Nov. 17, 1925.

1,561,526

G. S. VERNAM

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Filed Dec. 11, 1922

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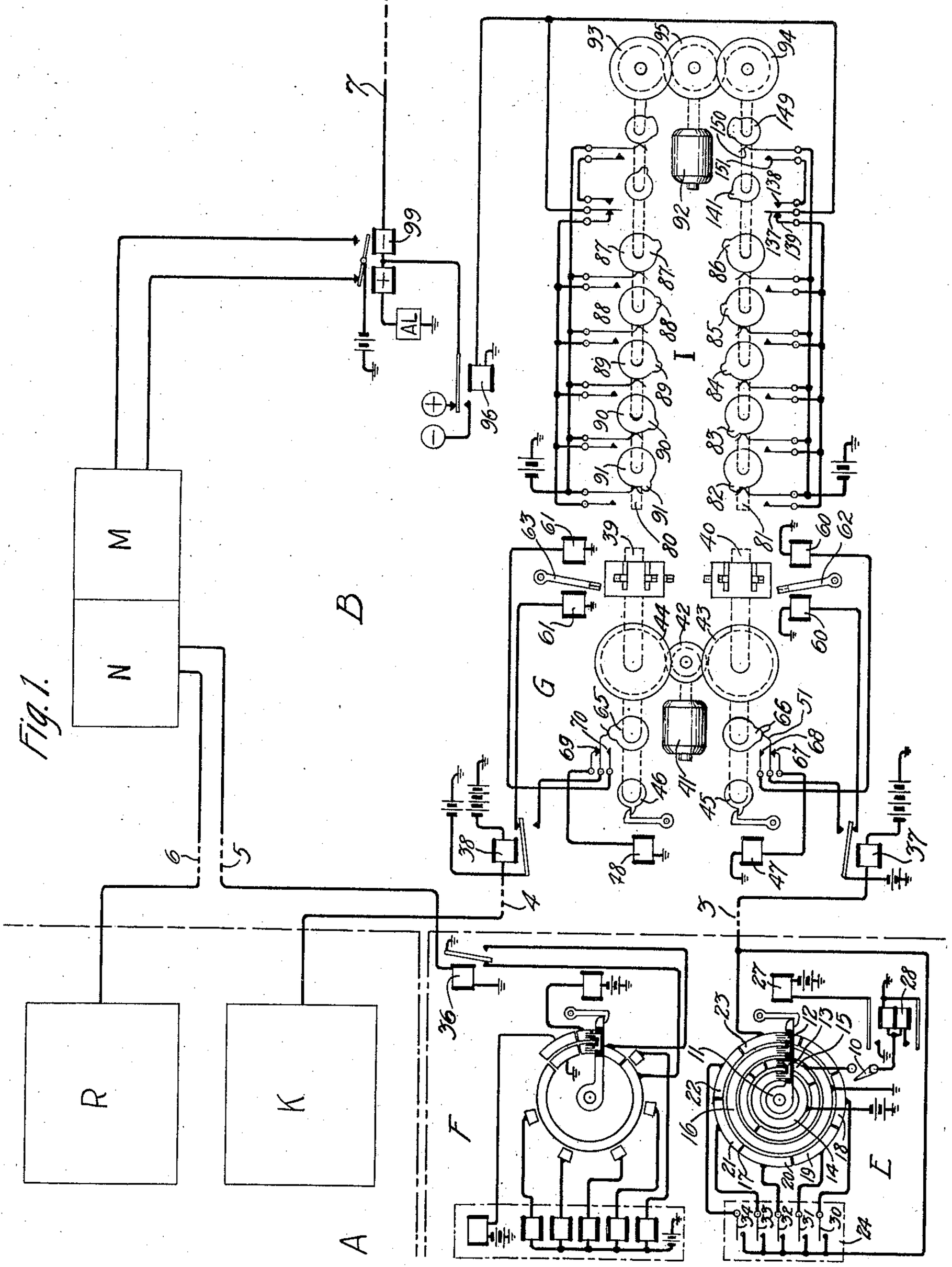

Fig. 1.

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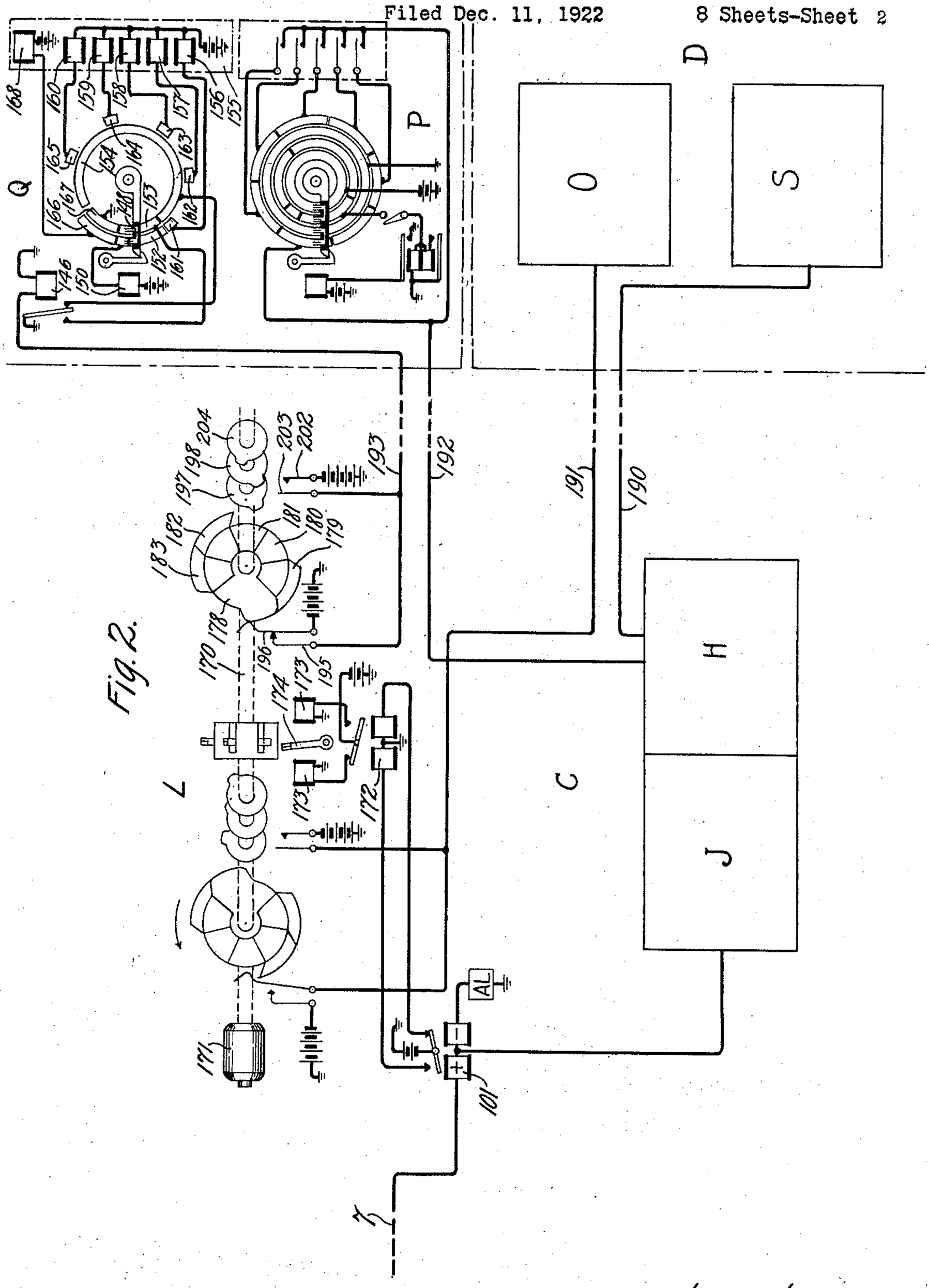

Fig. 2.

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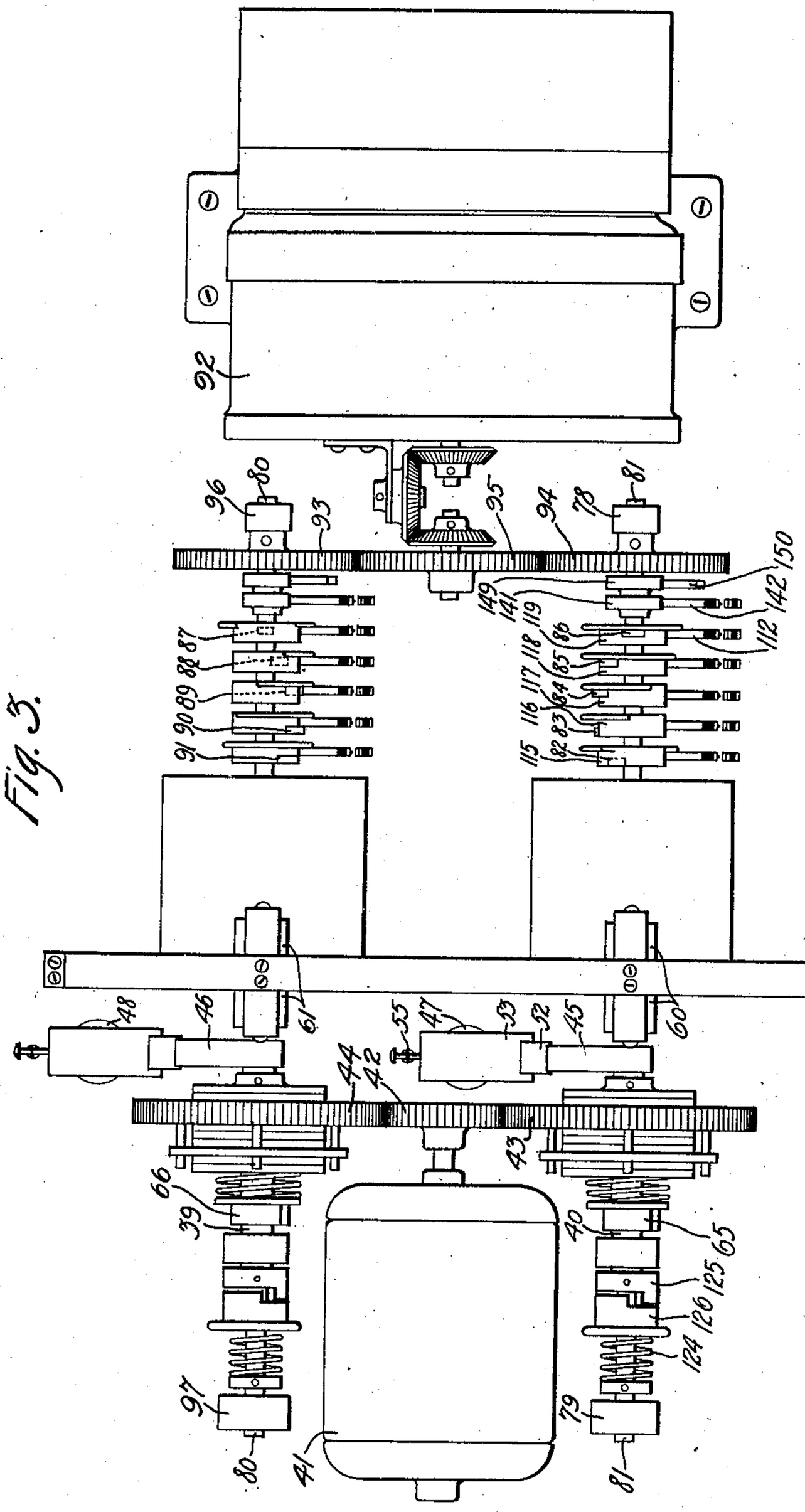
8 Sheets-Sheet 3

Fig. 3.



