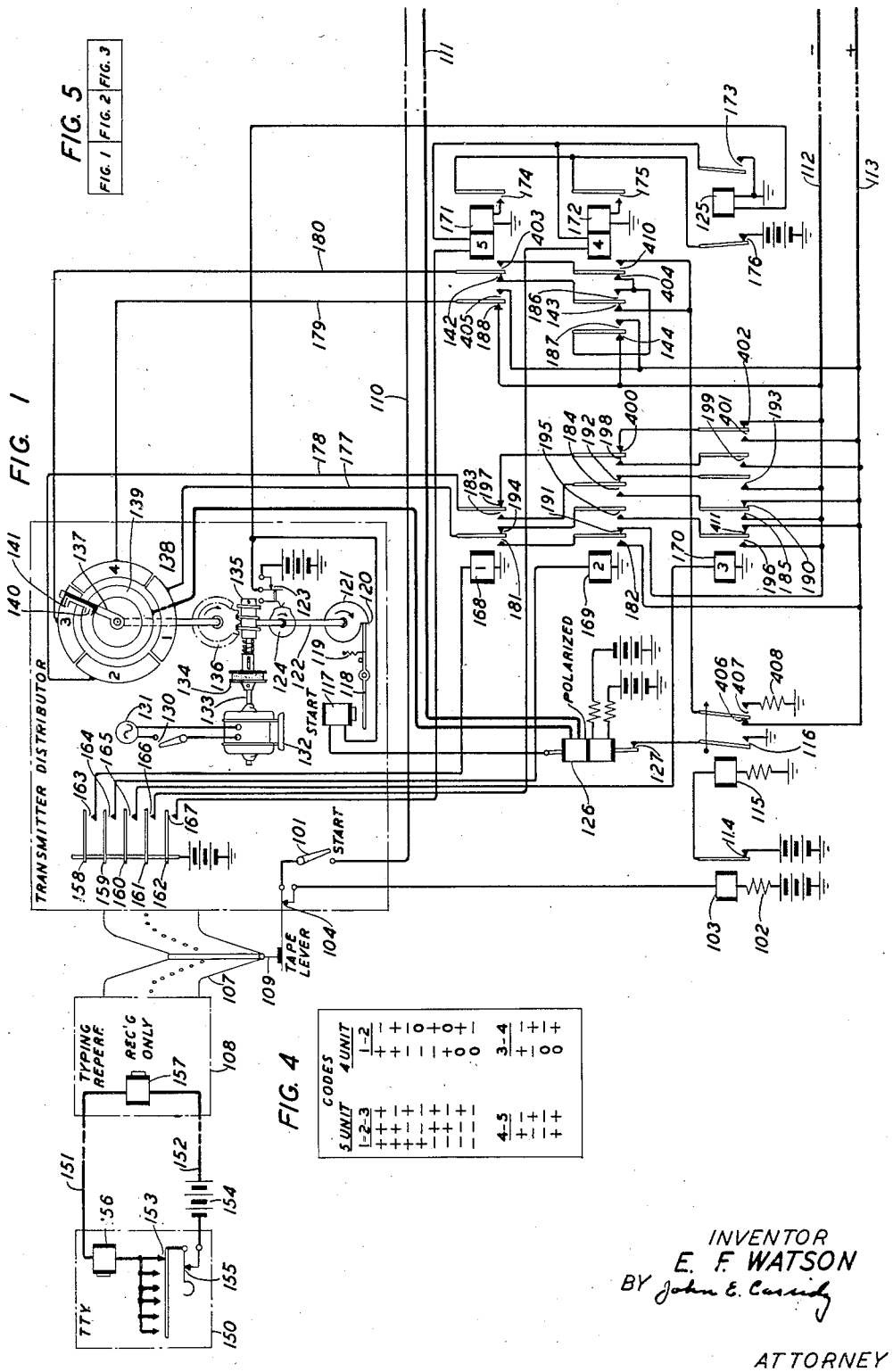
Jan. 25, 1949. E. F. WATSON 2,459,904

TELEGRAPH SIGNAL CODE TRANSLATOR

