 is of the 100-point type. More specifically, the contact bank 500 comprises ten groups of contact sets; each group of contact sets comprises ten individual contact sets; and each individual contact set comprises a number of contacts respectively associated with the wipers 601, 602, etc., of the wiper set 600.

In this form of the switch 100 the wiper set 600 is rotated continuously during the primary movement thereof in the clockwise direction, as indicated by the arrow P, from the normal position P0 successively through the positions P1, P2, etc., and P9 during the successive corresponding time intervals. Subsequently the wiper set 600 is rotated continuously during the secondary movement thereof in the clockwise direction, as indicated by the arrow S, from the operated position P1, P2, etc., forwardly toward the adjacent position P2, P3, etc., during the corresponding time intervals.

From an examination of the contact bank 500 shown in Fig. 5, it will be understood that, in order to operate the switch 100 to select the contact sets 11, 12, etc., the wiper set 600 is first rotated in the clockwise direction, during the primary movement thereof, from the normal position P0 engaging the contact set 90 to the position P1 to engage the contact set 00, and is then rotated in the clockwise direction, during the secondary movement thereof, from the operated position P1 toward the adjacent position P2 to engage the contact sets 11, 12, etc. Similarly, in order to operate the switch 100 to select the contact sets 01, 02, etc., the wiper set 600 is first rotated in the clockwise direction, during the primary movement thereof, from the normal position P0 engaging the contact set 90 back to the position P0 to engage the contact set 90, and is then rotated in the clockwise direction, during the secondary movement thereof, from the operated position P0 toward the adjacent position P1 to engage the contact sets 01, 02, etc. Ultimately, when the switch 100 is released the wiper set 600 is rotated in the clockwise direction from the engaged contact set back to the normal position P0 to engage the contact set 90.

Also the operating shaft 105 operates off-normal switch control mechanism illustrated diagrammatically as a cam 501 carried by the operating shaft 105 and an associated set of switch springs S505. The cam 501 comprises two projections 502 and 503 corresponding to the two normal positions of the wiper set 600; while the set of switch springs S505 comprises a set of contacts 506 which is engaged when the wiper set 600 occupies either one of its normal positions and a set of contacts 507 which is engaged when the wiper set 600 occupies other than one of its normal positions. This off-normal switch control mechanism is utilized in the switch 100, for a purpose more fully explained hereinafter.

Referring now more particularly to Figs. 7 and 9 of the drawings, there are illustrated diagrammatically a modified form of the wiper set 900 and the associated contact bank 700 of the switch 100 which may be utilized when the gear train, shown in Fig. 2, is incorporated therein. More particularly, the wiper set 900 is carried by the operating shaft 105 and comprises a first section 901, including a number of wipers 902, 903, etc., and a second section 911, including a number of wipers 912, 913, etc.; while the contact bank 700 is of the 100-point type and comprises a first section 701 associated with the first section 901 of the wiper set 900 and a second section 702 associated with the second sec-

tion 911 of the wiper set 900. Preferably the first section 901 of the wiper set 900 is arranged above the second section 911 thereof; and the first section 701 of the contact bank 700 is arranged above the second section 702 thereof. Each of the sections 701 and 702 of the contact bank 700 comprises five groups of contact sets; each group of contact sets comprises ten individual contact sets; and each individual contact set comprises a number of contacts. The contacts in each contact set in the first section 701 of the contact bank 700 are respectively associated with the wipers 902, 903, etc., of the first section 901 of the wiper set 900; while the contacts in each contact set in the second section 702 of the contact bank 700 are respectively associated with the wipers 912, 913, etc., of the second section 911 of the wiper set 900.

In this form of the switch 100 the wiper set 900 is rotated continuously during the primary movement thereof in the clockwise direction, as indicated by the arrow P, from the normal position P0 successively through the positions P1, P2, etc., and P9 during the successive corresponding time intervals. During this primary movement of the wiper set 900 the first section 901 thereof cooperates with the associated first section 701 of the contact bank 700 in the positions P0, P1, P2, P3 and P4 and the second section 911 thereof cooperates with the associated second section 702 of the contact bank 700 in the positions P5, P6, P7, P8 and P9. Subsequently the wiper set 900 is rotated continuously during the secondary movement thereof in the counterclockwise direction, as indicated by the arrow S, from the operated position P1, P2, etc., back toward the adjacent position P0, P1, etc., during the corresponding time intervals.

From an examination of the contact bank 700 shown in Fig. 7, it will be understood that, in order to operate the switch 100 to select the contact sets 11, 12, etc., the wiper set 900 is first rotated in the clockwise direction during the primary movement thereof, whereby the first section 901 of the wiper set 900 is moved from the normal position P0 engaging the contact set 10 to the position P1 to engage the contact set 20; the wiper set 900 is then rotated in the counterclockwise direction during the secondary movement thereof, whereby the first section 901 of the wiper set 900 is moved from the operated position P1 toward the adjacent position P0 to engage the contact sets 11, 12, etc. Similarly, in order to operate the switch 100 to select the contact sets 51, 52, etc., the wiper set 900 is first rotated in the clockwise direction during the primary movement thereof, whereby the first section 901 of the wiper set 900 is moved from the normal position P0 engaging the contact set 10 to bring the second section 911 of the wiper set 900 to the position P5 to engage the contact set 60; the wiper set 900 is then rotated in the counterclockwise direction during the secondary movement thereof, whereby the second section 911 thereof is moved from the operated position P5 and the first section 901 thereof is moved toward the adjacent position P4 to engage the contact sets 51, 52, etc. In order to operate the switch 100 to select the contact sets 61, 62, etc., the wiper set 900 is first rotated in the clockwise direction during the primary movement thereof, whereby the first section 901 of the wiper set 900 is moved from the normal position P0 engaging the contact set 10 to bring the second section 911 of the wiper set 900 to the position P6 to engage the contact set 70; the wiper set 900 is then rotated in the counterclockwise direction during the secondary movement thereof, whereby the second section 911 of the wiper set 900 is moved from the operated position P6 toward the adjacent position P5 to engage the contact sets 61, 62, etc. Similarly, in order to operate the switch 100 to select the contact sets 01, 02, etc., the wiper set 900 is first rotated in the clockwise direction during the primary movement thereof, whereby the first section 901 of the wiper set 900 is moved from the normal position P0 engaging the contact set 10 back to the position P0 to engage the contact set 10; the wiper set 900 is then rotated in the counterclockwise direction during the secondary movement thereof, whereby the first section 901 thereof is moved from the operated position P0 and the second section 911 thereof is moved toward the adjacent position P9 to engage the contact sets 01, 02, etc. Ultimately, when the switch 100 is released the wiper set 900 is rotated in the clockwise direction from the contact set engaged by either the first section 901 or the second section 911 thereof to bring the first section 901 thereof back to the normal position P0 to engage the contact set 10.

Also the operating shaft 105 operates off-normal switch control mechanism illustrated diagrammatically as a cam 701' carried by the operating shaft 105 and an associated set of switch springs S705. The cam 701' comprises a single projection 702' corresponding to the single normal position of the wiper set 900; while the set of switch springs S705 comprises a set of contacts 706 which is engaged when the wiper set 900 occupies its normal position, and a set of contacts 707 which is engaged when the wiper set 900 occupies other than its normal position. This off-normal switch control mechanism is utilized in the switch 100, for a purpose more fully explained hereinafter.

Referring now more particularly to Figs. 8 and 9 of the drawings there are illustrated diagrammatically a modified form of the wiper set 900 and the associated contact bank 800 of the switch 100 which may be utilized when the gear train, shown in Fig. 3, is incorporated therein. More particularly, the wiper set 900 is carried by the operating shaft 105 and comprises a first section 901, including a number of wipers 902, 903, etc., and a second section 911, including a number of wipers 912, 913, etc., as previously noted; while the contact bank 800 is of the 100-point type and comprises a first section 801 associated with the first section 901 of the wiper set 900 and a second section 802 associated with the second section 911 of the wiper set 900. Preferably the first section 901 of the wiper set 900 is arranged above the second section 911 thereof; and the first section 801 of the contact bank 800 is arranged above the second section 802 thereof. Each of the sections 801 and 802 of the contact bank 800 comprises five groups of contact sets; each group of contact sets comprises ten individual contact sets; and each individual contact set comprises a number of contacts. The contacts in each contact set in the first section 801 of the contact bank 800 are respectively associated with the wipers 902, 903, etc., of the first section 901 of the wiper set 900; the contacts in each contact set in the second section 802 of the contact bank 800 are respectively associated with the wipers 912, 913, etc., of the second section 911 of the wiper set 900.

In this form of the switch 100 the wiper set 900 is rotated continuously, during the primary movement thereof, in the clockwise direction, as indicated by the arrow P, from the normal position P0 successively through the positions P1, P2 etc. and P9 during the successive corresponding time intervals. During this primary movement of the wiper set 900 the first section 901 thereof cooperates with the associated first section 801 of the contact bank 800 in the positions P0, P1, P2, P3 and P4, and the second section 911 thereof cooperates with the associated second section 802 of the contact bank 800 in the positions P5, P6, P7, P8 and P9. Subsequently the wiper set 900 is rotated continuously during the secondary movement thereof, in the clockwise direction, as indicated by the arrow S, from the operated position P1, P2 etc. forwardly toward the adjacent position P2, P3, etc. during the corresponding time intervals.

From an examination of the contact bank 800 shown in Fig. 8, it will be understood that, in order to operate the switch 100 to select the contact sets 11, 12 etc., the wiper set 900 is first rotated in the clockwise direction during the primary movement thereof, whereby the first section 901 of the wiper set 900 is moved from the normal position P0 engaging the contact set 90 to the position P1 to engage the contact 00; the wiper set 900 is then rotated in the clockwise direction during the secondary movement thereof, whereby the first section 901 of the wiper set 900 is moved from the operated position P1 toward the adjacent position P2 to engage the contact sets 11, 12 etc. Similarly, in order to operate the switch 100 to select the contact sets 51, 52 etc., the wiper set 900 is first rotated in the clockwise direction during the primary movement thereof, whereby the first section 901 of the wiper set 900 is moved from the normal position P0 engaging the contact set 90 to bring the second section 911 of the wiper set 900 to the position P5 to engage the contact set 50; the wiper set 900 is then rotated in the clockwise direction during the secondary movement thereof, whereby the second section 911 thereof is moved from the operated position P5 toward the adjacent position P6 to engage the contact sets 51, 52 etc. Similarly, in order to operate the switch 100 to select the contact sets 01, 02 etc., the wiper set 900 is first rotated in the clockwise direction during the primary movement thereof, whereby the first section 901 of the wiper set 900 is moved from the normal position P0 engaging the contact set 90 back to the position P0 to engage the contact set 90; the wiper set 900 is then rotated in the clockwise direction during the secondary movement thereof, whereby the first section 901 thereof is moved from the operated position P0 toward the adjacent position P1 to engage the contact sets 01, 02 etc. Ultimately, when the switch 100 is released the wiper set 900 is rotated in the clockwise direction from the contact set engaged by either the first section 901 or the second section 911 thereof to bring the first section 901 thereof back to the normal position P0 to engage the contact set 90.

Also the operating shaft 105 operates off-normal switch control mechanism illustrated diagrammatically as a cam 801' carried by the operating shaft 105 and an associated set of switch springs S805. The cam 801' comprises a single projection 802' corresponding to the single normal position of the wiper set 900; while the set of switch springs S805 comprises a set of contacts 806 which is engaged when the wiper set 900 occupies its normal position and a set of contacts 807 which is engaged when the wiper set 900 occupies other than its normal position. This off-normal switch control mechanism is utilized in the switch 100, for a purpose more fully explained hereinafter.