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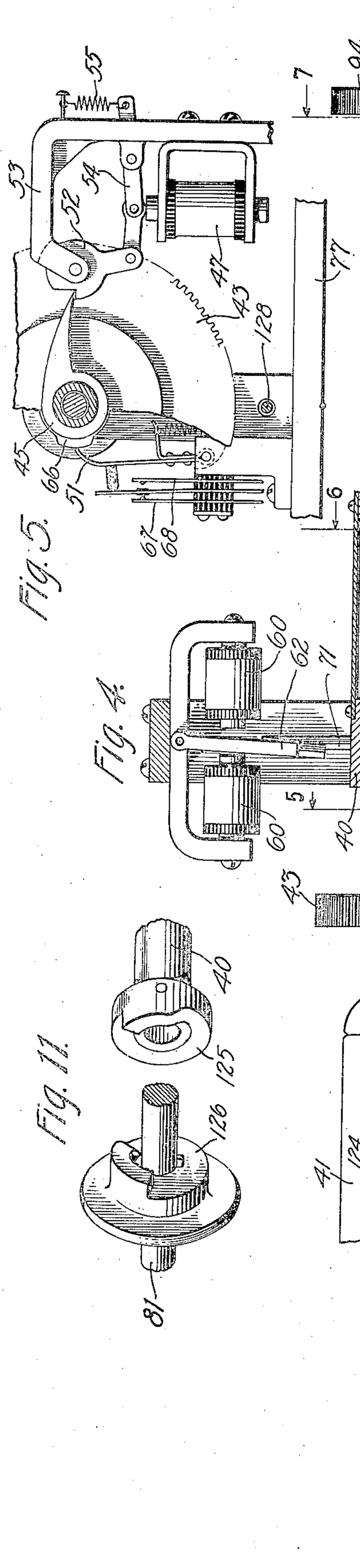

Fig. 5.

Fig. 4.

Fig. 11.

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Fig. 7.

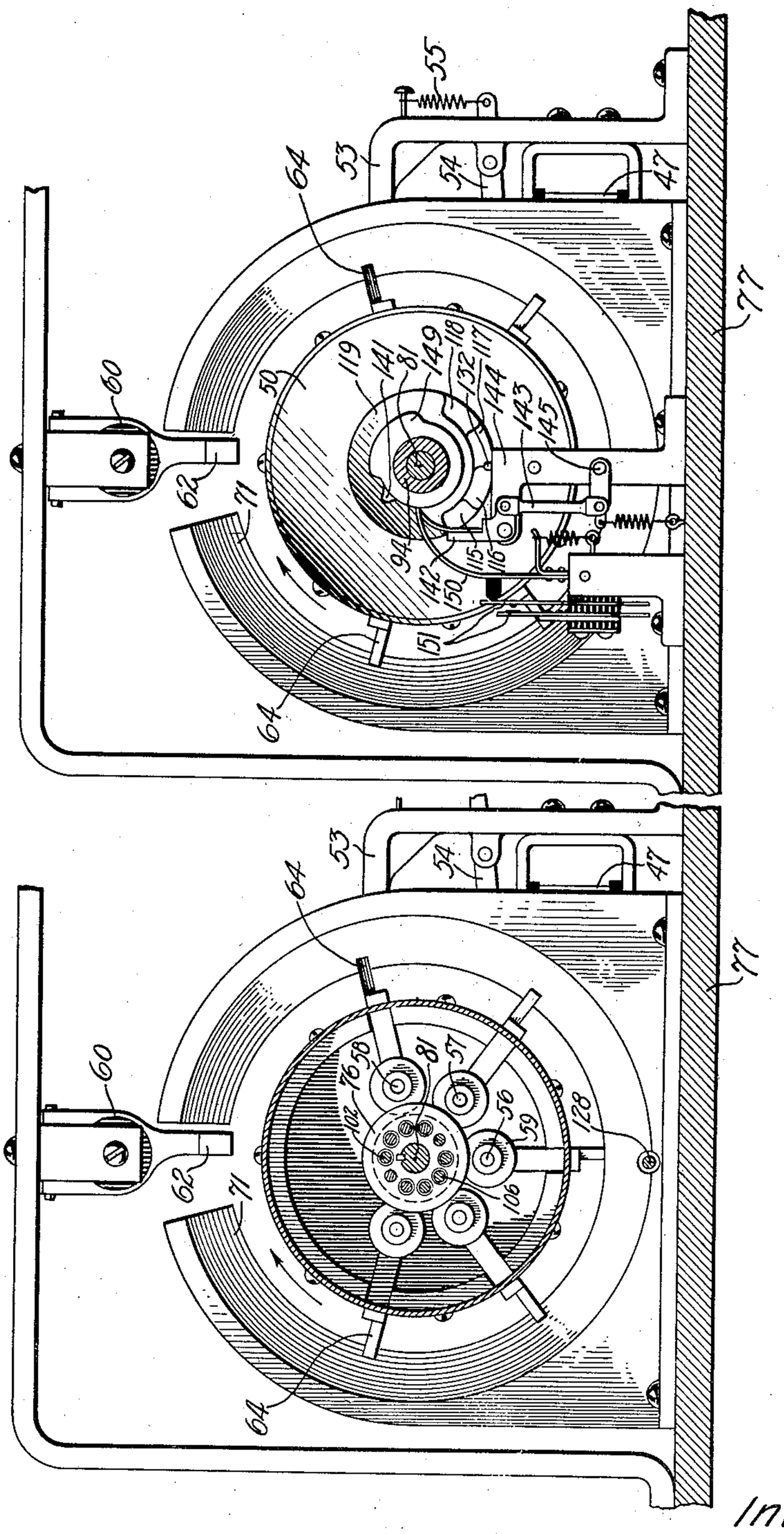

Fig. 6.

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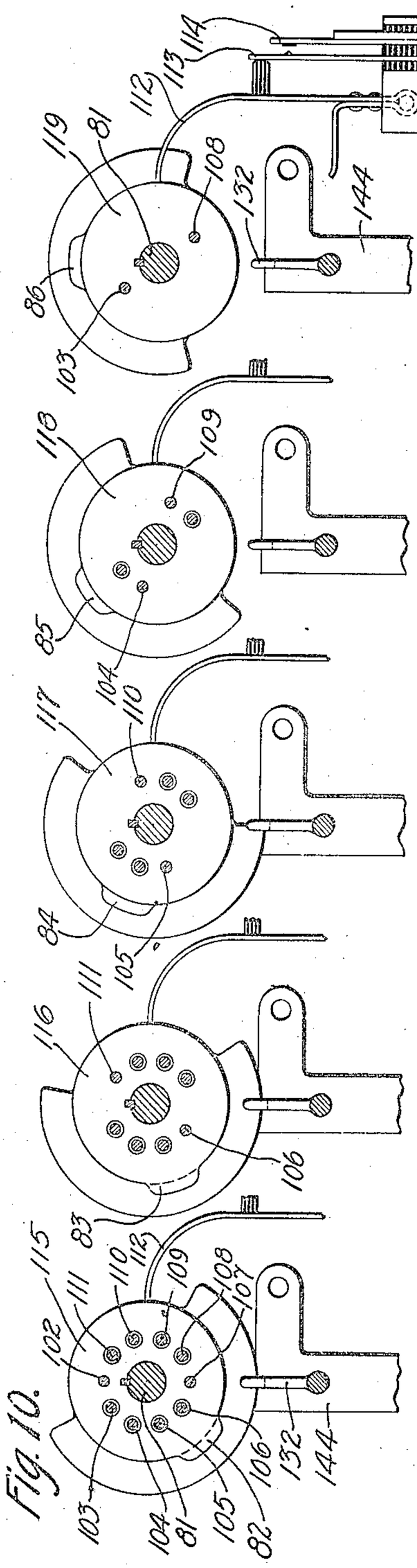

Fig. 10.

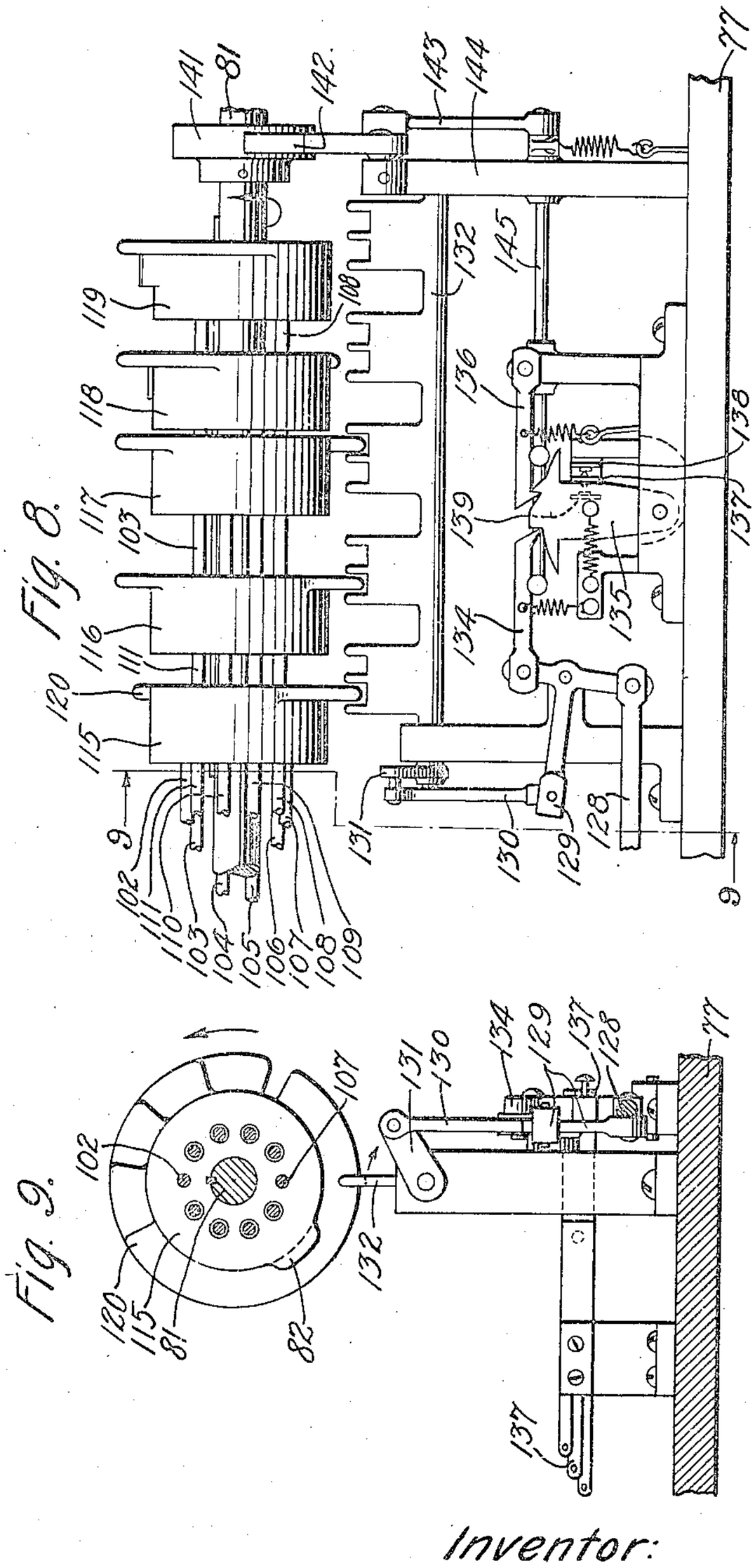

Fig. 8.