Filed Dec. 9, 1943 3 Sheets-Sheet 1



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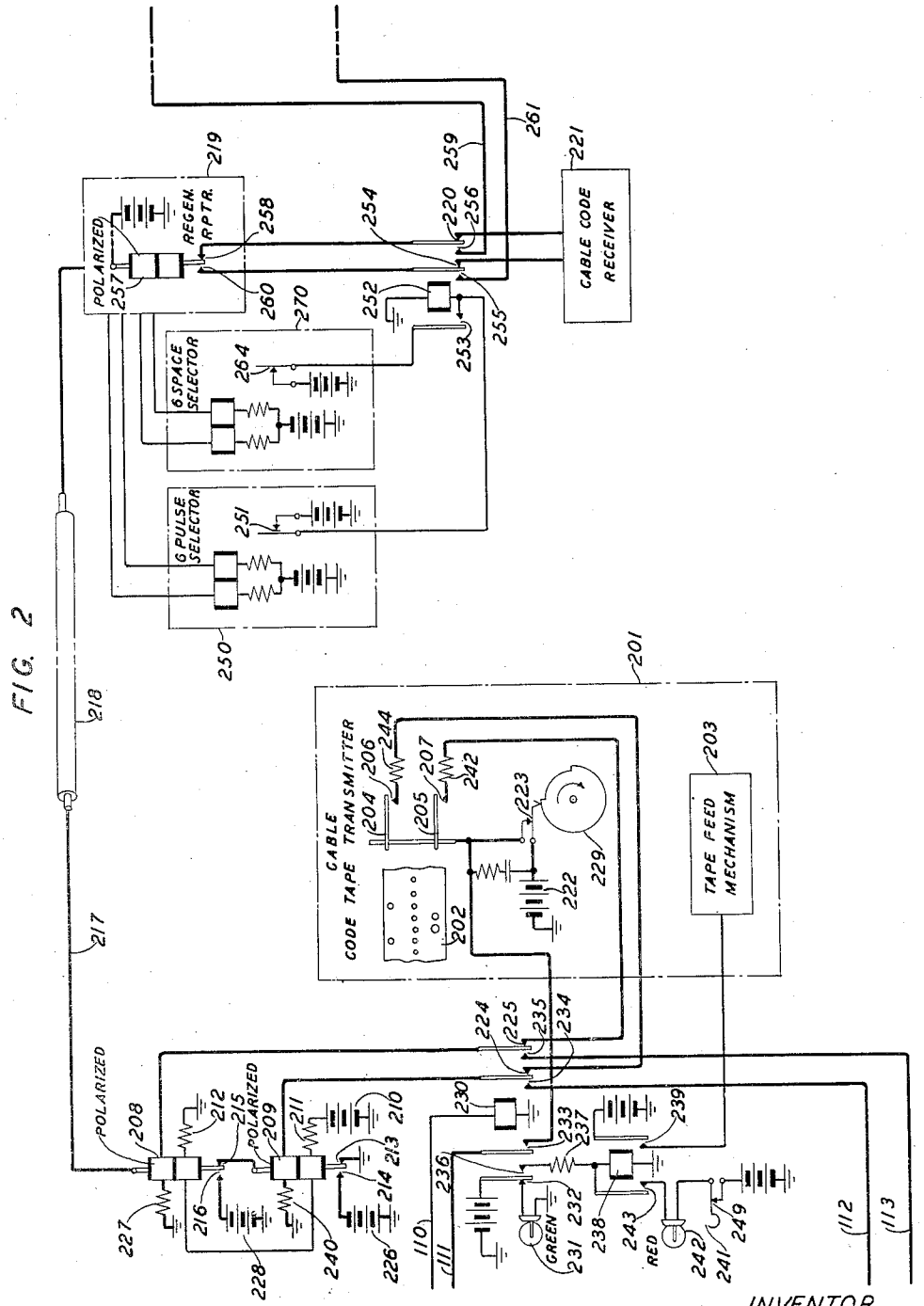