Referring now more particularly to Figs. 10 and 11 of the drawings there is illustrated an automatic telephone system comprising an exchange having a plurality of subscriber lines extending thereto, including the subscriber lines 1001 and 1101 respectively extending to the subscriber substations T1 and T2. Also the exchange comprises subscriber controlled switching apparatus for setting up connections between the various subscriber lines, the switching apparatus comprising a line switch individual to each subscriber line, the line switches 1002 and 1102 being individual to the subscriber lines 1001 and 1101, respectively, and a group of connectors including the connector 1000. Preferably, each of the line switches has access to each of the connectors and each of the connectors has access to each of the subscriber lines in the exchange.

Preferably each subscriber substation comprises conventional subscriber substation apparatus including a telephone instrument, a ringer and a calling device or dial. Preferably each line switch is identical to the line switches 1002 and 1102, which line switches are connected and arranged in accordance with conventional practice.

Preferably each of the connectors is identical to the connector 1000 which comprises an automatic switch of the character of the automatic switch 100 shown in Fig. 1; which automatic switch has incorporated therein a gear train of the character of that shown in Fig. 2 and is provided with an associated contact bank of the character of that shown either in Fig. 4 or in Fig. 7 and a corresponding wiper set of the character of that shown either in Fig. 6 or in Fig. 9. In other words, the automatic switch incorporated in the connector 1000 is of the type disclosed, wherein the wiper set thereof is advanced continuously during the primary movement thereof in the clockwise direction and then is advanced continuously during the secondary movement thereof in the counterclockwise direction, in the manner previously explained. Also this automatic switch comprises a go magnet M1056, a stop magnet M1057, a shift magnet M1058, three sets of switch springs S1035, S1036 and S1039, a wiper set including the wipers 1111 to 1115, inclusive, and an associated contact bank 1110.

Also the connector 1000 comprises a minor switch 1120, including a slide 1123, an associated contact bank 1124, a step magnet M1121 for moving the slide 1123 step by step with respect to the associated contact bank 1124, and a release magnet M1122 for releasing the slide 1123 and for causing it to be returned to its normal position. Also a set of switch springs S1125 is associated with the slide 1123 of the minor switch 1120.

Further the connector 1000 comprises a relay group including a line relay R1010, a hold relay R1020, a dial relay R1030, a first digit relay R1050, a second digit relay R1040, a go relay R1060, a stop relay R1065, a test relay R1070, an answer relay R1075, switch-through relay R1080, a ring relay R1090 and a reset relay R1095, and a control network.

In the connector 1000 the circuit elements of the relay group are strapped to the individual

wipers of the wiper set of the automatic switch and to certain elements of the minor switch 1120. More particularly, the conductors C1011, C1012, C1013, C1014 and C1015 are respectively strapped to the line wiper 1111, the line wiper 1112, the control wiper 1113, the unit wiper 1114 and the group wiper 1115 of the wiper set of the automatic switch; and the conductors C1016, C1017 and C1018 are respectively strapped to the conductors C1116, C1117 and C1118 extending to the minor switch 1120.

The mechanical construction and arrangement of the automatic switch 100 shown in Fig. 1, as well as the electrical connection and arrangement of the telephone system shown in Figs. 10 and 11, will best be understood from a consideration of the mode of operation of the apparatus incorporated in the system incident to the extension of a telephone connection from the subscriber substation T1 to the subscriber substation T2.

A call is initiated at the subscriber substation T1 by removing the receiver of the telephone instrument thereat from its associated switchhook, whereupon the line switch 1002 operates automatically to search for a trunk extending to an idle connector in accordance with conventional practice. Assuming that the connector 1000 is the first idle connector accessible to the line switch 1002, the line switch 1002 operates to seize the trunk 1005 extending thereto, the trunk 1005 being marked as idle by the absence of ground potential upon the control conductor C1008 thereof. When the line switch 1002 seizes the trunk 1005 further operation thereof is arrested and it operates to switch through, thereby to complete an obvious connection between the subscriber line 1001 and the line conductors C1006 and C1007 of the trunk 1005. When this connection is completed an obvious loop circuit is completed between the calling subscriber substation T1 and the upper and lower windings of the line relay R1010 in the connector 1000 by way of the subscriber line 1001, the line switch 1002 and the trunk 1005. When thus energized the line relay R1010 operates to complete, at the contacts 1011, an obvious circuit for energizing the winding of the hold relay R1020, thereby to cause the latter relay to operate. Also the line relay R1010 completes, at the contacts 1014, an obvious circuit, including the contacts 1061, for energizing the winding of the stop relay R1065 in series with the stop magnet M1057, thereby to cause the stop relay R1065 to operate and to cause the stop magnet M1057 to operate in order positively to lock the operating shaft 105 against rotation at this time. Upon operating, the hold relay R1020 completes, at the contacts 1022, an obvious path for applying ground potential to the control conductor C1008 of the trunk 1005, thereby to mark the connector 1000 as busy to the other line switches having access thereto. At this time an operative connection is completed between the calling subscriber substation T1 and the connector 1000, and the connector 1000 is in readiness to receive the first digit.

The subscriber at the calling subscriber substation T1 then dials the first digit at the calling device thereat, whereby a corresponding number of impulses are transmitted over the subscriber line 1001 to the line relay R1010. The line relay R1010 follows the impulses of the first digit, restoring each time the circuit for energizing in series the upper and lower windings thereof is interrupted and operating each time the circuit for energizing the upper and lower windings thereof in series is recompleted, in accordance with conventional practice. Upon restoring, the line relay R1010 interrupts, at the contacts 1011, the previously mentioned circuit for energizing the winding of the hold relay R1020 and completes, at the contacts 1012, an obvious path, including the contacts 1023 and 1043 and the conductors C1016 and C1116, for energizing the step magnet M1121 of the miner switch 1120. Also, upon restoring, the line relay R1010 completes, at the contacts 1013, an obvious circuit, including the contacts 1024, for energizing the winding of the dial relay R1030, thereby to cause the latter relay to operate. Also, upon restoring, the line relay R1010 interrupts, at the contacts 1014, the previously traced circuit for energizing the winding of the stop relay R1065 in series with the stop magnet M1057, thereby to cause the stop relay R1065 to restore and to cause the stop magnet M1057 to restore in order to release the operating shaft 105 for rotation at this time. Upon reoperating, the line relay R1010 recompletes, at the contacts 1011, the previously mentioned circuit for energizing the winding of the hold relay R1020; interrupts, at the contacts 1012, the previously traced circuit for energizing the step magnet M1121 of the minor switch 1120; and interrupts, at the contacts 1013, the previously traced circuit for energizing the winding of the dial relay R1030. Also the line relay R1010, upon reoperating, prepares, at the contacts 1014, the previously traced circuit for energizing the winding of the stop relay R1065 in series with the stop magnet M1057; however, the last-mentioned circuit is not completed at this time due to the operated position of the go relay R1060, in a manner more fully explained hereinafter. Both the hold relay R1020 and the dial relay R1030 are of the slow-to-release type; accordingly these relays do not restore during impulsing.

Upon operating, the step magnet M1121 of the minor switch 1120 drives the slide 1123 one step, whereby ground potential is applied to the first contact in the associated contact bank 1124 and the first marking conductor terminated thereby. The application of ground potential to the first marking conductor terminated by the first contact in the contact bank 1124 of the minor switch 1120 completes a circuit, including the group wiper 1115 and the engaged group contact of the contact set 10 in the contact bank 1110 of the automatic switch, the conductor C1015 and the contacts 1054, for energizing the winding of the go relay R1060 in series with the go magnet M1056. When thus energized the go relay R1060 operates to interrupt, at the contacts 1061, a point in the previously traced circuit for energizing the winding of the stop relay R1065 in series with the stop magnet M1057, as previously noted. Also the go relay R1060 interrupts, at the contacts 1063, a point in a circuit traced hereinafter for energizing the release magnet M1122 of the minor switch 1120. When thus energized the go magnet M1056 operates, thereby to clutch the stub shaft 140 to the operating shaft 105 of the automatic switch, in the manner previously explained.

When the slide 1123 of the minor switch 1120 is moved away from its normal position the set of switch springs S1125 is actuated, thereby to prepare the previously mentioned circuit for energizing the release magnet M1122. Also when the automatic switch is operated the wiper set thereof is advanced in the clockwise direction

with respect to the associated contact bank 1110, whereupon the sets of switch springs S1035, S1039 and S1036 are operated. More particularly, the set of switch springs S1035 is actuated into engagement, thereby to complete an obvious alternative path for applying ground potential to the control conductor C1006 of the trunk 1005, whereupon the trunk 1005 is further marked as busy to the line switches having access thereto. The set of switch springs S1039 is actuated into engagement, thereby to prepare a circuit traced hereinafter for energizing the winding of the first digit relay R1050. Finally the set of switch springs S1036 is actuated, thereby to interrupt, at the contacts 1038 thereof, a further point in an alternative circuit traced hereinafter for energizing the stop magnet M1057; and to prepare, at the contacts 1037 thereof, a further point in a circuit traced hereinafter for energizing the winding of the reset relay R1095 in series with the go magnet M1057.

In view of the foregoing explanation of the initial operation of the connector 1000, it will be understood that the line relay R1010 follows the first digit causing this digit to be registered by the step magnet M1121 of the minor switch 1120. More particularly, the step magnet M1121 is energized and subsequently deenergized a number of times corresponding to the first digit, whereby the slide 1123 is operated a corresponding number of steps, whereupon ground potential is applied to a corresponding number of the contacts in the associated contact bank 1124. As previously noted, the application of ground potential to the first contact in the contact bank 1124 associated with the slide 1123 of the minor switch 1120 initiates operation of the automatic switch incorporated in the connector 1000, whereupon the wiper set is rotated in the clockwise direction with respect to the associated contact bank 1110 of the automatic switch. At this point it is noted that the group contacts of the contact sets 10, 19, 18, 17, 16, 15, 14, 13, 12 and 11 in the contact bank 1110 of the automatic switch are connected to the first marking conductor terminated upon the first contact in the contact bank 1124 of the minor switch 1120. Similarly, the group contacts of the contact sets 20, 29, 28, 27, 26, 25, 24, 23, 22 and 21 in the contact bank 1110 of the automatic switch are connected to the second marking conductor terminated upon the second contact in the contact bank 1124 of the minor switch 1120. Finally, in this connection, it is noted that the slide 1123 is of such a length that it is capable of simultaneously bridging not more than nine of the contacts in the associated contact bank 1124 of the minor switch 1120, for a purpose more fully explained hereinafter.

Considering now the extension of the call from the calling subscriber substation T1 to the called subscriber substation T2 in greater detail, it is noted that the subscriber line 1101 extending to the called subscriber substation T2 is terminated upon the contact set 08 in the contact bank 1110 of the automatic switch; accordingly the first digit dialed at the calling subscriber substation T1 is 0 and the second digit to be dialed at the calling subscriber substation T1 will be 8. Hence, the first digit 0 dialed at the calling subscriber substation T1 is registered in the minor switch 1120 in the connector 1000, as previously explained.

During the registration of the first digit 0 the minor switch 1120 the automatic switch is operated, operation of the automatic switch being initiated when the first impulse is registered in the minor switch 1120, as previously noted. Accordingly when the first digit 0 is completely registered in the minor switch 1120 the wiper set of the automatic switch has traversed a considerable number of the contact sets in the associated contact bank 1110 and occupies a position in engagement with some contact set well beyond the contact set 20, such, for example, as the contact set 90. At this time, when the first digit 0 is completely registered in the minor switch 1120 the slide 1123 thereof bridges the contacts 2 to 0, inclusive, in the associated contact bank 1124, but does not engage the first contact in the associated contact bank 1124 due to the fact that the slide 1123 is capable of bridging simultaneously only nine contacts in the associated contact bank, as previously noted. Hence, at this time, ground potential is applied by way of the slide 1123 to each contact in the associated contact bank 1124 with the exception of the first contact therein. Hence, ground potential is applied to the marking conductors terminated by the second through the tenth contacts in the contact bank 1124 of the minor switch 1120 in order to cause continued operation of the automatic switch.