Fig. 9.

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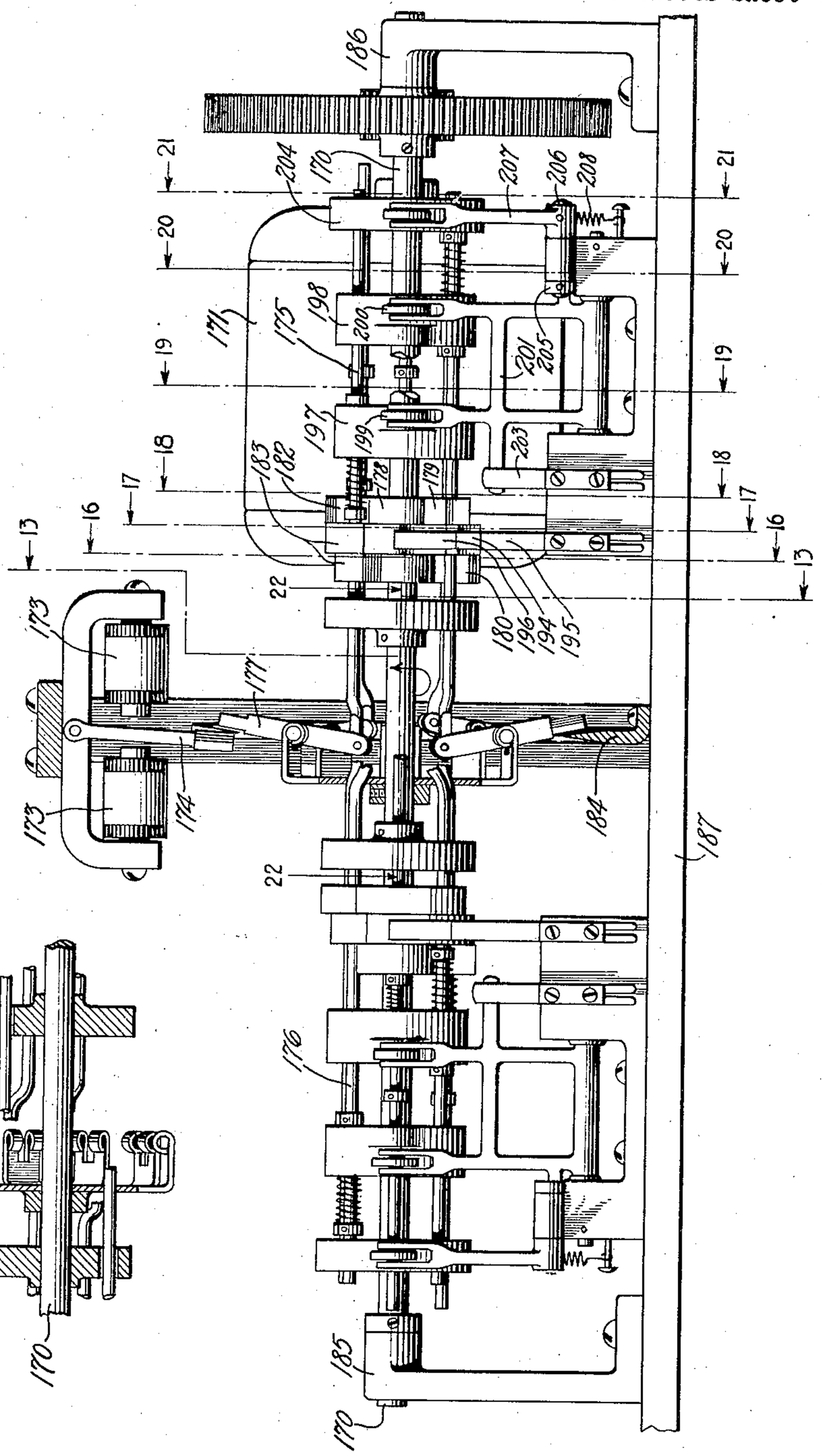

Fig. 12.

Fig. 22.

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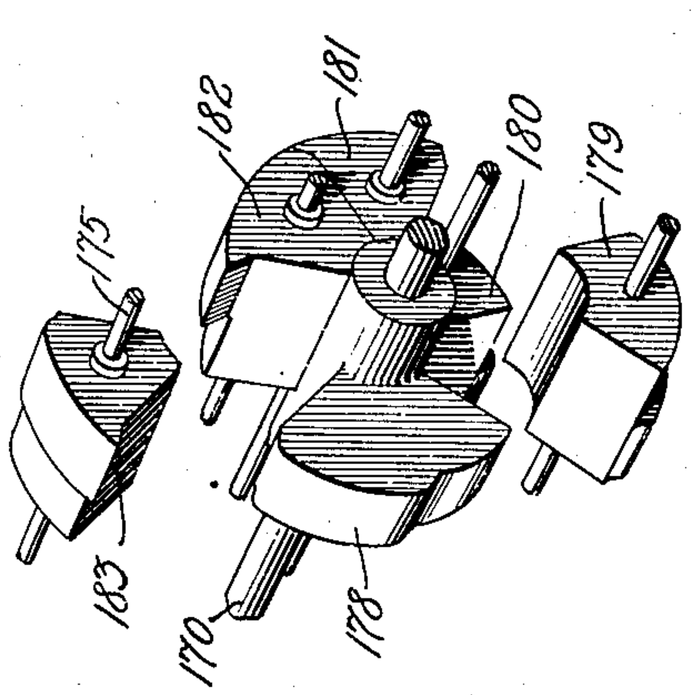