FIG. 2

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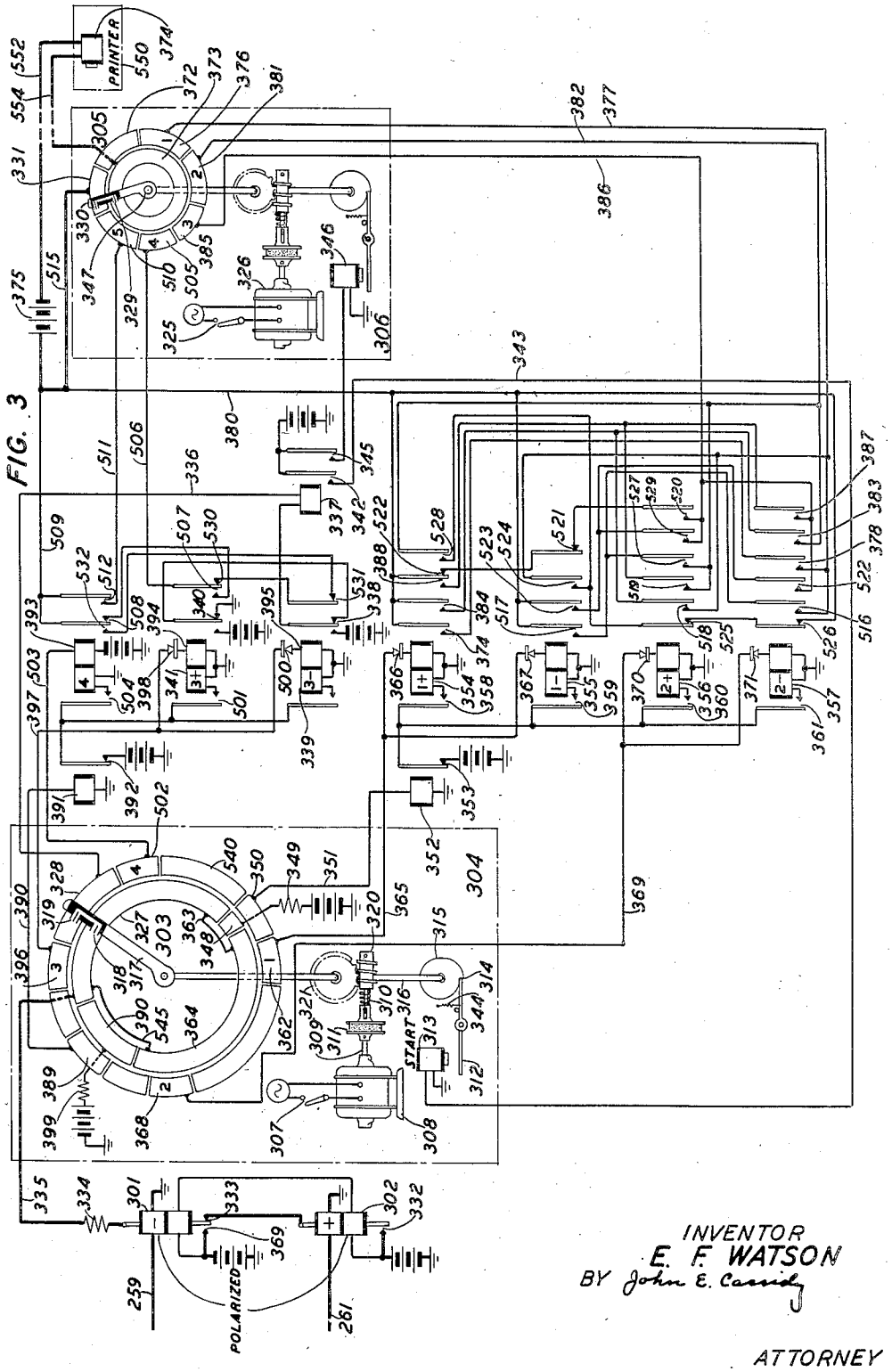
FIG. 3



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UNITED STATES PATENT OFFICE

2,459,904

TELEGRAPH SIGNAL CODE TRANSLATOR

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Application December 9, 1943, Serial No. 513,501

13 Claims. (Cl. 178—26)

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This invention relates to improvements in telegraph transmission systems. More specifically this invention relates to the translation of multielement permutation telegraph signals, in accordance with one code, into multielement permutation telegraph signals in accordance with a different code.