At the conclusion of the first digit 0 the line relay R1010 reoperates, thereby to retain the hold relay R1020 in its operated position and to interrupt, at the contacts 1013, the previously traced circuit for energizing the winding of the dial relay R1030, whereupon the latter relay restores shortly thereafter, the dial relay R1030 being of the slow-to-release type. Upon restoring, the dial relay R1030 prepares, at the contacts 1031, a further point in the previously mentioned circuit for energizing the winding of the first digit relay R1050. Operation of the automatic switch incorporated in the connector 1000 continues until the wiper set disengages the contact set 01 and reengages the contact set 10 in the associated contact bank 1110, whereupon the previously traced circuit for energizing in series the winding of the go relay R1060 and the go magnet M1056 is interrupted. The last-mentioned circuit is interrupted due to the engagement of the group wiper 1115 of the wiper set of the automatic switch with the group contact in the contact set 10 in the associated contact bank 1110, the ungrounded first marking conductor being terminated by the group contact of the contact set 10 in the contact bank 1110, as previously noted. When the above-mentioned circuit for energizing the winding of the go relay R1060 in series with the go magnet M1056 is thus interrupted, the go relay R1060 and the go magnet M1056 restore. Upon restoring the go relay R1060 completes, at the contacts 1061, the previously traced circuit for energizing the winding of the stop relay R1065 in series with the stop magnet M1057, thereby to cause the stop relay R1065 and the stop magnet M1057 to operate. When the go magnet M1056 restores and the stop magnet M1057 operates the operating shaft 105 is declutched from the stub shaft 140, in the manner previously explained, thereby to arrest further movement of the wiper set of the automatic switch incorporated in the connector 1000.

Also, upon restoring, the go relay R1060 completes, at the contacts 1062, the previously mentioned circuit for energizing the winding of the first digit relay R1050, this circuit extending from ground by way of the contacts 1097, 1062,

the set of switch springs S1039, the contacts 1052 and 1031 and the winding of R1050 to battery, whereupon the latter relay operates. Further the go relay R1060 completes, at the contacts 1063, the previously mentioned circuit for energizing the release magnet M1122 of the minor switch 1120. The last-mentioned circuit extends from ground by way of the set of switch springs S1125, C1117, C1017, the contacts 1063, C1018, C1118 and the release magnet M1122 to battery. When thus energized the release magnet M1122 operates in order to release the slide 1123, whereupon the slide 1123 is returned to its normal position. When the slide 1123 is thus released the set of switch springs S1125 is actuated into disengagement, thereby to interrupt the above-traced circuit for energizing the release magnet M1122, whereupon the latter magnet restores. At this time the minor switch 1120 is completely released.

Upon operating, the first digit relay R1050 completes, at the contacts 1051, an obvious holding circuit, including the contacts 1021, for energizing the winding thereof, interrupts, at the contacts 1052, the previously traced original operating circuit for energizing the winding thereof, interrupts, at the contacts 1054, a further point in the previously traced circuit for energizing the winding of the go relay R1060 in series with the go magnet M1056, and prepares, at the contacts 1053, an alternative circuit for energizing the winding of the go relay R1060 in series with the go magnet M1056. Also the first digit relay R1050 completes, at the contacts 1055, an obvious circuit for energizing the shift magnet M1058, thereby to cause the latter magnet to operate in order to render effective the gear train shown in Fig. 2 incorporated in the automatic switch provided in the connector 1000, in the manner previously explained. At this time the connector 1000 is in readiness to receive the second digit 8.

The subscriber at the calling subscriber substation T1 then dials the second digit 8, thereby to cause the line relay R1010 to follow in the manner previously explained. The line relay R1010 repeats, at the contacts 1012, the second digit 8 over the previously traced circuit to the step magnet M1121 of the mnior switch 1120, whereby the slide 1123 registers the second digit 8 in the associated contact bank 1124 of the minor switch 1120, in the manner previously explained. Also the line relay R1010 repeats the second digit 8 at the contacts 1013 to the dial relay R1030, thereby to cause the latter relay to operate and remain operated during impulsing, in the manner previously explained. Upon operating, the dial relay R1030 completes, at the contacts 1032, a circuit, including the contacts 1021 and 1051 and the resistor 1034, for energizing the winding of the second digit relay R1040. When the above-traced circuit is completed the second digit relay R1040 operates partially shortly thereafter, the second digit relay R1040 being of the combination slow-to-operate and marginal type. Upon operating partially, the second digit relay R1040 prepares, at the contacts 1042, an alternative circuit traced hereinafter for energizing the winding thereof; the last-mentioned circuit being interrupted at this time, at the contacts 1033, due to the operated position of the dial relay 1030.

When the registration of the second digit 8 in the minor switch 1120 is initiated the slide 1123 bridges the first eight contacts in the associated contact bank 1124, thereby to cause ground potential to be applied to the associated marking conductors in the manner previously explained. The application of ground potential to the first contact in the contact bank 1124 of the minor switch 1120 and consequently to the first marking conductor completes a circuit, including the unit wiper 1114 of the wiper set and the engaged unit contact of the contact set 10 in the associated contact bank 1110 of the automatic switch, C1014 and the contacts 1053, for energizing the winding of the go relay R1060 in series with the go magnet M1056, thereby to cause the go relay R1060 and the go magnet M1056 to operate. Upon operating, the go relay R1060 interrupts, at the contacts 1061, the previously traced circuit for energizing the winding of the stop relay R1065 in series with the stop magnet M1057, thereby to cause the stop relay R1065 and the stop magnet M1057 to restore. When the stop magnet M1057 restores and the go magnet M1056 operates the operating shaft 105 is again clutched to the stub shaft 140, whereby the wiper set of the automatic switch is moved in the counterclockwise direction with respect to the associated contact bank 1110, in the manner previously explained. Also, upon operating, the go relay R1060 interrupts, at the contacts 1062, a further point in the previously traced operating circuit for energizing the winding of the first digit relay R1050, and interrupts, at the contacts 1063, the previously traced circuit for energizing the release magnet M1122 of the minor switch 1120.

When the second digit 8 is registered in the minor switch 1120 the set of switch springs S1125 is operated, thereby to prepare a point in the previously traced circuit for energizing the release magnet M1122. Also the unit contacts in the contact sets 10, 01, 02, 03, 04, 05, 06 and 07 in the contact bank 1110 of the automatic switch are marked with ground potential, thereby to complete alternative circuits for continuing the energization of the winding of the go relay R1060 in series with the go magnet M1056, whereby operation of the wiper set of the automatic switch is continued.

At the conclusion of the second digit 8 the line relay R1010 reoperates, thereby to retain the hold relay R1020 in its operated position and to effect the restoration of the dial relay R1030 shortly thereafter, the dial relay R1030 being of the slow-to-release type. Upon restoring, the dial relay R1030 completes, at the contacts 1033, the previously mentioned alternative circuit for energizing the winding of the second digit relay R1040, the last-mentioned circuit extending from ground by way of the contacts 1021, 1051, 1042 and 1033 and the winding of R1040 to battery. Shortly after the second digit relay R1040 is thus energized it operates completely as it is of the combination slow-to-operate and marginal type, as previously noted. Upon operating completely the second digit relay R1040 completes, at the contacts 1041, a holding circuit, including the contacts 1042, 1051 and 1021, for energizing the winding thereof. Also the second digit relay R1040 interrupts, at the contacts 1043, a further point in the previously traced circuit for energizing the step magnet M1121 of the minor switch 1120, thereby positively to prevent the registration of further digits in the minor switch 1120 at this time. Finally the second digit relay R1040 completes, at the contacts 1044, either a circuit for energizing the winding of the switch-through relay R1030 in series with the lower winding of the test relay

R1070 or a path for short-circuiting the winding of the switch-through relay R1080, depending upon the idle or busy condition of the subscriber line 1101 extending to the called subscriber substation T2, in a manner more fully explained hereinafter.

At this point it is noted that, following the conclusion of the second digit 8, there is a considerable elapse of time prior to the restoration of the dial relay R1030 and another considerable elapse of time prior to the complete operation of the second digit relay R1040; during which time intervals operation of the automatic switch incorporated in the connector 1000 is completed and the idle or busy condition of the subscriber line 1101, extending to the called subscriber substation T2, is tested. More specifically, during the registration of the second digit 8 in the minor switch 1120, the wiper set of the automatic switch is being moved with reference to the associated contact bank 1110, in the manner previously explained; and when the second digit 8 is completely registered in the minor switch 1120 the wiper set of the automatic switch engages a contact set in the associated contact bank 1110 well beyond the contact set 10, such, for example, as the contact set 07. Accordingly, very shortly after the second digit 8 is registered in the minor switch 1120 the wiper set of the automatic switch disengages the contact set 07 and engages the contact set 08 in the associated contact bank 1110, whereby the previously traced circuit, including the unit wiper 1114 of the wiper set, for energizing the winding of the go relay R1060 in series with the go magnet M1056 is interrupted. The previously traced circuit for energizing the winding of the go relay R1060 in series with the go magnet M1056 is interrupted when the wiper set of the automatic switch disengages the contact set 07 and engages the contact set 08 in the associated contact bank 1110 due to the fact that the unit contact of the contact set 08 in the contact bank 1110 is connected to the ninth marking conductor terminated upon the ninth contact in the contact bank 1124 of the minor switch 1120; no ground potential being applied to the ninth contact in the contact bank 1124 of the minor switch 1120 due to the fact that the second digit 8 is registered in the contact bank 1124 of the minor switch 1120 at this time.

Accordingly, at this time, the go relay R1060 and the go magnet M1056 restore. Upon restoring, the go relay R1060 recompletes, at the contacts 1061, the previously traced circuit for energizing the winding of the stop relay R1065 in series with the stop magnet M1057, whereupon the stop relay R1065 and the stop magnet M1057 reoperate. When the go magnet M1056 restores and the stop magnet M1057 operates the operating shaft 105 is again declutched from the stub shaft 140, whereby further movement of the wiper set of the automatic switch is arrested, in the manner previously explained. Also, upon restoring, the go relay R1060 completes, at the contacts 1063, the previously traced circuit for energizing the release magnet M1122, thereby to cause the latter magnet to operate and release the slide 1123 of the minor switch 1120, in the manner previously explained. When the slide 1123 of the minor switch 1120 is thus released the set of switch springs S1125 is actuated into disengagement, thereby to interrupt the previously traced circuit for energizing the release magnet M1122, whereupon the latter magnet restores. At this time the minor switch 1120 is completely released.

Upon operating, the stop relay R1065 completes, at the contacts 1056, a test circuit for testing the idle or busy condition of the subscriber line 1101 extending to the called subscriber substation T2. More particularly, the control conductor of the subscriber line 1101 is connected by way of the control contact in the contact set 08 in the contact bank 1110 and the control wiper 1113 of the wiper set of the automatic switch, C1013 and the contacts 1066 and 1037 to the terminals of the winding of the switch-through relay R1080 and the lower winding of the test relay R1070. In the event the called subscriber substation T2 is busy at this time, ground potential appears upon the control conductor of the subscriber line 1101, thereby to complete the above-traced test circuit for energizing the lower winding of the test relay R1070 and to prepare the above-traced test path for short-circuiting the winding of the switch-through relay R1080. Shortly following the above-mentioned test of the idle or busy condition of the subscriber line 1101 extending to the called subscriber substation T2, the second digit relay R1040 operates in the manner previously explained. Upon operating, the second digit relay R1040 completes, at the contacts 1044, the previously mentioned path for short-circuiting the winding of the switch-through relay R1080, thereby positively to prevent operation of the latter relay at this time. When the lower winding of the test relay R1070 is thus energized the latter relay operates to complete, at the contacts 1071, an obvious circuit for energizing the primary winding of the busy tone transformer 1077 with busy tone current, to interrupt, at the contacts 1072, a circuit traced hereinafter for energizing the upper winding thereof, and to interrupt, at the contacts 1073, a circuit traced hereinafter for energizing the winding of the ring relay R1090.