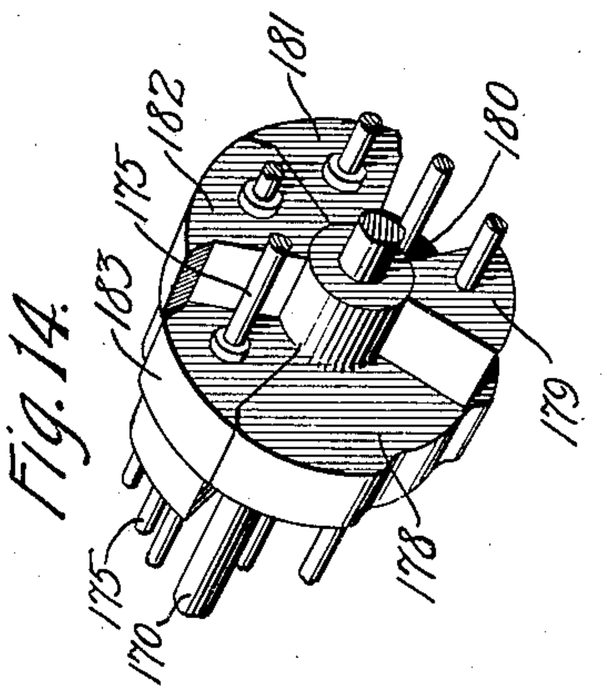

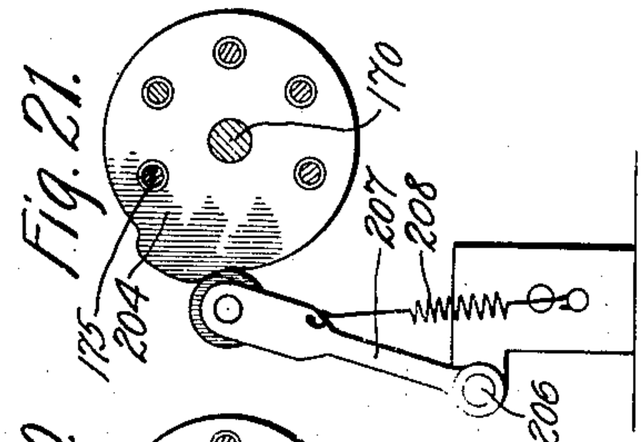

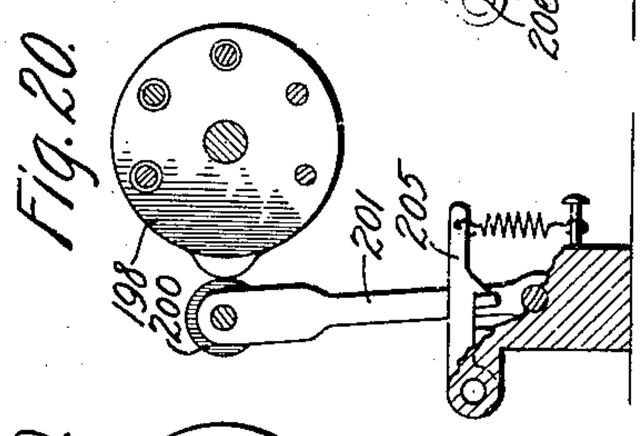

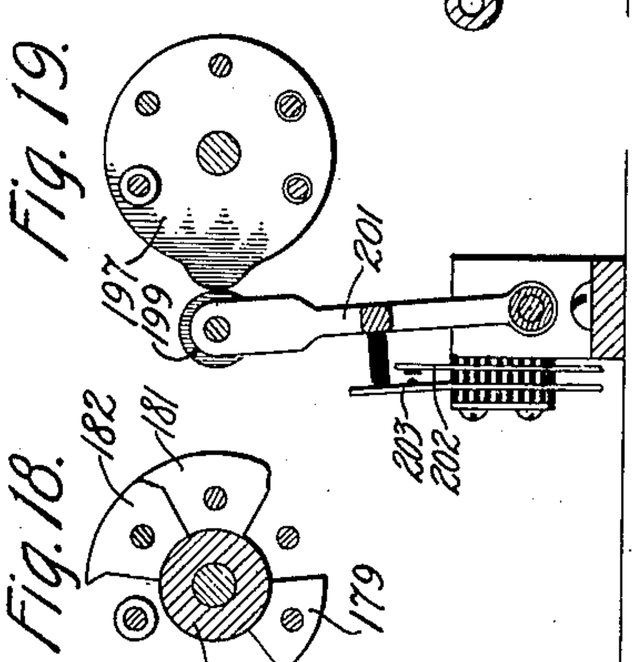

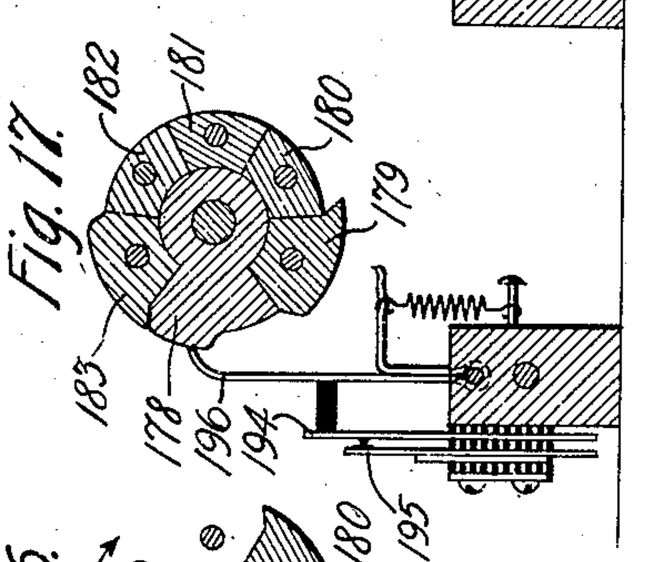

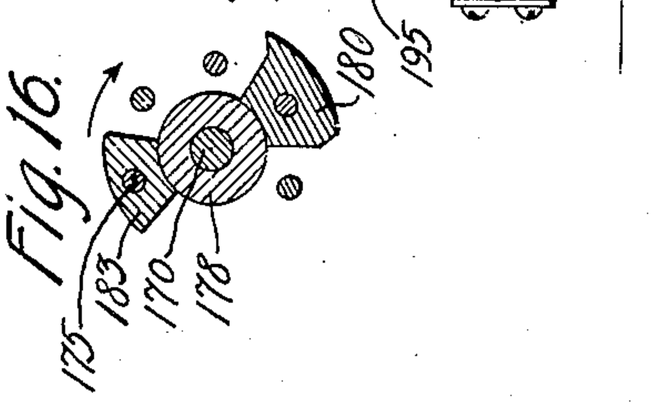

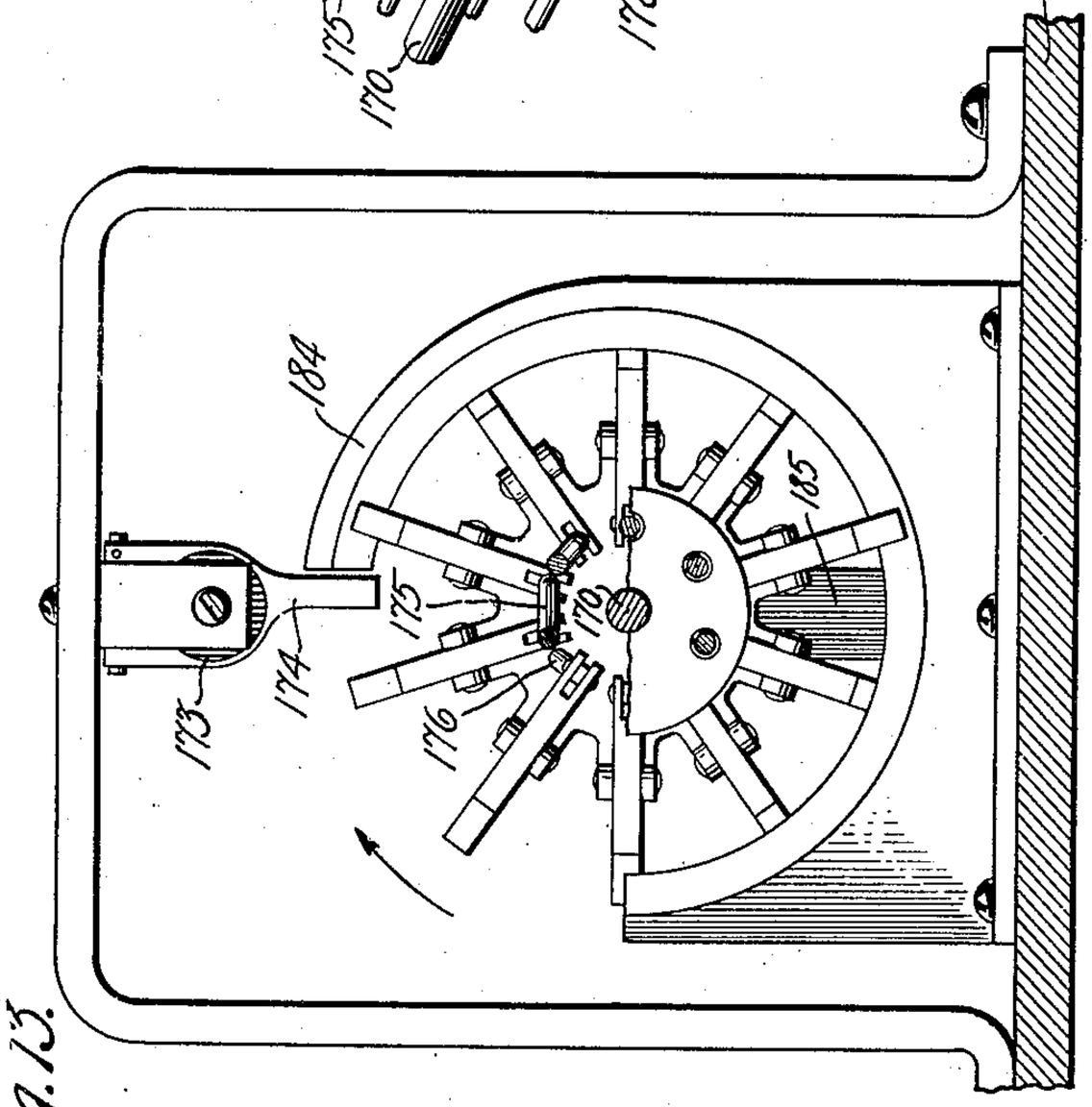

Inventor:
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Gifford Att'y.

Patented Nov. 17, 1925.

1,561,526

UNITED STATES PATENT OFFICE.

GILBERT S. VERNAM, OF BROOKLYN, NEW YORK, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

PRINTING TELEGRAPHY.

Application filed December 11, 1922. Serial No. 606,272.

To all whom it may concern:

Be it known that I, GILBERT S. VERNAM, residing at Brooklyn, in the county of Kings and State of New York, have invented certain Improvements in Printing Telegraphy, of which the following is a specification.

This invention relates to printing telegraph systems and particularly to synchronous multiplex systems with extension circuits.

Its object is a system of the above character wherein the selections received from a line of one character are transferred to a line of a different character by the operation of electrical contacts.

The invention in its preferred form provides distributing apparatus, intermediate a branch line and a main line, comprising a series of selectable elements which are positioned in accordance with selections received from the branch line and which are subsequently rendered effective for controlling the operation of electrical contacts to retransmit to the main line corresponding selections. Likewise, according to an embodiment of the invention, there is provided between the main line and the branch line a distributor in which there are arranged a plurality of selecting elements which position corresponding cams for operating a contact in accordance with the selections received from the main line.

The invention is illustrated in the accompanying drawing which represents one embodiment of the invention. Figures 1 and 2, when arranged so that Fig. 1 is to the left of Fig. 2, show diagrammatically a complete system. Fig. 3 is a plan view of the mechanism intermediate the branch line and the main line at the central station for transferring, storing and re-transmitting the impulses received from the branch line to the main line. Fig. 4 is an elevation of the mechanism shown in Fig. 3, a portion thereof being broken away for the purpose of more clearly illustrating the mechanism disclosed. Fig. 5 is a sectional view along the broken line 5—5. Fig. 6 is a sectional view along the broken line 6—6 of Fig. 4. Fig. 7 is a sectional view along the line 7—7 of Fig. 4. Fig. 8 is a detailed view of a portion of the mechanism illustrated in Fig. 4. Fig. 9 is a sectional view taken along the broken line 9—9 of Fig. 8. Fig. 10 shows the five operating cams of one channel which serve through their rotation to operate contacts, thereby retransmitting to the main line impulses corresponding to those received from the branch line. Fig. 11 is a perspective of a portion of the mechanism of Fig. 4. Fig. 12 is an elevation of the mechanism between the main line and the branch line at the central stations for transferring the impulses received from the main line to the branch line mechanically. Fig. 13 is a sectional view taken along the broken line 13—13 of Fig. 12. Fig. 14 is a perspective of the cams employed in the mechanism of Fig. 12. Fig. 15 is a perspective of the cams shown in Fig. 14 with portions thereof exploded to more clearly illustrate their construction. Fig. 16 is a sectional view taken along the broken line 16—16 of Fig. 12. Fig. 17 is a sectional view taken along the broken line 17—17 of Fig. 12. Fig. 18 is a sectional view taken along the broken line 18—18 of Fig. 12. Fig. 19 is a sectional view taken along the broken line 19—19 of Fig. 12. Fig. 20 is a sectional view taken along the broken line 20—20 of Fig. 12. Fig. 21 is a sectional view taken along the broken line 21—21 of Fig. 12. Fig. 22 is a sectional view taken along the broken line 22—22 of Fig. 12.

The invention in the embodiment disclosed comprises a branch office A which is connected with a main or central station B by extension circuits 3, 4, 5 and 6, a central or main station C connected with the main station B by a line conductor 7 equipped for duplex operation and a distant branch office D which, like branch office A, is connected with the associated central station C by line conductors 190, 191, 192 and 193.

At the branch office A, there are located transmitting equipments E and K and receiving apparatus F and R being shown diagrammatically. It is to be understood, of course, that the respective equipments may be located at different branch offices. The four extension circuits, 3, 4, 5 and 6 over which impulses are transmitted and

received respectively may be replaced by two line conductors equipped for duplex operation. Both the central stations B and C are provided with receiving distributors G and H of the start-stop type to receive the code combination of message impulses from the respective substations or branch offices and transfer them to multiplex synchronous distributors I and J also located at the offices B and C respectively through the instrumentalities of a plurality of mechanical storage elements. Also located at the central offices are the synchronous multiplex distributors L and M, each of which serves to receive the signaling impulses from the line conductor 7 connecting these two stations and transfers the same to the line conductors extending to the respective branch offices.

Branch office D, like branch office A, is provided with transmitting distributors P and S and receiving distributors Q and O of the start-stop type which serve their respective purposes. For the sake of clarifying the drawing, the apparatus individual to one channel has been shown in detail while that individual to the other channels has been shown schematically.