Where a first telegraph system arranged for the transmission of signals in accordance with a first code is connected to a second telegraph system arranged for the transmission of signals in accordance with a second and different code, it is necessary to translate the signal combinations in accordance with the first code into signal combinations in accordance with the second code before they can be transmitted over the second system. The invention herein performs such translation automatically, by electromechanical means. If the second system is reconnected to a third system employing the original code it is necessary to retranslate the signals into the original code. The invention herein performs such retranslation also automatically by electro-mechanical means.

In the invention herein a long non-loaded submarine cable system, designed for the transmission of the relatively slow three-condition permutation code telegraph signals or cable code signals, as they are known, and equipped at one end with a transmitter connected to a source of such signals and at the other end with a receiver arranged to receive such signals is used as a link between two relatively fast five-element two-condition permutation telegraph code signal systems. Ordinarily the cable is connected to its cable code tape transmitter and its cable code receiver. When signals originating in the five-element system are to be transmitted, a switch associated with the five-element system is operated. This disconnects the cable transmitter from its normal source of signal supply and connects it to the five-element system. Then a special multielement code signal which is generated automatically is impressed on the cable transmitter and transmitted to the distant end of the cable. In response to this the distant end of the cable is switched so that instead of being connected to its regular cable code receiver it is connected to a receiving retranslator. After the signal code combination which performs the switching has been transmitted the five-element two-condition signals generated by the transmitting mechanism associated with the five-element system are changed in a transmitting translator into

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four-element three-condition signals and impressed through a signal transmitter on the cable. At the distant end the four-element signals are directed to the receiving retranslator. Here the four-element signals are changed into the original five-element signals.

When transmission from the five-element system has ended, a second special multielement code signal which is generated automatically is transmitted to transfer the distant receiving end of the cable back to its regular code receiver.

The invention may be understood from the following description when read with reference to the associated drawings in which:

Fig. 1 shows the five-element system and the transmitting translator which translates the five-element signals into four-element signals;

Fig. 2 shows the cable code system including the tape transmitter, the relay transmitter, the cable, the cable code receiver, the transmitting switching mechanism which switches the cable relay transmitter from the cable code transmitter of Fig. 2 to the five-element system of Fig. 1 and the receiving switching mechanism which switches the receiving end of the cable between the cable code receiver of Fig. 2 and the four to five-element retranslating receiver of Fig. 3;

Fig. 3 shows the four to five-element retranslating receiver;

Fig. 4 is a table showing codes used in explaining the invention; and

Fig. 5 is a diagram showing the manner in which Figs. 1, 2 and 3 should be arranged to form an operative system.

Refer to Fig. 2. All of the apparatus indicated in this figure with the exception of the transmitting switching mechanism is well known in the cable telegraph art and it will not therefore be described in detail, except insofar as it is necessary to an understanding of the code translating and retranslating arrangement of the invention herein.

The cable code tape transmitter **201** may be of the general automatic cable code type shown in Patent 1,517,110, T. F. Foley, November 25, 1924, modified as shown in Fig. 2 herein. The regenerative repeater **219** in Fig. 2 may be of the type disclosed in Fig. 3 of Patent 1,827,460, F. G. Creed et al., October 13, 1931. The six pulse selectors **250** and **270** in Fig. 2 may be of the type disclosed in Patent 1,868,703, R. G. Griffith, July 26, 1932. It is understood, however, that the circuits of the present invention are not limited to one with co-operating apparatus in accordance with the spe-

cific embodiments of the foregoing patents but will function satisfactorily with other cable code transmitters, regenerators and pulse selectors.