The busy tone current traversing the primary winding of the busy tone transformer 1077 induces a corresponding busy tone voltage in the secondary winding thereof, whereby a corresponding busy tone current traverses a path extending from ground by way of the lower winding of the line relay R1010, the condenser 1015, the contacts 1089, the secondary winding of the busy tone transformer 1077, the contacts 1082, the condenser 1015 and the upper winding of the line relay R1010 to battery. The busy tone current traversing the above-traced path causes busy tone current to be returned over the trunk 1005, the line switch 1002 and the subscriber line 1001 to the calling subscriber substation T1, thereby to indicate to the subscriber thereat that the desired connection may not be had immediately due to the busy condition of the called subscriber substation T2. The subscriber at the calling subscriber substation T1 then proceeds to release the connector 1000 by replacing the receiver of the telephone instrument thereat upon its associated switchhook, in a manner more fully explained hereinafter.

Now assume that, when the wiper set of the automatic switch selects the contact set 08 in the associated contact bank 1110 terminating the subscriber line 1101 extending to the called subscriber substation T2, the called subscriber substation T2 is idle. In this event, no potential appears upon the control conductor of the subscriber line 1101 and the above-traced circuit, including the test circuit, is not completed for

energizing the lower winding of the test relay R1070, and shortly thereafter the second digit relay R1040 operates. Upon operating, the second digit relay R1040 completes, at the contacts 1044, an obvious circuit for energizing the winding of the switch-through relay R1080 in series with the lower winding of the test relay R1070, whereupon the switch-through relay R1080 operates; however, the test relay R1070 does not operate as the latter relay is of the marginal type. Upon operating, the switch-through relay R1080 interrupts, at the contacts 1087, the previously traced test circuit and completes, at the contacts 1086, a path, including the contacts 1066, C1013, the control wiper 1113 of the wiper set of the automatic switch and the engaged control contact in the contact set 08 in the associated contact bank 1110, for applying ground potential to the control conductor of the subscriber line 1101 extending to the called subscriber substation T2, thereby to mark the called subscriber substation T2 as busy at this time. Also the switch-through relay R1080 completes, at the contacts 1088, the previously mentioned circuit for energizing the winding of the ring relay R1090; the last-mentioned circuit extending from ground by way of the contacts 1073, the interrupter 1017, the contacts 1083, and the winding of R1090 to battery. The above-traced circuit for energizing the winding of the ring relay R1090 is completed intermittently by the interrupter 1017, whereby the ring relay R1090 operates and restores intermittently. Also the switch-through relay R1080 prepares, at the contacts 1081 and 1085, a connection traced hereinafter between the line conductors of the trunk 1005 and the line wipers 1111 and 1112 of the wiper set of the automatic switch, prepares, at the contacts 1083 and 1084, a circuit traced hereinafter for energizing in series the upper and lower windings of the answer relay R1075, and interrupts, at the contacts 1082 and 1089, the previously traced connection between the secondary winding of the busy tone transformer 1077 and the line conductors of the trunk 1005.

Each time the ring relay R1090 operates it completes, at the contacts 1092 and 1093, a circuit for projecting ringing current over the line conductors of the subscriber line 1101 extending to the called subscriber substation T2; and interrupts, at the contacts 1091 and 1094, further points in the previously mentioned circuit for energizing in series the upper and lower windings of the answer relay R1075. The circuit for projecting ringing current over the line conductors of the subscriber line 1101 extending to the called subscriber substation T2 extends from the source of ringing current 1018 by way of the contacts 1092, C1011, the line wiper 1111 of the wiper set of the automatic switch and the engaged line contact of the contact set 03 in the associated contact bank 1110 to one of the line conductors of the subscriber line 1101 and from the source of ringing current 1018 by way of the contacts 1093, C1012, the line wiper 1112 of the wiper set of the automatic switch and the engaged line contact of the contact set 00 in the associated contact bank 1110 to the other line conductor of the subscriber line 1101; the ringer at the called subscriber substation T2 being bridged across the line conductors of the subscriber line 1101. Accordingly the ringer at the called subscriber substation T2 is operated at this time and, when the subscriber thereat answers the call by removing the receiver of the telephone instrument thereat from its associated switchhook, a circuit substantially identical to that previously traced is completed for energizing in series the upper and lower windings of the answer relay R1075. The last-mentioned circuit extends from ground by way of the lower winding of the answer relay R1075, the contacts 1084 and 1094 and C1012 to the line wiper 1112 of the wiper set of the automatic switch; and from battery by way of the upper winding of the answer relay R1075, the contacts 1083 and 1091 and C1011 to the line wiper 1111 of the wiper set of the automatic switch; the line wipers 1111 and 1112 of the automatic switch being connected by way of the previously traced path to the called subscriber substation T2. When the answer relay R1075 is thus energized it operates to complete, at the contacts 1076, an obvious circuit, including the contacts 1072, for energizing the upper winding of the test relay R1070, thereby to cause the latter relay to operate. Upon operating, the test relay R1070 interrupts, at the contacts 1073, the previously traced circuit for energizing the winding of the ring relay R1090, thereby to prevent further intermittent operation of the latter relay. Also the test relay R1070 interrupts, at the contacts 1072, the above-traced circuit for energizing the upper winding thereof. However, the latter relay remains in its operated position in view of the fact that the lower winding thereof is energized in series with the winding of the switch-through relay R1080 at this time, the test relay R1070 being of the marginal type.

At this time, an operative connection is completed between the calling subscriber substation T1 and the called subscriber substation T2. More particularly, the calling subscriber substation T1 is connected by way of the subscriber line 1001, the line switch 1002 and the line conductors C1006 and C1007 of the trunk 1005 to the upper and lower windings of the line relay R1010; while the called subscriber substation T2 is connected by way of the subscriber line 1101, the automatic switch incorporated in the connector 1000, the conductors C1011, C1012, the contacts 1091, 1094 and 1081, 1085 and the condensers 1015, 1016 to the upper and lower windings of the line relay R1010.

The release of this established connection is under the control of the subscriber at the calling subscriber substation T1 and is effected when the subscriber thereat replaces the receiver of the telephone instrument thereat upon its associated switchhook in order to interrupt the previously traced circuit for energizing in series the upper and lower windings of the line relay R1010 in the connector 1000, whereupon the latter relay restores. Upon restoring, the line relay R1010 interrupts, at the contacts 1011, the previously mentioned circuit for energizing the winding of the hold relay R1020, thereby to cause the latter relay to restore shortly thereafter, the hold relay R1020 being of the slow-to-release type. Upon restoring, the hold relay R1020 interrupts, at the contacts 1021, the previously traced multiple holding circuits for energizing the windings of the first digit relay R1050 and the second digit relay R1040, thereby to cause the latter relays to restore. Upon restoring, the second digit relay R1040 interrupts, at the contacts 1044, the previously traced circuit for energizing the winding of the switch-through relay R1080 in series with the lower winding of the test relay R1070, thereby to cause the latter relays to restore. Upon restoring, the switch-

through relay R1080 interrupts, at the contacts 1083 and 1084, the previously traced circuit for energizing in series the upper and lower windings of the answer relay R1075, thereby to cause the latter relay to restore. Also, upon restoring, the hold relay R1020 interrupts, at the contacts 1024, the previously traced circuit for energizing the winding of the dial relay R1030, thereby to cause the latter relay to restore shortly thereafter, the dial relay R1030 being of the slow-to-release type. Further the hold relay R1020 completes, at the contacts 1025, the previously mentioned circuit for energizing the winding of the reset relay R1095 in series with the go magnet M1056, this circuit extending from ground by way of the contacts 1013 and 1025, the contacts 1037 of the set of switch springs S1035, the winding of R1095 and the go magnet M1056 to battery. When thus energized the reset relay R1095 and the go magnet M1056 operate. Further the line relay R1010 interrupts, at the contacts 1014, the previously traced circuit for energizing the winding of the stop relay R1065 in series with the stop magnet M1057, thereby to cause the stop relay R1065 and the stop magnet M1057 to restore.

When the go magnet M1056 operates and the stop magnet M1057 restores the operating shaft 105 is again clutched to the stub shaft 140, whereupon the wiper set of the automatic switch incorporated in the connector 1000 is rotated in the clockwise direction with respect to the associated contact bank 1110. In this connection it is pointed out that the wiper set of the automatic switch is driven in the clockwise direction at the relatively high speed due to the fact that the gear train shown in Fig. 2 is rendered ineffective at this time. More particularly, upon restoring, the first digit relay R1050 interrupts, at the contacts 1055, the previously mentioned circuit for energizing the shift magnet M1058, thereby to cause the latter magnet to restore. Upon restoring, the shift magnet M1058 renders ineffective the gear train, shown in Fig. 2, which is incorporated in the automatic switch 100 shown in Fig. 1, in the manner previously explained.

When the wiper set of the automatic switch is returned to its normal position, engaging the contact set 10 in the associated contact bank 1110, the sets of switch springs S1035, S1039 and S1036 are actuated. More particularly, the set of switch springs S1035 is actuated into disengagement, thereby to interrupt the application of ground potential to the control conductor C1008 of the trunk 1005 in order to mark the trunk 1005 and consequently the connector 1000 as idle to the line switches having access thereto. The set of switch springs S1039 is actuated into disengagement, thereby to interrupt a further point in the previously traced original operating circuit for energizing the winding of the first digit relay R1050. The set of switch springs S1036 is actuated in order to interrupt, at the contacts 1037 thereof, the previously traced circuit for energizing the winding of the reset relay R1095 in series with the go magnet M1056, thereby to cause the go magnet M1056 to restore immediately and the reset relay R1095 to restore shortly thereafter, the reset relay R1095 being of the slow-to-release type. Also the set of switch springs S1036 is actuated, thereby to complete, at the contacts 1038 thereof, an alternative circuit for energizing the stop magnet M1057, the last-mentioned circuit extending from ground by way of the contacts 1013 and 1025, the contacts 1038 of the set of switch springs S1036, the contacts 1096 and the stop magnet M1057 to battery. When thus energized the stop magnet M1057 operates. When the go magnet M1056 restores and the stop magnet M1057 operates the operating shaft 105 is again declutched from the stub shaft 140. At this time the automatic switch incorporated in the connector 1000 is completely released and the wiper set thereof occupies its normal position, engaging the contact set 10 in the associated contact bank 1110. Shortly thereafter the reset relay R1095 restores, thereby to prepare, at the contacts 1097, a further point in the previously traced original operating circuit for energizing the winding of the first digit relay R1050 and to interrupt, at the contacts 1096, the previously traced alternative circuit for energizing the stop magnet M1057. The stop magnet M1057 then restores; however, the operating shaft 105 remains declutched from the stub shaft 140 due to the action of gravity, in the manner previously explained.

The operative connection between the calling subscriber substation T1 and the called subscriber substation T2 is completely released and the connector 1000 is available for further use, assuming that the subscriber at the called subscriber substation T2 has replaced the receiver of the telephone instrument thereat upon its associated switchhook at this time.