The transmitting equipment E comprises an intermittently rotating distributor having a brush arm 11 which carries a pair of brushes 12 and 13 which in turn are arranged to make contact with rings 14, 15, 16 and 17. The outer ring 17 is divided into a plurality of segments 18, 19, 20, 21, 22 and 23 which are connected with the respective contacts of a transmitter shown diagrammatically at 24. In order that the brush arm 11 will be stopped and released once per revolution, a release magnet 27 is provided. This magnet 27 is under the control of a start relay 28 being controlled through a circuit completed by the brush 13 of the distributor. The transmitter 24 consists of a plurality of movable contacts 30, 31, 32, 33 and 34 which are connected to the respective segments forming the outer ring 17 of the distributor. Although the transmitter 24 has been shown diagrammatically as an automatic transmitter, any well-known type of transmitter may be substituted therefor which will provide equally good results.

At the central office B, there is shown a receiving distributor G of the start-stop type and a synchronously operated distributor I which controls through a plurality of selectable cams the energization of a pole changer relay 96 for controlling the application of current in accordance with the position of the cams to the apex of the ratio arms which includes the receiving relay 99 forming a part of the duplex equipment associated with the line conductor 7. The line relay 99 responds only to incoming impulses and is not responsive to outgoing impulses. Upon the operation of the multiplex distributor I, this relay will not respond to impulses which may be transferred thereto from the start-stop distributor G.

As shown in Figs. 3, 4 and 5, the start-stop distributor G comprises a pair of rotatable sleeves 39 and 40 which are driven through a friction clutch by power communicated thereto through suitable gears from a motor 41 and which are stopped and released once per revolution by the engagement of a release latch with stop arms 45 and 46 rigidly fastened to the sleeves 39 and 40 respectively. The sleeves 39 and 40 encircle shafts 80 and 81 forming a part of the multiplex distributor I. Shaft 81 is journalled in uprights 78 and 79 while shaft 80 is journalled in uprights 96 and 97 all of which are secured to base 77. The sleeves 39 and 40 are supported in suitable ball bearings. The release latches are controlled by electromagnets 47 and 48. These release magnets respond to the receipt of a starting impulse and act to permit the rotation of the respective sleeves. Rigidly secured to each of the sleeves is a drum 50 in which there is concentrically arranged about the shaft 81, a plurality of selectable rods 56, the number corresponding to the code employed. In the present system, the Baudot or five-unit code is used which requires a corresponding number of these slidable rods 56. For positioning the slidable rods 56 into one or two positions, a pair of electromagnets 60 and 61 under the control of line relays 37 and 38 respectively are provided. Each of these magnets controls the movement of an armature, the free end of which carries a wedge shaped projection whereby members 64, secured to the rods 56, will be deflected to one side or the other of a stationary locking vane 71. Each of the rods 56 also carries a member 59 which is positioned with respect to a groove in a corresponding selecting disk by means of helical springs positioned on each side thereof. The selecting disks 72, 73, 74, 75 and 76 are spaced along the shaft 81 and are arranged to be positioned in accordance with the movement of their corresponding selecting rod.

Also secured to the sleeves 39 and 40 are cams 65 and 66 respectively which control the opening and closure of contacts 67, 68, 69 and 70. When the cams 65 and 66 are in their normal position, contacts 67 and 69 are closed, thereby conditioning the circuit extending to the release magnets 47 and 48 from the back contacts on the relays 37 and 38 so that when these relays are deenergized, relays 47 and 48 are energized for releasing the sleeves 39 and 40 for rotation. The instant the cams 65 and 66 are set into rotation, contacts 67 and 69 are broken while contacts 68 and 70 are completed. The com-

pletion of these contacts extends the circuit from the contacts controlled by the relays 37 and 38 to one of the magnets 60 and 61, whereupon the magnets are energized in accordance with the operation of these relays.

As shown in Fig. 5, the stop arm 45 normally engages a holding pawl 52 which is rotatably fastened to a yoke 53. This pawl 52 has one end thereof secured to a portion of a toggle joint 54 which is arranged to be operated upon the movement of a solenoid due to the energization of the magnet 47 controlled by the deenergization of relay 37. Upon the energization of magnet 47, the toggle joint 54 will be operated, thereby withdrawing the holding pawl 52 out of the path of the arm 54 and permitting the sleeve, upon which this arm is secured, to be rotated by power communicated thereto through the gears and friction clutch previously referred to. Folowing this the toggle joint 54 will be reset by the action of spring 55.

The shafts 80 and 81, which form a part of the multiplex distributor I, are driven by power derived from a motor 92 through gears 93 and 94 secured to shafts 80 and 81 respectively and gear 95 and associated bevelled gears for permitting of orientation. This motor 92 is of the type commonly employed in multiplex printing telegraph systems being driven, due to the operation of a body, such as a tuning fork having a natural period of motion. As this does not form a part of the present invention, a detailed description thereof is considered unnecessary, it being assumed, however, that the motor 92 is synchronized with the corresponding motor at the distant station by means of well-known synchronizing equipment. Revolvable with the shafts 80 and 81 are a plurality of cams 82, 83, 84, 85, 86, 87, 88, 89, 90 and 91 which control the opening and closure of contacts associated therewith for causing the energization and deenergization of pole changer relay 96. As shown in Fig. 4, the cams 82, 83, 84, 85 and 86 are mounted on drums 115, 116, 117, 118 and 119 each of which have a flange 120, the purpose of which will be more clearly described hereinafter. These drums with their respective cams are secured by means of rods to the corresponding selecting disks 72 to 76 inclusive and are movable horizontally in accordance with the movement of the disk individual thereto. It is thus seen that when the selecting disks are moved either to the left or right dependent upon the energization of the electromagnet 60 and the deflection of the arm 64 secured thereto to one side or the other of the stationary vane 71, the drum associated therewith will be moved to a corresponding position. As shown in Figs. 4 and 10 these cams are mounted on the respective drums such that to make cams 82 and 83 effective it is necessary to move the drums to the right while in the case of cams 84, 85 and 86, the corresponding drums must be moved to the left. Consequently, the cams will be moved either out of or in alignment with its associated contact so that, upon its continued rotation, the contact will be operated for transmitting over the main line an impulse corresponding to that which previously energized the magnet 60 and caused the setting of the selecting disks.

Under certain conditions, the movement of the selecting disks 72, 73, 74, 75 and 76 will be translated directly to the cams secured to the drums 115 to 119 inclusive. However, when the phase relation between the start-stop distributor G and the multiplex distributor I is such that the transferring of the movements of the rods 56 to selecting disks 72 to 76 and accordingly to the corresponding cams which are secured to the drums 115 to 119 is such that a mutilation of impulses would result, mechanism is provided whereby the transfer will be delayed. As shown in Figs. 4, 8 and 9, this transfer mechanism comprises a comb like member 132 which is arranged to be rotated either forwards or backwards, the flanges 120 on the drums being arranged to engage the grooves in this member so that when the member 132 is up, the movement of the corresponding drum is prevented for a portion of a revolution. For moving of the comb 132 either up or down, a pair of cams 125 and 126 are provided. The cam 125 is rigidly connected to the sleeve 40 while the cam 126 is keyed to the shaft 81. As shown in Fig. 11, each of these cams 125 and 126 is provided with a projecting portion which, under certain conditions, will be engaged with one another. The cam 125 being secured to the sleeve 40 will be rotated at a speed determined by the speed of the motor 41 and its intermediate gear, while the cam 126 is driven at the same speed as the motor 92. The cam 126 tends normally under the action of a spring 124 to engage the projection on the cam 125 and has associated therewith a pivoted lever which is moved in accordance with the movement of this cam. Fastened to one end of the pivoted lever 127 is a rod 128 extending to a bell crank lever 129 associated with the comb mechanism 132. This bell crank lever 129 controls the movement of lever 130 and a stepping pawl 134. The lever 130 operates, as shown in Fig. 9 on a bell crank lever 131 which is secured to the comb 132. The pawl 134 is arranged to engage teeth formed in the upper surface of a pivoted member 135 which is arranged to cause the engagement of spring 137 with either contact springs 138 or 139. As shown in Fig. 8 the edge of

pivoted member 135 is in engagement with contact spring 137 for producing the desired result, this member 135 being held in the position set by a holding pawl 136. Each of the elements just referred to is provided with suitable retractile springs for maintaining the respective elements in a normal position.

When the projections on the cams 125 and 126 act with each other, the cam 126, which is keyed to the multiplex shaft but able to move horizontally, is forced to the right and at the same time, lever 127 is moved for causing the corresponding movement of the bell crank lever 129 through the rod 128, whereupon the comb 132 is moved up and the pivoted member 135 moved to the right to close the contacts 137 and 138. The transfer contacts being now closed and the cams 82 to 86 prevented from moving due to the engagement of the flanges 120 with the teeth of the comb 132, an idle signal will be transmitted over the line conductor 7 upon the engagement of the cam 149, rigidly secured to the shaft 81 with its associated contacts. When the projections on the cams 125 and 126 act against each other, the multiplex cam which is keyed to the multiplex shaft but able to move horizontally is forced to the left, and at the same time, the lever 127 is operated, whereby the intermediate mechanism is also operated for lowering the comb. Since one of the cams is keyed to the multiplex and the other is rigidly rotated with the start-stop mechanism, their action depends on the phase relation between the multiplex shaft and the sleeve, which forms a part of the start-stop mechanism, the speeds of rotation of the multiplex and start-stop mechanisms being approximately the same, but since the start-stop mechanism must stop for an instant during each revolution, its accumulative speed is slower. This makes it evident that the phase relation of the two parts will be changed at each revolution, which accordingly makes it necessary for the provision of mechanism for controlling the transferring of the movements from the selecting disks forming a part of the start-stop mechanism to the cams of the multiplex mechanism.

Following the transmission of the fifth impulse, cam 141 secured to the shaft 81 is effective for causing the downward movement of bell crank lever 142. This bell crank lever 142 is arranged to cause the movement of a link 143 which is fastened to a shaft 145 which has a pair of projecting portions extending underneath the pawls 134 and 136. When the cam 141 is effective on the bell crank lever 142, the link 143 is rotated for causing the corresponding movement of the shaft 145 and the disengagement of the pawls 134 and 136 from the teeth in the pivoted member 135, whereupon this member is restored to normal under the action of its retractile spring. Upon the restoration of the pivoted member 135 to normal, the transfer contacts 137 and 138 are accordingly open. The transmission of the next series of impulses may be effected.

It is, of course, to be understood that a similar mechanism is associated with the sleeve 39 and the shaft 80 of the start-stop distributor G and the multiplex distributor I respectively for producing the same functions as described in connection with the sleeve 40 and the shaft 81 of the respective mechanisms. Further description of the mechanism associated with the other part of the apparatus is, therefore, considered unnecessary as it would merely mean a duplication of the description which has gone before.