The cable transfer relay 230 is normally in the released condition indicated to connect the cable code tape transmitter 201 to the cable relay transmitter comprising relays 208 and 209. In Fig. 2 the cable code tape transmitter, which is well known in the art, is shown enclosed in a rectangle 201. The three-condition code is perforated in a tape 202 and the tape is fed by the well-known tape feed mechanism indicated by a rectangle 203, over the code element sensing pins 204 and 205. When a particular signal element is represented by a perforation in the tape the corresponding pin is admitted through the perforation to close its associated contact. When a particular signal element is represented by an unperforated element in the tape neither of the two sensing pins is admitted and their associated contacts remain open. Contact 223 is under control of rotatable curbing and transmitting cam 229. For an interval, equal to one-fourth the period of rotation of cam 229, during which interval the tape is feeding and the pins may change their positions in accordance with the perforations, contact 223 is open as the cam follower engages the depressed periphery of cam 229. After the pins are positioned the cam follower is raised and contact 223 is closed. It will be made apparent below that during the interval while contact 223 is open both relays 208 and 209 are in the released condition. This applies ground to the cable for a short interval between signal elements to discharge the cable. This is known in the art as curbing.

The armatures of the cable transmitting relays 208 and 209 are biased to the positions indicated by the effect of current flowing from battery 210 through resistance 211, bottom winding of relay 209, bottom winding of relay 208 and resistance 212 to ground. When neither one of contacts 206 and 207 is closed the armatures of relays 208 and 209 remain in the positions indicated. For this condition a circuit may be traced from ground through contact 213, armature of relay 209, contact 215, armature of relay 208 and through conductor 217 which extends through cable 218. The ground when transmitted during the proper interval for a signal element controls the regenerative repeater 219 in a well-known manner to impress a corresponding signal element on cable code receiver 221. When ground is connected to conductor 217 during the curbing interval the cable is discharged in a well-known manner.

If contact 206 is closed a circuit may be traced from ground through battery 222, contact 223, sensing pin 204, contact 206, resistance 244, contact 224, winding of relay 209 and resistance 240 to ground, actuating the armature of relay 209 to the left to engage contact 214. A circuit may then be traced from battery 226 through contact 214, armature of relay 209 and contact 215 to conductor 217 from where it extends over a path through regenerative repeater 219 which impresses a corresponding signal on receiver 221.

If contact 207 is closed a circuit may be traced from battery 222 through contact 223, sensing pin 205, contact 207, resistance 242, contact 225, top winding of relay 208 and resistance 227 to ground, actuating the armature of relay 208 to the left to engage contact 216, which connects positive battery 228 through contact 216 to conductor 217, from where it extends over a path

heretofore traced. Thus a signal element which is impressed on the submarine cable may be of any one of three conditions, namely, positive battery, negative battery or ground. Successive signal elements in accordance with the cable code are used to define each character.

Normally, as mentioned above, the three-condition cable code tape transmitter 201 is connected to the three-condition cable transmitting relays 208 and 209. Relay 230 is in the released condition and green lamp 231 is lighted over an obvious circuit through contact 232 of relay 230 to indicate that tape transmitter 201 is connected to the cable.

The circuits are arranged so that when there is any message to be transmitted from the five-element, two-condition system of Fig. 1, a switch in Fig. 1 is closed to operate relay 230. This disconnects the cable code tape transmitter 201 from the relay transmitter comprising relays 208 and 209 and connects the five-element system of Fig. 1 to the relay transmitter.

The relay transmitter comprising relays 208 and 209 which is arranged to generate three-condition signals, always remain connected to the cable. When signals generated in the five-element system are to be transmitted, the cable relay transmitter is first switched so as to be connected to the system of Fig. 1. Then since at the distant cable terminal the cable is normally connected to the cable code receiver 221 it is necessary to disconnect receiver 221 and connect the receiver to the receiving retranslator per Fig. 3. This is done automatically by transmitting a special train of signal elements which operates a switching device at the distant receiving end of the cable to connect the cable to the retranslator per Fig. 3. After this has been accomplished transmission from Fig. 1 may proceed. But since the signals originally generated in the system per Fig. 1 are five-element two-condition signals it is necessary to translate them into four-element three-condition signals before they are impressed on the relay transmitter comprising relays 208 and 209. After the translated signals are transmitted over the cable and directed into the retranslator receiver per Fig. 3, they are retranslated in the apparatus of Fig. 3 to their original form and transmitted over a five-element system connected to the retranslator. The manner in which the foregoing is performed will now be described in detail.