Referring now more particularly to Figs. 10 and 12 of the drawings, there is illustrated a modified form of the automatic telephone system comprising an exchange having a plurality of subscriber lines extending thereto, including the subscriber lines 1001 and 1201 respectively extending to the subscriber substations T1 and T3. Also the exchange compises subscriber controlled switching apparatus for setting up connections between the various subscriber lines, the switching apparatus comprising a line switch individual to each subscriber line, the line switches 1002 and 1202 being individual to the subscriber lines 1001 and 1201, respectively, and a group of connectors including the connector 1000. Preferably each of the line switches has access to each of the connectors and each of the connectors has access to each of the subscriber lines in the exchange.

Preferably each subscriber substation comprises conventional subscriber substation apparatus including a telephone instrument, a ringer and a calling device or dial. Preferably each line switch is identical to the line switches 1002 and 1202, which line switches are connected and arranged in accordance with conventional practice.

Preferably each of the connectors is identical to the connector 1000 which comprises an automatic switch of the character of the automatic switch 100 shown in Fig. 1; which automatic switch has incorporated therein a gear train of the character of that shown in Fig. 3 and is provided with an associated contact bank of the character of that shown either in Fig. 5 or in Fig. 8 and a corresponding wiper set of the character of that shown either in Fig. 6 or in Fig. 9. In other words, the automatic switch incorporated in the connector 1000 is of the type disclosed, wherein the wiper set thereof is advanced continuously during the primary movement thereof in the clockwise direction and then is advanced continuously during the secondary movement thereof further in the clockwise direction, in the manner previously explained. Also this automatic switch comprises a go magnet M1056,

a stop magnet M1057, a shift magnet M1058, three sets of switch springs S1035, S1036 and S1039, a wiper set including the wipers 1211 to 1215, inclusive, and an associated contact bank 1210.

Also the connector 1000 comprises a minor switch 1220, including a slide 1223, an associated contact bank 1224, a step magnet M1221 for moving the slide 1223 step by step with respect to the associated contact bank 1224 and a release magnet M1222 for releasing the slide 1223 and for causing it to be returned to its normal position. Also a set of switch springs S1225 is associated with the slide 1223 of the minor switch 1220.

Further the connector 1000 comprises a relay group and a control network connected and arranged in the manner previously described.

In the connector 1000 the circuit elements of the relay group are strapped to the individual wipers of the wiper set of the automatic switch and to certain elements of the minor switch 1220. More particularly, the conductors C1011, C1012, C1013, C1014 and C1015 are respectively strapped to the line wiper 1211, the line wiper 1212, the control wiper 1213, the unit wiper 1214 and the group wiper 1215 of the wiper set of the automatic switch; and the conductors C1016, C1017 and C1018 are respectively strapped to the conductors C1216, C1217 and C1218 extending to the minor switch 1220.

The mechanical construction and arrangement of the automatic switch 100 shown in Fig. 1, as well as the electrical connection and arrangement of the telephone system shown in Figs. 10 and 12, will best be understood from a consideration of the mode of operation of the apparatus incorporated in the system incident to the extension of a telephone connection from the subscriber substation T1 to the subscriber substation T3.

The subscriber at the calling subscriber substation T1 first initiates the call in the manner previously explained, whereby the associated line switch 1002 seizes an idle connector, such, for example, as the connector 1000. The subscriber at the calling subscriber substation T1 then dials the first and second digits of the directory number of the called subscriber substation T3, the digits 9 and 8, in view of the fact that the subscriber line 1201 extending to the called subscriber substation T3 is terminated by the contact set 98 in the contact bank 1210 of the automatic switch incorporated in the connector 1000.

The operation of the relay group in the connector 1000, to cause the first digit 9 to be registered in the minor switch 1212, is the same as that previously explained, whereupon the slide 1223 of the minor switch 1220 bridges the first nine contacts in the associated contact bank 1224 in order to cause ground potential to be applied to the associated first nine marking conductors. The application of ground potential to the first nine marking conductors causes ground potential to be applied continuously to the group wiper 1215 of the wiper set of the automatic switch incorporated in the connector 1000 and the consequent rotation of the wiper set in the clockwise direction until the wiper set engages the contact set 80 in the associated contact bank 1210. When the wiper set engages the contact set 80 in the associated contact bank 1210 further operation thereof is arrested and the minor switch 1220 is released in the manner explained. Also, at this time, the shift magnet M1058 operates in order to render the gear train shown in Fig. 3 effective, in the manner previously explained.

The second digit 8 is then registered in the minor switch 1220, whereby the slide 1223 bridges the first eight contacts in the associated contact bank 1224 causing ground potential to be applied to the first eight marking conductors. The application of ground potential to the first eight marking conductors causes ground potential to be applied continuously to the unit wiper 1214 of the wiper set of the automatic switch until the wiper set engages the contact set 98 in the associated contact bank 1210 during the secondary rotation of the wiper set in the clockwise direction. When the wiper set engages the contact set 98 in the contact bank 1210 ground potential is removed from the unit wiper 1214 thereof due to the fact that the unit contact in the contact set 98 is connected to the ninth marking conductor having no ground potential thereon on the ninth contact in the contact bank 1224 of the minor switch 1220. Accordingly, at this time, the automatic switch incorporated in the connector 1000 has operated to select the contact set 98 in the contact bank 1210 terminating the subscriber line 1201 extending to the called subscriber substation T3.

The relay group in the connector 1000 then operates in order to test the idle or busy condition of the called subscriber substation T3, whereupon busy tone current is returned to the calling subscriber substation T1 or ringing current is projected over the subscriber line 1201 to the called subscriber substation T3, in the manner previously explained. The subsequent operation of the relay group in the connector 1000, in response to the answering of the call at the called subscriber substation T3, is the same as that previously explained, whereupon an operative connection is completed between the calling subscriber substation T1 and the called subscriber substation T3.

The subsequent release of the established connection between the calling subscriber substation T1 and the called subscriber substation T3 is under the control of the subscriber at the calling subscriber substation T1 and is effected when the subscriber thereat replaces the receiver of the telephone instrument thereat upon its associated switchhook, in the manner previously explained.

Referring now more particularly to Figs. 13 and 14 of the drawings there is illustrated another modified form of the automatic telephone system comprising an exchange having a plurality of subscriber lines extending thereto, including the subscriber lines 1301 and 1401 respectively extending to the subscriber substations T4 and T5. Also the exchange comprises subscriber controlled switching apparatus for setting up connections between the various subscriber lines, the switching apparatus comprising a line switch individual to each subscriber line, the line switches 1302 and 1402 being individual to the subscriber lines 1301 and 1401, respectively, and a group of connectors including the connector 1300. Preferably each of the line switches has access to each of the connectors and each of the connectors has access to each of the subscriber lines in the exchange.

Preferably each subscriber substation comprises subscriber substaiton apparatus, including a telephone instrument and a ringer of conventional construction and arrangement, and a calling device or dial embodying the unique construction and arrangement disclosed in the copending

application of Bernard D. Willis, Serial No. 413,177, filed October 1, 1941. As disclosed in the Willis application mentioned, this calling device is so constructed and arranged that it transmits a single impulse of variable length or time duration as contrasted with conventional calling devices which transmit a variable series of impulses, this calling device including a finger dial and having the same general external appearance as a conventional calling device.

Preferably each of the connectors is identical to the connector 1300 which comprises an automatic switch of the character of the automatic switch 100 shown in Fig. 1; which automatic switch has incorporated therein a gear train of the character of that shown in Fig. 2 and is provided with an associated contact bank of the character of that shown either in Fig. 4 or in Fig. 7 and a corresponding wiper set of the character of that shown either in Fig. 6 or in Fig. 9. In other words, the automatic switch incorporated in the connector 1300 is of the type disclosed, wherein the wiper set thereof is advanced continuously during the primary movement thereof in the clockwise direction and then is advanced continuously during the secondary movement thereof in the counterclockwise direction, in the manner previously explained. Also this automatic switch comprises a go magnet M1356, a stop magnet M1357, a shift magnet M1358, three sets of switch springs S1335, S1336 and S1339, a wiper set, including the wipers 1411 to 1413, inclusive, and an associated contact bank 1410.

Also the connector 1300 comprises a relay group, including a line relay R1310, a hold relay R1320, a dial relay R1330, a first digit relay R1350, a second digit relay R1340, a go relay R1360, a stop relay R1365, a test relay R1370, an answer relay R1375, a switch-through relay R1380, a ring relay R1390 and a reset relay R1395, and a control network.

In the connector 1300 the circuit elements of the relay group are strapped to the individual wipers of the wiper set of the automatic switch. More particularly, the conductors C1311, C1312 and C1313 are respectively strapped to the line wiper 1411, the line wiper 1412 and the control wiper 1413 of the wiper set of the automatic switch.

The mechanical construction and arrangement of the automatic switch 100 shown in Fig. 1, as well as the electrical connection and arrangement of the telephone system shown in Figs. 13 and 14, will best be understood from a consideration of the mode of operation of the apparatus incorporated in the system incident to the extension of the telephone connection from the subscriber substation T4 to the subscriber substation T5.

A call is initiated at the subscriber substation T4 by removing the receiver of the telephone instrument thereat from its associated switchhook, whereupon the line switch 1302 operates automatically to search for a trunk extending to an idle connector in accordance with conventional practice. Assuming that the connector 1300 is the first idle connector accessible to the line switch 1302, the line switch 1302 operates to seize the trunk 1305 extending thereto, the trunk 1305 being marked as idle by the absence of ground potential upon the control conductor C1308 thereof. When the line switch 1302 seizes the trunk 1305 further operation thereof is arrested and it operates to switch through, thereby to complete an obvious connection between the subscriber line 1301 and the line conductors C1306 and C1307 of the trunk 1305. When this connection is completed an obvious loop circuit is completed between the calling subscriber substation T4 and the upper and lower windings of the line relay R1310 in the connector 1300 by way of the subscriber line 1301, the line switch 1302 and the trunk 1305. When thus energized the line relay R1310 operates to complete, at the contacts 1311, an obvious circuit for energizing the winding of the hold relay R1320, thereby to cause the latter relay to operate. Also the line relay R1310 completes, at the contacts 1314, an obvious circuit, including the contacts 1361, for energizing the winding of the stop relay R1365 in series with the stop magnet M1357, thereby to cause the stop relay R1365 to operate and to cause the stop magnet M1357 to operate in order positively to lock the operating shaft 105 against rotation at this time. Upon operating, the hold relay R1320 completes, at the contacts 1322, an obvious path for applying ground potential to the control conductor C1308 of the trunk 1305, thereby to mark the connector 1300 as busy to the other line switches having access thereto. At this time an operative connection is completed between the calling subscriber substation T4 and the connector 1300, and the connector 1300 is in readiness to receive the first digit.

The subscriber at the calling subscriber substation T4 then dials the first digit at the calling device thereat, thereby to cause the previously traced connection between the calling subscriber substation T4 and the line relay R1310 in the connector 1300 to be interrupted, to remain interrupted for a corresponding given time interval and then to be recompleted at the conclusion of the given time interval. The duration of the given time interval is determined by the particular digit dialed at the calling device at the calling subscriber substation T4, as disclosed in the previously mentioned Willis application. Accordingly the line relay R1310 restores, remains restored for the given time interval and then reoperates. Upon restoring, the line relay R1310 interrupts, at the contacts 1311, the previously mentioned circuit for energizing the winding of the hold relay R1320 and completes, at the contacts 1312, an obvious circuit, including the contacts 1323 and 1374, for energizing the winding of the go relay R1360 in series with the go magnet M1356, thereby to cause the go relay R1360 and the go magnet M1356 to operate. Also, upon restoring, the line relay R1310 completes, at the contacts 1313, an obvious circuit, including the contacts 1324, for energizing the winding of the dial relay R1330, thereby to cause the latter relay to operate. Further, upon restoring, the line relay R1310 interrupts, at the contacts 1314, the previously traced circuit for energizing the winding of the stop relay R1365 in series with the stop magnet M1357, thereby to cause the stop relay R1365 to restore and to cause the stop magnet M1357 to restore in order to release the operating shaft 105 for rotation at this time. Upon operating, the go relay R1360 interrupts, at the contacts 1361, a further point in the previously traced circuit for energizing the winding of the stop relay R1365 in series with the stop magnet M1357 and interrupts, at the contacts 1362, a point in a circuit traced hereinafter for energizing the winding of the first digit relay R1350. When the go magnet M1356 operates and the stop magnet M1357 restores the operating shaft 105 is clutched to the stub shaft 140 of the automatic switch, in the manner previously explained,

whereby the wiper set of the automatic switch is driven in the clockwise direction with respect to the associated contact bank 1410.