Located at the station C and connected with the line conductor 7 is a multiplex distributing apparatus L which, like the start-stop apparatus G at station B is provided with a plurality of selectable elements for selecting and positioning a plurality of cams. The selectable elements, or rods, there being two groups 175 and 176, are arranged concentrically about a shaft 170 which is journaled in a pair of uprights 185 and 186, the uprights 185 and 186 being rigidly secured to a base 187 in any well-known manner. The group of selectable elements 175 is individual to one channel, while the elements of the group 176 are individual to another channel, as shown in Fig. 12. Each of the selectable elements has pivoted at one end thereof a member 177. This pivoted member is arranged to occupy either of two positions depending upon the position of a wedge shaped projection carried by armature 174 of magnets 173. To each of the selectable elements 175 and 176, there is secured an operating cam which is arranged to cause the operation of a pair of contacts 194 and 195 through the action of an operating element 196 for the transmission of impulses to the branch office D in accordance with the impulses received from the line connecting the central stations B and C. The cams 179, 180, 181, 182 and 183 which are individual to the selectable elements 175 are arranged concentrically about shaft 170 and in operative relation with cam 178 which is rigidly secured to the shaft 170.

The selectable elements in each of the groups 175 and 176 are at their extreme outer ends, spaced about the shaft 170, but in order that each group of selectable elements will be operated successively, they are bent at their inner ends in a manner such that they occupy only 180° as shown in Figs.

12, 13 and 22. Such an arrangement permits the sequential operation of the selectable elements whereby the cams are positioned accordingly for the operation of the associated contact and the transmission of impulses to the branch office D in accordance with those received from the main line 7. It is, of course, to be understood that the elements of the group 175 are individual to the one channel while those of group 176 are individual to another channel the time being divided such that the impulses of each channel will follow successively.

The pivoted member 177 upon its rotation is arranged to be deflected to one side or the other of a stationary vane 184 due to the positioning of a wedge-shaped projection on the free end of the armature 174 under the control of magnets 173. With the members 177 in their normal position, the cams 179 and 180 will be to the left of the cam 178, while the cams 181, 182 and 183 are on the right thereof. When this condition exists, the contacts 195 and 194 are closed upon the passage of the cam 178 underneath the operating element 196 of the contacts 194 and 195, which is the condition for closing the loop circuit extending to the branch office D and consequently causing the stoppage of the start-stop distributors at that station.

Arranged to be moved with two and three of the selectable elements are a pair of cams 197 and 198 Figs. 12, each of which are in operative relation to members 199 and 200 individual thereto for causing the movement of a bail 201, and consequently the operation of contacts 202 and 203. When either of the cams 179 or 180 is moved to the right, the cam section of 197 engages the member 200, whereupon the contacts 202 and 203 will be opened as long as these cams remain in this position or until the reset cam 204 is effective. The operation of the member 200 thereby opens contacts 202 and 203 for removing the battery connection from the line conductor 193, as shown in Fig. 2, whereupon the line relay 146 at station D is free to respond to the actuations of sending contacts 194 and 195. Likewise, if any one of the cam seections 181, 182 and 183 is moved to the left, the member 199 is operated for causing the corresponding opening of contacts 202 and 203. In order that the contacts 202 and 203 will be maintained open, for the complete signal period, a locking member 205 rotatably mounted on a shaft 206 is provided. The locking member 205 has a projection on its under side which engages a projecting member secured to the bail of which the members 199 and 200 form a part. Thus, when either of the members 199 or 200 is operated, these members will be retained in the position set until the locking member 205 is rotated to move the projection carried thereby out of the path of the projecting portion of the bail 201. The shaft 206, to which the locking member 205 is secured, is rotated upon the movement of member 207, which is held in operative relation with respect to reset cam 204 by a retractile spring 208. The reset cam 204 is rigidly secured to the shaft 170 and is positioned such that its raised portion will come in contact with member 207 just prior to the completion of the cycle of rotation of shaft 170. Following the opening of contacts 202 and 203 by the operation of either of the operating elements 199 and 200, the system is now in condition for the transmission of the code combination of impulses in accordance with those received from the main line.

Following the transmission of the fifth impulse, the cam 178 again engages operating element 196 for causing the closure of contacts 194 and 195, whereupon line relay 146 is energized for preventing the energization of release magnet 150 of the receiving mechanism Q and the operation of the distributing mechanism associated therewith. When the depressed portion of cam 178 is brought into alignment with operating element 196, contacts 194 and 195 are opened, whereupon line relay 146 is deenergized for causing the energization of release magnet 50 and the operation of the associated distributing mechanisms.

The receiving equipment Q at the branch office D comprises a receiving printer, diagrammatically shown at 155, which comprises the usual selecting magnets 156 to 160, inclusive, and the printing magnet 168. The respective magnets having their windings connected to segments 161, 162, 163, 164 and 165, forming a part of the outer ring of the receiving distributor. This distributor, like the sending distributor at station A, has a brush arm 147 carrying a brush 148, which is arranged to bridge the segments forming a part of the outer ring with the segments 153, 154 and 167 for controlling the energization of respective ones of the selecting magnets, depending upon the energization of relay 146, which in turn is controlled by the opening and closure of the contacts associated with the multiplex distributor L.

Inasmuch as the apparatus associated with the other channels of the system is identical with the system just described, further description thereof is considered unnecessary here. The rectangles designated by the characters J, H, M, and N represent the equipment between the lines extending to the branch offices and the main line, and the equipment between the main line and the lines to the branch offices, respectively, which, as previously described, are shown diagrammatically for the sake of clarifying the drawings.

The operation of the equipment just described is as follows: Assume for the sake

of clearness that the transmitting equipment E at branch office A is idle, having been stopped by the operation of switch 10 at the conclusion of a preceding message. With this switch operated, relay 28 and magnet 27 will remain deenergized and the brush arm will come to rest against the starting latch in the position shown in Fig. 1. Under these conditions, as the brush 12 is resting on segment 23 relay 37 will be held energized and the circuit of starting magnet 47 will be held open at the upper contact of relay 37. Sleeve 40 and all of the mechanism attached to it will be at rest as stop arm 45 will now be held by pawl 52. Cam 125, which is permanently attached to sleeve 40 will be at rest also. The inner shaft 81, with its attachments, including cam 126, will continue to rotate. The projecting portions of cams 125 and 126 will act against each other to cause cam 126 to be pushed to the left and suddenly released once during each revolution of shaft 81. Cam 126 acting through the linkage previously described, will raise and lower comb 132. When cam 126 is pushed to the right by spring 124, the pawl 134 is moved in the same direction carrying with it member 135 and thereby actuating the transfer springs 137. As shown on Fig. 1 this connects pole changing relay 96 to the idle signal contacts instead of the regular sending contacts so that the character of the signal transmitted will now depend on the idle signal cam. This cam is so shaped that it closes the circuit for operating relay 96 and transmitting a negative impulse to the line during a portion of a revolution thus sending the same signal as though cams 84, 85 and 86 had operated their corresponding contacts in succession. As will be described later, this so-called "idle signal" has no effect on the receiving printer at branch office D.

When member 135 has been pushed to the right, as just described, it will be held by pawl 136 while the idle signal is being transmitted, during which time pawl 134 will be withdrawn by the action of cam 126. Immediately after the idle signal has been transmitted by contacts 151, pawls 134 and 136 will be raised by the action of cams 141 and shaft 145, as previously described, thus allowing member 135 and transfer contact 137 to return to their normal or left-hand position. When cam 126 is pushed to the right again at the beginning of the next revolution, pawl 134 and member 135 will be again pushed to the right and the entire cycle of operations will be repeated with the result that an idle signal will be transmitted over the corresponding panel as long as transmitting equipment E remains at rest. During this time the operation of transmitting equipment K may proceed at will.

At the other end of the line, line relay 101 will respond to the transmitted impulses and will cause the energization of control relay 172 and consequently the setting of the cams 179 to 183, inclusive, as determined by the characteristics of the idle signal. As previously stated, cam 197 is moved with cams 179 and 180, while cam 198 is moved with cams 181, 182 and 183. When the cams are set by an idle signal, as previously described, cams 197 and 198 are moved to a position such that their raised portions do not engage the operating elements 199 and 200; consequently bail 201 is held in a position to close contacts 202 and 203 which will hold closed the line 193 extending to station D and prevent the energization of release magnet 150 and consequently the release of the brush arm 147. Accordingly, brush arm 147 is held against rotation and no impulses are recorded on the selecting magnets 156 to 160 and the printer mechanism 155 remains idle.

Assume now that branch office A desires to communicate with branch office D, in which case the transmitter 24 will be operated to set up particular combinations depending upon the characters of the message which is to be transmitted and the contacts of a switch 10 will be closed to energize starting relay 28 and starting magnet 27 to release the sending brush arm. Let it also be assumed that it is desired to transmit a character in which contacts 30, 32 and 34 of the transmitter 24 are actuated for closing their respective contacts.

As previously described, when the brush 13 passes over segments 14 and 15, at each revolution an energizing circuit is completed for start control relay 28. This relay completes a locking circuit for itself as well as the energizing circuit of release magnet 27. It is thus evident that the brush arm 11 will be stopped and started once for each cycle of rotation. Upon the energization of the release magnet 27, the latch which holds the brush arm 11 against rotation is moved out of the path thereof, whereupon the brush arm 11 is rotated by power communicated thereto from a motor (not shown). The brush arm 11 in rotating causes the brush 12 to consecutively complete circuits extending from the segments 18, 19, 20, 21 and 22 and the contacts of the transmitter 24, which have been operated, through the winding of relay 37 at station B. It is, of course, to be understood that the transmitting equipment designated by the character K may likewise be operated independently for causing the operation of relay 38 at the same time.

The instant the brush 12 passes off of segment 23 an open circuit condition is established. Relay 37 is thus caused to reverse the position of its armature and connects battery with the winding of release

relay 47 over a circuit extending from battery, through the armature and upper contact of relay 37, operating element 51, contacts 67 and the winding of release relay 47 to ground. The completion of this circuit causes the energization of release magnet 47, whereupon the toggle joint 54, Fig. 5 is operated for moving the holding pawl 52 out of the path of the stop arm 45. As previously described, the stop arm 45 is rigidly secured to the sleeve 40 to which power is communicated from a motor 41 through suitable gearing and a friction clutch. The withdrawal of the holding pawl 52 from the path of the stop arm 45 thus permits the rotation of the sleeve 40. Following its release the cam 66 is rotated, whereupon the operating element 51 disengages contacts 67 and engages contacts 68 so that the upper contact of relay 37 is now connected with one of the windings of selecting magnet 60.

When sleeve 40 is released, the comb 132 will be either raised or lowered, depending on the position of cam 126. Sleeve 40 rotates at substantially the same speed as shaft 81, so that the comb will remain in its initial position for at least one revolution. The momentary stopping of the brush arm 11 at the end of each revolution causes sleeve 40 and consequently cam 125 to be retarded slightly. As a result the phase relation between cams 125 and 126 will gradually change, causing cam 126 and its associated mechanism to go slowly through the same motions that they perform rapidly when the sending mechanism is idle, as previously described. If character signals are being sent continuously by transmitting equipment E, the comb mechanism will go through cycles of operations as follows: Comb 132 will remain raised during about 40 revolutions of the shaft. It will then be slowly lowered and will remain down for about the same length of time. Cam 126 will then be operated rapidly to the right, raising the comb and operating member 135, as previously described, to send one "idle signal." Member 135 will then be restored and will remain in its normal or left-hand position until cam 126 "trips off" again.