Also when the automatic switch is operated the sets of switch springs S1035, S1039 and S1036 are operated. More particularly, the set of switch springs S1035 is actuated into engagement, thereby to complete an obvious alternative path for applying ground potential to the control conductor C1308 of the trunk 1305, whereupon the trunk 1305 is further marked as busy to the line switches having access thereto. The set of switch springs S1339 is actuated into engagement, thereby to prepare a further point in the previously mentioned circuit for energizing the winding of the first digit relay R1350. Finally the set of switch springs S1336 is actuated, thereby to interrupt, at the contacts 1338 thereof, a further point in an alternative circuit traced hereinafter for energizing the stop magnet M1357; and to prepare, at the contacts 1337 thereof, a further point in a circuit traced hereinafter for energizing the winding of the reset relay R1395 in series with the go magnet M1356.

Upon reoperating, the line relay R1310 recompletes, at the contacts 1311, the previously mentioned circuit for energizing the winding of the hold relay R1320, thereby to retain the latter relay in its operated position; the hold relay R1320 being of the slow-to-release type does not restore during any digit. Also the line relay R1310 interrupts, at the contacts 1312, the previously traced circuit for energizing the winding of the go relay R1360 in series with the go magnet M1356, thereby to cause the go relay R1360 and the go magnet M1356 to restore. Further the line relay R1310 recompletes, at the contacts 1314, the previously traced circuit for energizing the winding of the stop relay R1365 in series with the stop magnet M1357, thereby to cause the stop relay R1365 and the stop magnet M1357 to reoperate. When the go magnet M1356 restores and the stop magnet M1357 operates the operating shaft 105 is declutched from the stub shaft 140 of the automatic switch, thereby to arrest further operation of the wiper set in the clockwise direction with respect to the contact bank 1410, in the manner previously explained. Finally, upon reoperating, the line relay R1310 interrupts, at the contacts 1313, the previously traced circuit for energizing the winding of the dial relay R1330, thereby to cause the latter relay to restore shortly thereafter, the dial relay R1330 being of the slow-to-release type. Upon restoring, the dial relay R1330 completes, at the contacts 1331, the previously mentioned circuit for energizing the winding of the first digit relay R1350, this circuit extending from ground by way of the contacts 1362 and 1397, the set of switch springs S1339, the contacts 1352 and 1331 and the winding of R1350 to battery. When thus energized the first digit relay R1350 operates to complete, at the contacts 1351, an obvious holding circuit, including the contacts 1321, for energizing the winding thereof. Also the first digit relay R1350 interrupts, at the contacts 1352, the previously traced original operating circuit for energizing the winding thereof and completes, at the contacts 1355, an obvious circuit for energizing the shift magnet M1358, thereby to cause the latter magnet to operate. Upon operating, the shift magnet M1358 renders effective the gear train, shown in Fig. 2, incorporated in the automatic switch provided in the connector 1300 in the manner previously explained. At this time the connector 1300 is in readiness to receive the second digit.

Considering now the extension of the call from the calling subscriber substation T4 to the called subscriber substation T5 in greater detail, it is noted that the subscriber line 1401 extending to the called subscribed substation T5 is terminated upon the contact set 08 in the contact bank 1410 of the automatic switch. Accordingly the first digit dialed at the calling subscriber substation T4 is 0 and the second digit to be dialed at the calling subscriber substation T4 will be 8. Hence, incident to the dialing of the first digit 0, the line relay R1310 restored, remained restored for an elapsed time corresponding to ten unit time intervals and then reoperated, all in the manner previously explained. Accordingly, at the conclusion of the first digit 0, the wiper set of the automatic switch engages the contact set 10 in the associated contact bank 1410.

The subscriber at the calling subscriber substation T4 then dials the second digit 8, thereby to cause the line relay R1310 to restore, to remain restored for an elapsed time corresponding to eight unit time intervals and then to reoperate. Upon restoring, the line relay R1310 interrupts, at the contacts 1311, the previously mentioned circuit for energizing the winding of the hold relay R1320; however, the latter relay does not restore during the digit as it is of the slow-to-release type, as previously noted. Also, upon restoring, the line relay R1310 again completes, at the contacts 1312, the previously traced circuit for energizing the winding of the go relay R1360 in series with the go magnet M1356, thereby to cause the go relay R1360 and the go magnet M1356 to operate. Also upon restoring, the line relay R1310 again interrupts, at the contacts 1314, the previously traced circuit for energizing the winding of the stop relay R1365 in series with the stop magnet M1357, thereby to cause the stop relay R1365 and the stop magnet M1357 to restore. Further the line relay R1310 recompletes, at the contacts 1313, the previously traced circuit for energizing the winding of the dial relay R1330, thereby to cause the latter relay to reoperate.

When the go magnet M1356 operates and the stop magnet M1357 restores the operating shaft 105 is again clutched to the stub shaft 140 of the automatic switch, whereby the wiper set of the automatic switch is rotated in the counterclockwise direction with respect to the associated contact bank 1410 due to the fact that the gear train, shown in Fig. 2, incorporated in the automatic switch is rendered effective at this time by virtue of the operated position of the shift magnet M1358.

Upon operating, the dial relay R1330 completes, at the contacts 1332, a circuit, including the contacts 1321 and 1351 and the resistor 1334, for energizing the winding of the second digit relay R1340. When the above-traced circuit is completed the second digit relay R1340 operates partially shortly thereafter, the second digit relay R1340 being of the combination slow-to-operate and marginal type. Upon operating partially, the second digit relay R1340 prepares, at the contacts 1342, an alternative circuit traced hereinafter for energizing the winding thereof; the last-mentioned circuit being interrupted at this time, at the contacts 1333, due to the operated position of the dial relay R1330.

At the conclusion of the second digit 8 the line relay R1310 reoperates, thereby to recomplete, at

the contacts 1311, the previously mentioned circuit for energizing the winding of the hold relay R1320 and again to interrupt, at the contacts 1312, the previously traced circuit for energizing the winding of the go relay R1360 in series with the go magnet M1356. Also, upon reoperating, the line relay R1310 interrupts, at the contacts 1313, the previously traced circuit for energizing the winding of the dial relay R1330, thereby to cause the latter relay to restore shortly thereafter, the dial relay R1330 being of the slow-to-release type. Further the line relay R1310, upon reoperating, recompletes, at the contacts 1314, the previously traced circuit for energizing the winding of the stop relay R1365 in series with the stop magnet M1357, thereby to cause the stop relay R1365 and the stop magnet M1357 to operate. When the go magnet M1356 restores and the stop magnet M1357 operates the operating shaft 105 is again declutched from the stub shaft 149 of the automatic switch, thereby to arrest further rotation of the wiper set in the counterclockwise direction with respect to the associated contact bank 1410.

Upon restoring, the dial relay R1330 completes, at the contacts 1333, the previously mentioned alternative circuit for energizing the winding of the second digit relay R1340, the last-mentioned circuit extending from ground by way of the contacts 1321, 1351, 1342 and 1333 and the winding of R1340 to battery. Shortly after the second digit relay R1340 is thus energized it operates completely as it is of the combination slow-to-operate and marginal type, as previously noted. Upon operating completely, the second digit relay R1340 completes, at the contacts 1341, a holding circuit, including the contacts 1342, 1351 and 1321, for energizing the winding thereof. Also the second digit relay R1340 completes, at the contacts 1344, either a circuit for energizing the winding of the switch-through relay R1380 in series with the lower winding of the test relay R1370 or a path for short-circuiting the winding of the switch-through relay R1380, depending upon the idle or busy condition of the subscriber line 1401 extending to the called subscribed substation T5, in a manner more fully explained hereinafter.

At this point it is noted that, following the conclusion of the second digit 8, there is a considerable elapse of time prior to the restoration of the dial relay R1330 and another considerable elapse of time prior to the complete operation of the second digit relay R1340; during which time intervals operation of the automatic switch incorporated in the connector 1300 is completed and the idle or busy condition of the subscriber line 1401 extending to the called subscriber substation T5 is tested. Accordingly, at the conclusion of the second digit 8, the wiper set of the automatic switch engages the contact set 08 in the associated contact bank 1410, whereby a test circuit for testing the idle or busy condition of the subscriber line 1401 extending to the called subscriber substation T5 is completed. More particularly, the control conductor of the subscriber line 1401 is connected by way of the control contact in the contact set 08 in the contact bank 1410 and the control wiper 1413 of the wiper set of the automatic switch, C1313, the contacts 1366 and 1387 to the terminals of the winding of the switch-through relay R1380 and the lower winding of the test relay R1370. In the event the called subscriber substation T5 is busy at this time, ground potential appears upon the control conductor of the subscriber line 1401, thereby to complete the above-traced test circuit for energizing the lower winding of the test relay R1370 and to prepare the above-traced test path for short-circuiting the winding of the switch-through relay R1380. Shortly following the above-mentioned test of the idle or busy condition of the subscriber line 1401 extending to the called subscriber substation T5, the second digit relay R1340 operates in the manner previously explained. Upon operating, the second digit relay R1340 completes, at the contacts 1344, the previously mentioned path for short-circuiting the winding of the switch-through relay R1380, thereby positively to prevent operation of the latter relay at this time. When the lower winding of the test relay R1370 is thus energized the latter relay operates to complete, at the contacts 1371, an obvious circuit for energizing the primary winding of the busy tone transformer 1377 with busy tone current, to interrupt, at the contacts 1372, a circuit traced hereinafter for energizing the upper winding thereof, and to interrupt, at the contacts 1373, a circuit traced hereinafter for energizing the winding of the ring relay R1390.

The busy tone current traversing the primary winding of the busy tone transformer 1377 induces a corresponding busy tone voltage in the secondary winding thereof, whereby a corresponding busy tone current traverses a path extending from ground by way of the lower winding of the line relay R1310, the condenser 1316, the contacts 1389, the secondary winding of the busy tone transformer 1377, the contacts 1382, the condenser 1315 and the upper winding of the line relay R1310 to battery. The busy tone current traversing the above-traced path causes busy tone current to be returned over the trunk 1305, the line switch 1302 and the subscriber line 1301 to the calling subscriber substation T4, thereby to indicate to the subscriber thereat that the desired connection may not be had immediately due to the busy condition of the called subscriber substation T5. The subscriber at the calling subscriber substation T4 then proceeds to release the connector 1300 by replacing the receiver of the telephone instrument thereat upon its associated switchhook, in a manner more fully explained hereinafter.

Now assume that, when the wiper set of the automatic switch selects the contact set 08 in the associated contact bank 1410 terminating the subscriber line 1401 extending to the called subscriber substation T5, the called subscriber substation T5 is idle. In this event, no potential appears upon the control conductor of the subscriber line 1401, and the above-traced circuit, including the test circuit, is not completed for energizing the lower winding of the test relay R1370 and shortly thereafter the second digit relay R1340 operates. Upon operating, the second digit relay R1340 completes, at the contacts 1344, an obvious circuit for energizing the winding of the switch-through relay R1380 in series with the lower winding of the test relay R1370, whereupon the switch-through relay R1380 operates; however, the test relay R1370 does not operate as the latter relay is of the marginal type. Upon operating, the switch-through relay R1380 interrupts, at the contacts 1387, the previously traced test circuit and completes, at the contacts 1386, a path, including the contacts 1366, C1313, the control wiper 1413 of the wiper set of the automatic switch and the engaged control

contact in the contact set 08 in the associated contact bank 1410, for applying ground potential to the control conductor of the subscriber line 1401 extending to the called subscriber substation T5, thereby to mark the called subscriber substation T5 as busy at this time. Also the switch-through relay R1380 completes, at the contacts 1388, the previously mentioned circuit for energizing the winding of the ring relay R1390; the last-mentioned circuit extending from ground by way of the contacts 1373, the interrupter 1317, the contacts 1388 and the winding of R1390 to battery. The above-traced circuit for energizing the winding of the ring relay R1390 is completed intermittently by the interrupter 1317, whereby the ring relay R1390 operates and restores intermittently. Also the switch-through relay R1380 prepares, at the contacts 1381 and 1385, a connection traced hereinafter between the line conductors of the trunk 1305 and the line wipers 1411 and 1412 of the wiper set of the automatic switch, prepares, at the contacts 1383 and 1384, a circuit traced hereinafter for energizing in series the upper and lower windings of the answer relay R1375, and interrupts, at the contacts 1382 and 1389, the previously traced connection between the secondary winding of the busy tone transformer 1377 and the line conductors of the trunk 1305.

Each time the ring relay R1390 operates it completes, at the contacts 1392 and 1393, a circuit for projecting ringing current over the line conductors of the subscriber line 1401 extending to the called subscriber substation T5 and interrupts, at the contacts 1391 and 1394, further points in the previously mentioned circuit for energizing in series the upper and lower windings of the answer relay R1375. The circuit for projecting ringing current over the line conductors of the subscriber line 1401 extending to the called subscriber substation T5 extends from the source of ringing current 1318 by way of the contacts 1392, C1311, the line wiper 1411 of the wiper set of the automatic switch and the engaged line contact of the contact set 08 in the associated contact bank 1410 to one of the line conductors of the subscriber line 1401, and from the source of ringing current 1318 by way of the contacts 1393, C1312, the line wiper 1412 of the wiper set of the automatic switch and the engaged line contact of the contact set 08 in the associated contact bank 1410 to the other line conductor of the subscriber line 1401; the ringer at the called subscriber substation T5 being bridged across the line conductors of the subscriber line 1401. Accordingly the ringer at the called subscriber substation T5 is operated at this time and when the subscriber thereat answers the call by removing the receiver of the telephone instrument thereat from its associated switchhook a circuit substantially identical to that previously traced is completed for energizing in series the upper and lower windings of the answer relay R1375. The last-mentioned circuit extends from ground by way of the lower winding of the answer relay R1375, the contacts 1384 and 1394, C1312 to the line wiper 1412 of the wiper set of the automatic switch; and from battery by way of the upper winding of the answer relay R1375, the contacts 1383 and 1391, C1311 to the line wiper 1411 of the wiper set of the automatic switch; the line wipers 1411 and 1412 of the automatic switch being connected by way of the previously traced path to the called subscriber substation T5. When the answer relay R1375 is thus energized it operates to complete, at the contacts 1376, an obvious circuit, including the contacts 1372, for energizing the upper winding of the test relay R1370, thereby to cause the latter relay to operate. Upon operating, the test relay R1370 interrupts, at the contacts 1373, the previously traced circuit for energizing the winding of the ring relay R1390, thereby to prevent further intermittent operation of the latter relay. Also the test relay R1370 interrupts, at the contacts 1372, the above-traced circuit for energizing the upper winding thereof; however, the latter relay remains in its operated position in view of the fact that the lower winding thereof is energized in series with the winding of the switch-through relay R1380 at this time, the test relay R1370 being of the marginal type.

At this time an operative connection is completed between the calling subscriber substation T4 and the called subscriber substation T5. More particularly, the calling subscriber substation T4 is connected by way of the subscriber line 1301, the line switch 1302 and the line conductors C1306 and C1307 of the trunk 1305 to the upper and lower windings of the line relay R1310; while the called subscriber substation T5 is connected by way of the subscriber line 1401, the automatic switch incorporated in the connector 1300, the conductors C1311, C1312, the contacts 1391, 1394 and 1381, 1385 and the condensers 1315, 1316 to the upper and lower windings of the line relay R1310.

The release of this established connection is under the control of the subscriber at the calling subscriber substation T4 and is effective when the subscriber thereat replaces the receiver of the telephone instrument thereat upon its associated switchhook in order to interrupt the previously traced circuit for energizing in series the upper and lower windings of the line relay R1310 in the connector 1300, whereby the latter relay restores. Upon restoring, the line relay R1310 interrupts, at the contacts 1311, the previously mentioned circuit for energizing the winding of the hold relay R1320, thereby to cause the latter relay to restore shortly thereafter, the hold relay R1320 being of the slow-to-release type. Upon restoring, the hold relay R1320 interrupts, at the contacts 1321, the previously traced multiple holding circuits for energizing the windings of the first digit relay R1350 and the second digit relay R1340, thereby to cause the latter relays to restore. Upon restoring, the second digit relay R1340 interrupts, at the contacts 1344, the previously traced circuit for energizing the winding of the switch-through relay R1380 in series with the lower winding of the test relay R1370, thereby to cause the latter relays to restore. Upon restoring, the switch-through relay R1380 interrupts, at the contacts 1383 and 1384, the previously traced circuit for energizing in series the upper and lower windings of the answer relay R1375, thereby to cause the latter relay to restore. Also, upon restoring, the hold relay R1320 interrupts, at the contacts 1324, the previously traced circuit for energizing the winding of the dial relay R1330, thereby to cause the latter relay to restore shortly thereafter, the dial relay R1330 being of the slow-to-release type. Further the hold relay R1320 completes, at the contacts 1325, the previously mentioned circuit for energizing the winding of the reset relay R1365 in series with the go magnet M1356, this circuit extending from ground by way of the con-

tacts 1313 and 1325, the contacts 1337 of the set of switch springs S1336, the winding of R1395 and the go magnet M1356 to battery. When thus energized the reset relay R1395 and the go magnet M1356 operate. Further the line relay R1310 interrupts, at the contacts 1314, the previously traced circuit for energizing the winding of the stop relay R1365 in series with the stop magnet M1357, thereby to cause the stop relay R1365 and the stop magnet M1357 to restore.

When the go magnet M1356 operates and the stop magnet M1357 restores the operating shaft 105 is again clutched to the stub shaft 140, whereby the wiper set of the automatic switch incorporated in the connector 1300 is rotated in the clockwise direction with respect to the associated contact bank 1410. In this connection it is pointed out that the wiper set of the automatic switch is driven in the clockwise direction at the relatively high speed due to the fact that the gear train, shown in Fig. 2, is rendered ineffective at this time. More particularly, upon restoring, the first digit relay R1350 interrupts, at the contacts 1355, the previously mentioned circuit for energizing the shift magnet M1358, thereby to cause the latter magnet to restore. Upon restoring, the shift magnet M1358 renders ineffective the gear train, shown in Fig. 2, which is incorporated in the automatic switch 100 shown in Fig. 1, in the manner previously explained.

When the wiper set of the automatic switch is returned to its normal position, engaging the contact set 10 in the associated contact bank 1410, the sets of switch springs S1335, S1339 and S1336 are actuated. More particularly, the set of switch springs S1335 is actuated into disengagement, thereby to interrupt the application of ground potential to the control conductor C1308 of the trunk 1305 in order to mark the trunk 1305 and consequently the connector 1300 as idle to the line switches having access thereto. The set of switch springs S1339 is actuated into disengagement, thereby to interrupt a further point in the previously traced original operating circuit for energizing the winding of the first digit relay R1350. The set of switch springs S1336 is actuated in order to interrupt, at the contacts 1337 thereof, the previously traced circuit for energizing the winding of the reset relay R1395 in series with the go magnet M1356, thereby to cause the go magnet M1356 to restore immediately and the reset relay R1395 to restore shortly thereafter, the reset relay R1395 being of the slow-to-release type. Also the set of switch springs S1336 is actuated, thereby to complete, at the contacts 1338 thereof, an alternative circuit for energizing the stop magnet M1357, the last-mentioned circuit extending from ground by way of the contacts 1313 and 1325, the contacts 1338 of the set of switch springs S1335, the contacts 1396 and the stop magnet M1357 to battery. When thus energized the stop magnet M1357 operates. When the go magnet M1356 restores and the stop magnet M1357 operates the operating shaft 105 is again declutched from the stub shaft 140. At this time the automatic switch incorporated in the connector 1300 is completely released and the wiper set thereof occupies its normal position, engaging the contact set 10 in the associated contact bank 1410. Shortly thereafter the reset relay R1395 restores, thereby to prepare, at the contacts 1397, a further point in the previously traced original operating circuit for energizing the winding of the first digit relay R1350 and to interrupt, at the contacts 1396, the previously traced alternative circuit for energizing the stop magnet M1357. The stop magnet M1357 then restores; however, the operating shaft 105 remains declutched from the stub shaft 140 due to the action of gravity, in the manner previously explained.

The operative connection between the calling subscriber substation T4 and the called subscriber substation T5 is completely released and the connector 1300 is available for further use, assuming that the subscriber at the called subscriber substation T5 has replaced the receiver of the telephone instrument thereat upon its associated switchhook at this time.

Referring now more particularly to Figs. 13 and 15 of the drawings, there is illustrated a further modified form of the automatic telephone system comprising an exchange having a plurality of subscriber lines extending thereto, including the subscriber lines 1301 and 1501 respectively extending to the subscriber substations T4 and T6. Also the exchange comprises subscriber controlled switching apparatus for setting up connections between the various subscriber lines, the switching apparatus comprising a line switch individual to each subscriber line, the line switches 1302 and 1502 being individual to the subscriber lines 1301 and 1501, respectively, and a group of connectors including the connector 1300. Preferably each of the line switches has access to each of the connectors and each of the connectors has access to each of the subscriber lines in the exchange.

Preferably each subscriber substation comprises subscriber substation apparatus, including a telephone instrument and a ringer of conventional construction and arrangement, and a calling device or dial embodying the unique construction and arrangement disclosed in the copending application of Bernard D. Willis, Serial No. 413,177, filed October 1, 1941. As disclosed in the Willis application mentioned, this calling device is so constructed and arranged that it transmits a single impulse of variable length or time duration as contrasted with conventional calling devices which transmit a variable series of impulses, this calling device including a finger dial and having the same general external appearance as a conventional calling device.

Preferably each of the connectors is identical to the connector 1300 which comprises an automatic switch of the character of the automatic switch 100 shown in Fig. 1; which automatic switch has incorporated therein a gear train of the character of that shown in Fig. 3 and is provided with an associated contact bank of the character of that shown either in Fig. 5 or in Fig. 8 and a corresponding wiper set of the character of that shown either in Fig. 6 or in Fig. 9. In other words, the automatic switch incorporated in the connector 1300 is of the type disclosed, wherein the wiper set thereof is advanced continuously during the primary movement thereof in the clockwise direction, and is then advanced continuously during the secondary movement thereof further in the clockwise direction, in the manner previously explained. Also this automatic switch comprises a go magnet M1356, a stop magnet M1357, a shift magnet M1358, three sets of switch springs S1335, S1336 and S1339, a wiper set including the wipers 1511 to 1513, inclusive, and an associated contact bank 1510.

Further the connector 1300 comprises a relay group and a control network connected and arranged in the manner previously described.