Upon the passage of the brush 12 over segment 18, to which contact 30 of the transmitter is connected, an energizing circuit for relay 37 is completed. Relay 37 now closes its lower contact for causing the energization of the right hand magnet of selecting magnet 60. The right hand magnet of selecting magnet 60 being now energized, armature 62 is moved to the right. The sleeve 40 being now rotated, the pivoted element 64, which is secured to the selecting rod individual to the selecting disk 72, engages the projection on the armature 62, whereupon the element 64 is caused to pass on the left-hand side of the locking vane 71. If the comb member 132 is at this instant in its downward position, the movement of the rod 56 will be transferred directly to the drum 115, upon which cam 82 is mounted. However, if the comb member 132 is in its upward position as shown in Figs. 4 and 8, the drum 115 will be prevented from moving until the phase relation between the multiplex shaft 81 and the start-stop mechanism G is such that the transfer may be made without causing the mutilation of signals. In this case the springs associated with member 59 serve to temporarily store the signal. The contact 31 of the transmitter 24 being open, relay 37 is caused to reverse the position of its armature upon the passage of the brush 12 over segment 19, to which this contact is connected. Accordingly, an energizing circuit is completed through the upper contact of relay 37 with the left-hand magnet of selecting magnet 60. The armature 62 is thus moved to its extreme left-hand position, whereupon the pivoted elements 64 individual to the selecting disk 73 is upon its continued rotation moved to the right of the stationary vane 71. Like in the previous case, the drum 116, which is horizontally movable with the selecting disk 73, will be moved to the position determined by the position of the operating element 64 with respect to the stationary vane 71, providing the comb member 132 is in its downward position. Similarly, contacts 32 and 34 of transmitter 24 being closed, conditions similar to that described in connection with contact 30 will be established for causing the positioning of the selecting disks 74 and 76 in accordance with the energization of relay 37 and the positioning of the operating elements 64 on the proper side of the stationary vane 71. Relay 37 will, however, not be energized upon the passage of the brush 12 over segment 21, to which this contact is connected, as for the particular selection chosen, this contact is open. A condition now exists similar to that described in connection with the selecting disk 73, which was moved to the right.

If the comb member 132 is up, the cams are held in the position of the previous selection until the space in the flange arrives at a point opposite the comb, and then the transfer occurs. It will be seen that the selections will be transferred in succession in either case.

Providing the comb member 132 is in its downward position, the drums 115 to 119, inclusive, will be positioned in accordance with the positioning of the corresponding selecting rods 56, so that upon the rotation of the cams individual thereto their contacts will be operated for causing the operation of pole changer relay 96 and the transmission of impulses over the line conductor

7 in accordance with those received from the branch office A. As shown in Fig. 10, the cams 82 to 86, inclusive, are spaced at different angles about the shaft 81 so that their associated contacts will be operated consecutively. Also these cams are positioned on the drums, such that in order to operate the associated contacts, drums 115 and 116 must be moved to the right, while drums 117, 118 and 119 must be moved to the left. With the drums in these positions the associated contacts will be operated consecutively. As for example, when the cam 86 comes in contact with operating element 112 individual thereto, contacts 113 and 114 are closed, and accordingly pole changer relay 96 is energized for transmitting over the line conductor 7 a negative impulse. When the cams are in a position whereby they do not engage their associated operating element, the contacts will be opened and the pole changer relay 96 deenergized for transmitting a positive impulse over the line conductor 7.

Assume now that the time the impulses were received from the station A that the phase relations of the start-stop and multiplex mechanisms was such that the cams 125 and 126 individual to the respective mechanisms were together and accordingly the comb member 132 was in the upward position. As previously stated, when the comb member 132 is in the upward position, the flanges 120 individual to each of the drums 115 to 119, inclusive, engage the teeth of the comb, and the cams are held from following the movement of the selecting levers and rods during a certain part of the revolution.

Sleeve 40 and the mechanism attached to it is continually retarded by the action of the stop mechanism, so that eventually each selecting impulse as received after the rim on the corresponding drum has become disengaged from the comb. Drums 115 to 119, inclusive, will now be in a condition whereupon they may be moved directly upon the setting of the selecting rods 56. Cam 126 will now engage cam 125, whereupon, through the linkage previously described, comb 132 is moved downwardly. The comb will remain down for a number of revolutions, as previously mentioned, and will be suddenly raised again when cam 26 is pushed to the right and will then hold the selecting drums, causing the character-selection set up to be delayed for one revolution. At this time member 135 will be pushed to the right to cause the transmission of the idle signal, as previously described. After this signal has been transmitted pawls 134 and 136 will be raised momentarily to let member 135 be restored. The delayed character will now be transmitted. In this case pawl 134 will remain in its right-hand position for a number of revolutions, or until the cam is drawn down.

For the particular selection chosen, the cams 82, 83, 84, 85 and 86 will be moved to the right, left, right, left and right, respectively, and owing to their position on the drums 115, 116, 117, 118 and 119, the contacts associated therewith will be operated for causing the energization and deenergization of pole changer relay 96 to send the following group of impulses: negative, positive, positive, negative, and positive. These impluses in traversing the line conductor 7 pass through the windings of line relay 101 at the station C. As in the case previously described, relay 101 responds only to incoming impulses, it being unaffected by impulses transmitted from the station C to station B. The above referred to group of impulses in traversing the windings of the line relay 101, successfully causes the energization of relay 172, and consequently the energization of one or the other of the selecting magnets 173. The energization of the selecting magnets 173 causes the positioning of the armature controlled thereby, such that the operating element 177 individual to each of the selectable rods to which the cams 179, 180, 181, 182 and 183 are connected will be positioned either to the left or right of the stationary locking vane 184. Prior to the setting of the selectable rods, however, cam 178 allows operating element 196 to move for opening the circuit extending from battery, over the line conductor 193, and including the winding of line relay 146 at branch office D. Line relay 146 in deenergizing completes an energizing circuit for release magnet 150 of the receiving equipment Q, whereupon the brush arm 147 is free to rotate, power being communicated thereto from a suitable motor through a friction clutch (not shown). The impulses being received successively, cause the setting of the cams 179 to 183, such that the cams 179, 181 and 183 are moved to a position so that upon their continued rotation they cause the closure of contacts 194 and 195, and accordingly the energization of line relay 146. For the other selections the depressed portion of the cams is in alignment with the operating element 196 so that for this condition the contacts 194 and 195 remain open, thereby transmitting to the branch office open impulses.

Inasmuch as the brush arm 147 is under the control of the multiplex distributor L or the cam section 178, this distributor will be operated in synchronism with the multiplex distributor, that is, the brush arm 147 will pass over the segments individual to the cam sections 179 to 183, inclusive, at a time when these cams are in alignment with operating element 196. For example,

as the brush arm 147 is passing over segment 161, and since the cam 179 is moved to the right so that its raised portion upon its continued rotation is in alignment with the operating element 196 and the contacts 194 and 195 are closed, line relay 146 is energized, whereupon selecting magnet 156 of the printing mechanism 155 is operated. Accordingly, the selecting element individual to the magnet 156 will be positioned for the selection of a code bar entering into the selection of the particular character desired. Likewise, when the brush 148 is passing over segments 163 and 165, line relay 146 will be energized and the selecting magnets 158 and 160 will be energized for functioning in a manner similar to that described in connection with selecting magnet 156. However, upon the passage of the brush 148 over segments 162 and 164, the line relay 146 is deenergized, thereby removing the ground connection from the ring 154 so that upon the passage of the brush 148 over the segments individual to the magnets 157 and 159, such magnets will not be energized and their selectable elements will remain in their previous position. Following the passage of the brush 148 off of segment 145, this brush engages segments 166 and 167 for completing an energizing circuit for printing magnet 168 for the printing of the character selected in accordance with the energization of the selecting magnets 156 to 160. After the brush 148 has passed off of segments 166 and 167, its brush arm is arrested due to the engagement thereof with the latch under the control of release magnet 150, and will be held against rotation until the cam 178 again opens the line circuit 193 for controlling the energization of release magnet 150.

Should the transmitter 24 discontinue the transmission of impulses, the sending distributor at station A would, of course, be operated, but owing to the fact that none of the contacts of the transmitter 24 are operated, relay 37 in station B is deenergized and remains deenergized during the complete cycle of rotation of the brush arm 11, except for a momentary operation when brush 12 passes over segment 23. Upon the deenergization of line relay 37, release magnet 47 of the start-stop mechanism G is energized and the sleeve 40, as previously described, is free to rotate. Upon the continued rotation of the sleeve 40, and owing to the fact that the line relay 37 is deenergized, the selecting disks 172 to 176, inclusive, will all be moved to the left for causing the corresponding positioning of the drums 115 to 119, inclusive, upon which cams 82 to 83, inclusive, are mounted. Upon the continued rotation of the cams 82 to 86, pole changer relay 96 is energized for transmitting over the line 7 impulses in accordance with the setting of the cams of the multiplex distributor I.

As all of the drums have been moved to the left, the contacts associated with cams 82 and 83 will not be operated (these cams being on the left side of their drums and therefore not in alignment with the contact operating members), while cams 84, 85 and 86 will operate their corresponding contacts successively (these cams being on the right side of their drums). The signal transmitted under these conditions will be the same as that transmitted by the idle signal cam 149 and contacts 151. Likewise, as in the previous case, line relay 101 responds to such impulses for causing the energization of control relay 172 and consequently the setting of the cams 179 to 183, inclusive. As previously stated, cam 197 is moved with two of the cams 179 to 183, while cam 198 is moved with three of the cam sections, such as 181, 182 and 183. When the condition previously given exists, cams 197 and 198 are moved to a position such that their raised portion do not engage the operating elements 199 and 200. Consequently bail 201 is held in a position to close contacts 202 and 203, which closes the line extending to station D and prevents the energization of release magnet 150, and consequently the release of the brush arm 147, and operation of the printer 155.

It is, of course, understood that the transmission of impulses over the other channels of the system is accomplished in a manner identical to that described in connection with the transmission of impulses between stations A and D, and utilizing the equipment individual to the particular channel selected. Further description of the operation of the system pertaining to the other channels is considered unnecessary.

Although the invention has been disclosed and described in connection with a particular type of apparatus, it is, of course, obvious that various departures may be made without departing from the spirit and scope of the present invention.

What is claimed is:

1. In a telegraph system, a plurality of stations, a multiplex synchronous system connecting two of said stations, an extension circuit extending from one of said stations to a distant station, means for transmitting code combinations of message impulses over said extension circuit, means comprising a plurality of selectively movable elements, and cam sectors controlled by said elements for retransmitting to said multiplex system impulses in accordance with those transmitted over said extension circuit.

2. In a telegraph system, a plurality of

stations, a multiplex synchronous system connecting two of said stations, an extension circuit extending from one of said stations to a distant station, means for transmitting code combinations of message impulses over said extension circuit, a plurality of selectable elements positioned in accordance with the impulses received from said extension circuit, and mechanically operated means set by said elements for controlling the transmission of corresponding impulses to said multiplex system.