In the connector 1300 the circuit elements of the relay group are strapped to the individual wipers of the wiper set of the automatic switch. More particularly, the conductors C1311, C1312, and C1313 are respectively strapped to the line wiper 1511, the line wiper 1512 and the control wiper 1513.

The mechanical construction and arrangement of the automatic switch 100 shown in Fig. 1, as well as the electrical connections and arrangement of the telephone system shown in Figs. 13 and 15, will best be understood from a consideration of the mode of operation of the apparatus incorporated in the system incident to the extension of a telephone connection from the subscriber substation T4 to the subscriber substation T6.

The subscriber at the calling subscriber substation T4 first initiates the call in the manner previously explained, whereby the associated line switch 1302 seizes an idle connector, such, for example, as the connector 1300. The subscriber at the calling subscriber substation T4 then proceeds to dial the first and second digits of the directory number of the called subscriber substation T6, the digits 9 and 8, in view of the fact that the subscriber line 1501 extending to the called subscriber substation T6 is terminated by the contact set 98 in the contact bank 1510 of the automatic switch incorporated in the connector 1300.

The operation of the relay group in the connector 1300 in response to the first digit 9, to rotate the wiper set of the automatic switch in the clockwise direction to engage the contact set 80 in the associated contact bank 1510, is substantially identical to that previously described. When the wiper set engages the contact set 80 in the associated contact bank 1510 further operation thereof is arrested and the shift magnet M1358 is operated in order to render the gear train, shown in Fig. 3, effective, in the manner previously explained.

Also the operation of the relay group in the connector 1300 in response to the second digit 8, to rotate the wiper set of the automatic switch further in the clockwise direction to engage the contact set 98 in the associated contact bank 1510, is substantially identical to that previously described. When the wiper set engages the contact set 98 in the associated contact bank 1510, further operation thereof is arrested. At this time the connector 1300 has operated to select the contact 98 in the contact bank 1510 terminating the subscriber line 1501 extending to the called subscriber substation T6.

The relay group in the connector 1300 then operates in order to test the idle or busy condition of the called subscriber substation T6, whereupon busy tone current is returned to the calling subscriber substation T4 or ringing current is projected over the subscriber line 1501 to the called subscriber substation T6, in the manner previously explained. The subsequent operation of the relay group in the connector 1300, in response to the answering of the call at the called subscriber substation T6, is the same as that previously explained, whereupon an operative connection is completed between the calling subscriber substation T4 and the called subscriber substation T6.

The subsequent release of the established connection between the calling subscriber substation T4 and the called subscriber substation T6 is under the control of the subscriber substation T4 and is effected when the subscriber thereat replaces the receiver of the telephone instrument thereat upon its associated switchhook, in the manner previously explained.

While several embodiments of the automatic switch, as well as several embodiments of the automatic telephone system, incorporating the present invention, have been disclosed, it will be understood that various modifications may be made therein which are within the true spirit and scope of the invention.

What is claimed is:

1. An automatic switch comprising a contact bank including a plurality of groups of contacts arranged in a row, each of said groups including N contacts, a contact controlling member mounted for both primary and secondary movements along said row of contacts, means for imparting primary movement to said member at a substantially uniform speed NS, whereby said member selects from said contact bank one group of contacts per unit time interval during the primary movement thereof, and means for imparting secondary movement to said member at a substantially uniform speed S, whereby said member selects from the previously selected group of contacts one contact per unit time interval during the secondary movement thereof.

2. An automatic switch comprising a contact bank including a plurality of groups of contacts arranged in an annular row, each of said groups including N contacts, a contact controlling member mounted for both primary and secondary rotations along said annular row of contacts, means for imparting primary rotation to said member at a substantially uniform angular speed $N\theta$, whereby said member selects from said contact bank one group of contacts per unit time interval during the primary rotation thereof, and means for imparting secondary rotation to said member at a substantially uniform angular speed θ, whereby said member selects from the previously selected group of contacts one contact per unit time interval during the secondary rotation thereof.

3. An automatic switch comprising a contact bank including a plurality of groups of contacts arranged in a row, each of said groups including N contacts, a contact controlling member mounted for both primary and secondary movements in opposite directions along said row of contacts, means for imparting primary movement in one direction to said member at a substantially uniform speed NS, whereby said member selects from said contact bank one group of contacts per unit time interval during the primary movement thereof, and means for imparting secondary movement in the opposite direction to said member at a substantially uniform speed S, whereby said member selects from the previously selected group of contacts one contact per unit time interval during the secondary movement thereof.

4. An automatic switch comprising a contact bank including a plurality of groups of contacts arranged in an annular row, each of said groups including N contacts, a contact controlling member mounted for both primary and secondary rotations in opposite directions along said annular row of contacts, means for imparting primary rotation in one direction to said member at a substantially uniform angular speed $N\theta$, whereby said member selects from said contact bank one group of contacts per unit time interval during the primary rotation thereof, and

means for imparting secondary rotation in the opposite direction to said member at a substantially uniform angular speed θ, whereby said member selects from the previously selected group of contacts one contact per unit time interval during the secondary rotation thereof.

5. An automatic switch comprising a contact bank including a plurality of groups of contacts arranged in a row, each of said groups including N contacts, a contact controlling member mounted for both primary and secondary movements in the same direction along said row of contacts, means for imparting primary movement in one direction to said member at a substantially uniform speed NS, whereby said member selects from said contact bank one group of contacts per unit time interval during the primary movement thereof, and means for imparting secondary movement further in said one direction to said member at a substantially uniform speed S, whereby said member selects from the previously selected group of contacts one contact per unit time interval during the secondary movement thereof.

6. An automatic switch comprising a contact bank including a plurality of groups of contacts arranged in an annular row, each of said groups including N contacts, a contact controlling member mounted for both primary and secondary rotations in the same direction along said annular row of contacts, means for imparting primary rotation in one direction to said member at a substantially uniform angular speed $N\theta$, whereby said member selects from said contact bank one group of contacts per unit time interval during the primary rotation thereof, and means for imparting secondary rotation further in said one direction to said member at a substantially uniform angular speed θ, whereby said member selects from the previously selected group of contacts one contact per unit time interval during the secondary rotation thereof.

7. An automatic switch comprising a contact bank including a plurality of groups of contacts arranged in a row, each of said groups including N contacts, a contact controlling member mounted for both primary and secondary movements along said row of contacts, an operating shaft, transmission mechanism selectively operative to impart to said member from said operating shaft primary movement at a substantially uniform speed NS and secondary movement at a substantially uniform speed S, whereby said member is controlled to select from said contact bank one group of contacts per unit time interval during the primary movement thereof and to select from the previously selected group of contacts one contact per unit time interval during the secondary movement thereof.

8. An automatic switch comprising a contact bank including a plurality of groups of contacts arranged in a row, each of said groups including N contacts, a contact controlling member mounted for both primary and secondary movements along said row of contacts, an operating shaft, transmission mechanism operatively connecting said operating shaft to said member and having primary and secondary transmission ratios bearing the relation N:1, and means for controlling said transmission mechanism selectively to render effective the transmission ratios thereof, thereby to impart to said member primary movement at a substantially uniform speed NS and secondary movement at a substantially uniform speed S, whereby said member is controlled to select from said contact bank one group of contacts per unit time interval during the primary movement thereof and to select from the previously selected group of contacts one contact per unit time interval during the secondary movement thereof.

9. An automatic switch comprising a contact bank including a plurality of groups of contacts arranged in an annular row, each of said groups including N contacts, a contact controlling member mounted for both primary and secondary rotations along said annular row of contacts, an operating shaft mounted for rotation at a substantially uniform angular speed $N\theta$, transmission mechanism including a gear train having a transmission ratio of N:1 and selectively operative to connect said operating shaft directly to said member and to connect said operating shaft through said gear train to said member, and means for selectively controlling the operation of said mechanism, thereby to impart to said member primary rotation at a substantially uniform angular speed $N\theta$ and secondary rotation at a substantially uniform angular speed θ, whereby said member is controlled to select from said contact bank one group of contacts per unit time interval during the primary rotation thereof and to select from the previously selected group of contacts one contact per unit time interval during the secondary rotation thereof.

10. An automatic switch comprising a contact bank including a plurality of groups of contacts arranged in a row, each of said groups including N contacts, a contact controlling member having a normal position and mounted for both primary and secondary movements along said row of contacts, means for imparting primary movement to said member away from its normal position at a substantially uniform speed NS for a time interval substantially AT, thereby to cause said member to select from said contact bank the A group of contacts during the primary movement thereof, and means for imparting secondary movement to said member away from said last-mentioned position at a substantially uniform speed S for a time interval substantially BT, thereby to cause said member to select from said A group of contacts the B contact during the secondary movement thereof.

11. An automatic switch comprising a contact bank including a plurality of groups of contacts arranged in a row, each of said groups including N contacts, a contact controlling member having a normal position and mounted for both primary and secondary movements along said row of contacts, a drive shaft, an operating shaft, clutch mechanism selectively operative to impart to said operating shaft from said drive shaft primary and secondary movements respectively corresponding to primary and secondary time intervals, and transmission mechanism selectively operative to impart to said member from said operating shaft corresponding primary and secondary movements at respective substantially uniform speeds NS and S, whereby said member is controlled to select from said contact bank the one of said groups of contacts corresponding to said primary time interval during the primary movement thereof and to select from said one group of contacts the one of said contacts corresponding to said secondary time interval during the secondary movement thereof.

12. An automatic switch comprising a contact bank including a plurality of groups of con-

tacts arranged in a row, each of said groups including N contacts, a contact controlling member having a normal position and mounted for both primary and secondary movement along said row of contacts, a drive shaft, an operating shaft, clutch mechanism selectively operative to impart to said operating shaft from said drive shaft primary and secondary movements respectively corresponding to primary and secondary time intervals, first electromagnetic means for controlling the operation of said clutch mechanism, transmission mechanism selectively operative to impart to said member from said operating shaft corresponding primary and secondary movements at respective substantially uniform speeds NS and S, and second electromagnetic means for controlling the operation of said transmission mechanism, whereby said member is controlled to select from said contact bank the one of said groups of contacts corresponding to said primary time interval during the primary movement thereof and to select from said one group of contacts the one of said contacts corresponding to said secondary time interval during the secondary movement thereof.

13. In a switching system, an automatic switch comprising a contact bank including a plurality of groups of contacts arranged in a row, each of said groups including N contacts, a contact controlling member mounted for both primary and secondary movements along said row of contacts, a digit register, means for registering variable primary and secondary digits in said digit register, means responsive to the registration of a primary digit in said digit register for imparting primary movement to said member at a substantially uniform speed NS for a number of unit time intervals corresponding to said primary digit, thereby to cause said member to select from said contact bank the one of said groups of contacts corresponding to said primary digit, and means responsive to the registration of a secondary digit in said digit register for imparting secondary movement to said member at a substantially uniform speed S for a number of unit time intervals corresponding to said secondary digit, thereby to cause said member to select from said one group of contacts the one of said contacts corresponding to said secondary digit.

14. In a switching system, an automatic switch comprising a contact bank including a plurality of groups of contacts arranged in a row, each of said groups including N contacts, a contact controlling member mounted for both primary and secondary movements along said row of contacts, means for transmitting primary and secondary impulses of variable time duration to said switch, means for imparting primary movement to said member at a substantially uniform speed NS during said primary impulse, thereby to cause said member to select from said contact bank the one of said groups of contacts corresponding to the number of unit time intervals of the time duration of said primary impulse, and means for imparting secondary movement to said member at a substantially uniform speed S during said secondary impulse, thereby to cause said member to select from said one group of contacts the one of said contacts corresponding to the number of unit time intervals of the time duration of said secondary impulse.

WM. WALTER OWEN,
Executor of the Estate of Bernard D. Willis, Deceased.