3. In a telegraph system, a plurality of stations, a multiplex synchronous system connecting two of said stations, an extension circuit extending from one of said stations to a distant station, means for transmitting code combinations of message impulses over said extension circuit, means comprising a plurality of mechanically movable selectable elements intermediate said extension circuit and said multiplex synchronous system, and means operated by said elements for transmitting to said multiplex system impulses in accordance with those transmitted over said extension circuit.

4. In a telegraph system, a plurality of stations, a multiplex synchronous system connecting two of said stations, an extension circuit extending from one of said stations to a distant station, means for transmitting code combinations of message impulses over said extension circuit, means comprising a plurality of selectable elements, and means operated directly upon the operation of said elements for transmitting to said multiplex system impulses in accordance with those transmitted over said extension circuit.

5. In a telegraph system, a plurality of stations, a multiplex synchronous system connecting two of said stations, an extension circuit extending from one of said stations to a distant station, means for transmitting code combinations of message impulses over said extension circuit, means comprising a plurality of rotatable selectable elements, and a plurality of contacts operated sequentially by said elements upon their rotation for transmitting to said multiplex system impulses in accordance with those transmitted over said extension circuit.

6. In a telegraph system, a plurality of stations, a multiplex synchronous system connecting two of said stations, an extension circuit extending from one of said stations to a distant station, means for transmitting code combinations of message impulses over said extension circuit, means associated with said extension circuit comprising a plurality of all-mechanical selectable elements controlled by the impulses transmitted over said extension circuit, and means operated as determined by the setting of said selectable elements for transmitting to said multiplex system impulses in accordance with those transmitted over said extension circuit.

7. In a telegraph system, a plurality of stations, a multiplex synchronous system connecting two of said stations, an extension circuit extending from one of said stations to a distant station, means for transmitting code combinations of message impulses over said extension circuit, intermittently operating mechanism comprising a plurality of all-mechanical selectable elements, means for setting said elements in predetermined combinations in accordance with the impulses received from said extension circuit, and means controlled by said selectable elements for transmitting to said multiplex system impulses in accordance with those transmitted over said extension circuit.

8. In a telegraph system, a plurality of stations, a multiplex synchronous system connecting two of said stations, an extension circuit extending from one of said stations to a distant station, means for transmitting code combinations of message impulses over said extension circuit, intermittently operated mechanism associated with said extension circuit comprising a plurality of selectable elements having two operative positions, means for effecting the movement of said elements into one or the other of their operative positions, means controlled by the setting of said elements, and means operated by said last mentioned means or transmitting to said multiplex system impulses in accordance with those transmitted over said extension circuit.

9. In a telegraph system a plurality of stations, a multiplex synchronous system connecting two of said stations, an extension circuit extending from one of said stations to a distant station, means for transmitting code combinations of message impulses over said extension circuit, intermittently operated mechanism associated with said extension circuit comprising a plurality of selectable elements, a selecting magnet common to said elements for effecting the setting thereof in accordance with the impulses received from said extension circuit, continuously operated means responsive to the setting of said elements, and means controlled by said last recited means for transmitting to said multiplex system impulses in accordance with those transmitted over said extension circuit.

10. In a telegraph system, a plurality of stations, a multiplex synchronous system connecting two of said stations, an extension circuit extending from one of said stations to a distant station, means for transmitting code combinations of message impulses over said extension circuit, mechanism associated with said extension circuit normally tending

to rotate comprising a plurality of selectable elements, means responsive to an impulse transmitted over said extension circuit for permitting the rotation of said elements, means operated in accordance with the impulses transmitted over said extension circuit for setting said elements in predetermined combinations sequentially, and means operated by said elements for transmitting to said multiplex system impulses in accordance with those transmitted over said extension circuit.

11. In a telegraph system, a plurality of stations, a multiplex synchronous system connecting two of said stations, an extension circuit extending from one of said stations to a distant station, means for transmitting code combinations of message impulses over said extension circuit, mechanism associated with said extension circuit comprising a plurality of intermittently rotatably selectable elements, means for setting said elements in accordance with the impulses received from said extension circuit, a plurality of cams positioned in accordance with the setting of selecting elements, and means operated by said cams for transmitting to said multiplex system impulses in accordance with those transmitted over said extension circuit.

12. In a telegraph system, a plurality of stations, a multiplex synchronous system connecting two of said stations, an extension circuit extending from one of said stations to a distant station, means for transmitting code combinations of message impulses over said extension circuit, mechanism associated with said extension circuit comprising a plurality of rotatably selectable elements, means for positioning said elements in predetermined combinations, a plurality of cams positioned in accordance with the setting of said elements, and means operated sequentially by said cams for transmitting to said multiplex system impulses in accordance with those transmitted over said extension circuit.

13. In a telegraph system, a plurality of stations, a multiplex synchronous system connecting two of said stations, an extension circuit extending from one of said stations to a distant station, means for transmitting code combinations of message impulses over said extension circuit, intermittently operated mechanism associated with said extension circuit comprising a plurality of selectable elements positioned in accordance with the impulses received from said extension circuit, means controlled by said selectable elements for transmitting to said multiplex system impulses in accordance with those transmitted over said extension circuit, and means controlled jointly by said intermittently operated mechanism and the means controlled by said selectable elements for controlling the transfer of the effects of said selectable elements to said multiplex synchronous system.

14. In a telegraph system a plurality of stations, a multiplex synchronous system connecting two of said stations, an extension circuit extending from one of said stations to a distant station, means for transmitting code combinations of message impulses over said extension circuit, means associated with said extension circuit comprising a plurality of intermittently rotating selectable elements, a stationary vane, means for positioning said selectable elements on one position or the other with respect to said stationary vane, a plurality of continuously rotating cams positioned in accordance with the setting of said selectable elements, and contacts individual to each of said cams operated upon the continued rotation thereof for transmitting to said multiplex system impulses in accordance with those transmitted from said extension circuit.

15. In a telegraph system, a plurality of stations, a main line connecting two of said stations, an extension circuit extending from one of said stations to a distant station, means for transmitting code combinations of message impulses over said main line and synchronously operated means associated with said main line comprising a plurality of mechanically movable selectable rods operated in accordance with the impulses transmitted over said main line, and means operated by said elements for transmitting directly to said extension circuit impulses in accordance with the setting of said elements.

16. In a telegraph system, a plurality of stations, a main line connecting two of said stations, an extension circuit extending from one of said stations to a distant station, means for transmitting code combinations of message impulses over said main line and synchronously operated means associated with said main line comprising a plurality of mechanically movable selectable rods, means for setting said elements in accordance with impulses transmitted over said main line, means controlled by said elements for transmitting directly to said extension circuit corresponding impulses, and recording means at the distant station for recording such impulses.

17. In a telegraph system, a plurality of stations, a multiplex synchronous system connecting two of said stations, an extension circuit extending from one of said stations to a distant station, means for transmitting code combinations of message impulses over said multiplex system, means comprising a plurality of selectable elements operated in accordance with the impulses transmitted over said multiplex system, a single transmitting contact operated mechanically by said elements sequentially for

transmitting to said extension circuit impulses in accordance with the setting of said elements and recording means at the distant station for recording such impulses.

18. In a telegraph system, a plurality of stations, a multiplex synchronous system connecting two of said stations, an extension circuit extending from one of said stations to a distant station, means for transmitting code combinations of message impulses over said multiplex system, means comprising a plurality of cam sections, means for setting said cam sections in accordance with the impulses transmitted over said multiplex system, means controlled by said cam sections for transmitting to said extension circuit impulses in accordance with the setting of said cam sections, and recording means at the distant station for recording such impulses.

19. In a telegraph system, a plurality of stations, a multiplex synchronous system connecting two of said stations, an extension circuit extending from one of said stations to a distant station, means for transmitting code combinations of message impulses over said multiplex system, means comprising a plurality of cam sections, means for setting said cam sections in accordance with the impulses transmitted over said multiplex system, a single contact operated sequentially by said cam sections for transmitting to said extension circuit impulses in accordance with the setting of said cam sections, and recording means at the distant station for recording such impulses.

20. In a telegraph system, a plurality of stations, a multiplex synchronous system connecting two of said stations, an extension circuit extending from one of said stations to a distant station, means for transmitting code combinations of message impulses over said multiplex system, means comprising a plurality of continuously rotating selectable elements, means for setting said elements sequentially in accordance with the impulses transmitted over said multiplex system, a cam individual to each of said selectable elements, means operated by said cams for transmitting to said extension circuit impulses in accordance with the setting of said selectable elements, and recording means at the distant station for recording such impulses.

21. In a telegraph system, a plurality of stations, a multiplex synchronous system connecting two of said stations, an extension circuit extending from one of said stations to a distant station, means for transmitting code combinations of message impulses over said multiplex system, means comprising a plurality of selectable elements, a single magnet responsive to impulses transmitted over said multiplex system for effecting the positioning of said selectable elements in predetermined combinations, a cam individual to each of said selectable elements and inovable therewith, a single contact operated by said cam sequentially for transmitting to said extension circuit impulses in accordance with the setting of said selectable elements, and recording means at the distant station for recording the effects of such impulses.

22. In a telegraph system, a plurality of stations, a multiplex synchronous system connecting two of said stations, an extension circuit extending from one of said stations to a distant station, intermittently operating mechanism at said distant station, means for transmitting code combinations of message impulses over said multiplex system, means comprising a plurality of selectable rods mechanically moved in accordance with the impulses transmitted over said multiplex system for transmitting directly from said selectable elements to said extension circuit corresponding impulses, and means associated with said selectable elements and operated invariably at the commencement of each signal period for transmitting to said distant station a starting impulse for releasing said intermittently operating mechanism.

23. In combination, a plurality of groups of selectable elements, means for rotating said elements, means controlled by said elements, and means common to said groups of elements for selectively positioning said groups of elements successively for controlling the operation of said second recited means.

24. In combination, a rotatable shaft, a plurality of groups of selectable elements spaced about said shaft and rotatable therewith, an operating member individual to each of said selectable elements, and a single electromagnetic means for selectively positioning said groups of elements successively for causing the corresponding positioning of said operating members.

25. In combination, a rotatable shaft, a plurality of groups of selectable elements spaced about said shaft and rotatable therewith, each of said elements being arranged to occupy either of two positions, an operating member individual to each of said selectable elements, and a single means for selectively positioning said groups of elements successively upon their continued rotation to one or the other of their operating positions to cause the corresponding positioning of said operating members.

26. In combination, a rotatable shaft, a plurality of groups of selectable elements spaced about said shaft and rotatable therewith, each of said elements being arranged to occupy either of two positions, a cam section individual to each of said selectable elements, a single selecting magnet respon-

sive to line current impulses for selectively positioning said groups of elements successively upon their continued rotation to one or the other of their operating positions to cause the corresponding positioning of said cam sections, and a single contact operated by said cam sections sequentially for transmitting impulses in accordance with those which effected the operation of said single selecting magnet.

In testimony whereof, I have signed my name to this specification this 7th day of December 1922.

GILBERT S. VERNAM.