Refer now to Figs. 1, 2 and 3. Normally relay 103, Fig. 1, is in the released condition. Contact 114 is closed. Relay 115 is thus operated over an obvious circuit through contact 114. Contact 116 is thus open and ground is disconnected from start magnet 117. Switch 130, which is open, is first closed connecting power supply 131 to motor 132. Motor 132 rotates driving shaft 133. Worm gear, 135 rigidly connected to the driven motor shaft, spur gear 136 rigidly secured to distributor shaft 122 and distributor shaft 122 are coupled to driving shaft 133 through friction clutch 134. Cams 121, 124, and rotatable arm 137 of the four-element transmitting distributor 138 are rigidly secured to shaft 122. The driven portion of the mechanism is prevented from rotating by the right-hand end of lever 118 which is interposed in the path of raised shoulder 120 on the periphery of cam 121 under the influence of spring 119 which is attached to the right-hand end of the lever. Shaft 122 is normally stopped in such a position that continuous conducting ring 139 of distributor 138 is connected through

brushes 140 and 141 to distributor segment 3. Cam 124 is in the position indicated. Contact 123 is closed. Relay 125 is operated as shown from battery supplied through contact 123. The armature of relay 126 is actuated to the right to close contact 127 under the influence of the flow of biasing current through the bottom winding of relay 126 over an obvious circuit.

When signals generated in the five-element system are to be transmitted, start key 101 is operated. A circuit may then be traced from battery through resistance 102, winding of relay 103, tape lever contact 104, switch 101, conductor 110, and the winding of relay 230, Fig. 2, to ground, operating relay 230. It is pointed out that tape lever 104 is controlled by tape 107. When there is sufficient slack in tape 107, due to an accumulation of punched tape, lever 109 is lowered and contact 104 is closed. When tape 107 is taut lever 109 is raised and contact 104 is opened to stop the operation of the transmitter distributor. This mechanism is well known in the art. It is disclosed in Patent No. 2,055,567, E. F. Watson, Sept. 20, 1936.

The operation of relay 230 opens contacts 232, 224 and 225 and closes contacts 236, 233, 234 and 235. The opening of contacts 224 and 225 disconnects the cable code tape transmitter 201 from the transmitting relays 208 and 209. The closing of contacts 234 and 235 connects the operating windings of relays 208 and 209 to conductors 112 and 113 which connect the cable relay transmitter to the five-element transmitting system. The opening of contact 232 extinguishes lamp 231. The closing of contact 236 establishes a circuit from battery through contact 236, resistance 237, and the winding of relay 238 to ground, operating relay 238. Contact 243 closes. This establishes a circuit from battery through contact 249 of key 241, lamp 242, contact 243 and the winding of relay 238 to ground. This locks relay 238 under control of key 241 and lights red lamp 242 as an indication that the cable relay transmitter comprising relays 208 and 209 is connected to the five-element system. While relay 238 was released no battery was supplied through contact 239 to a magnet control of the tape feed mechanism 203 of transmitter 201. The closing of contact 239 connects battery to the magnet of tape feed mechanism 203 and the feeding of tape through transmitter 201 stops immediately. The rotation of transmitting and curbing cam 229 continues. Cam 229 in addition to controlling the length of a signal impulse transmitted over the cable and controlling curbing cooperates in the performance of another function, viz., to time the signals sent from the transmitter of Fig. 1 including the transmission of a train of impulses over the cable 218 to switch the receiving end of the cable from the cable code receiver 221 to the receiving retranslator per Fig. 3. The manner in which this is performed will now be described.

It has been explained that whenever the cable relay transmitter is seized by the five-element system, per Fig. 1, a special train of impulses is transmitted over cable 218 to switch the receiving end of the cable from the cable code receiver 221 to the receiving retranslator per Fig. 3. This is done automatically in response to the seizure of the transmitting end of the cable by the operation of start switch 101. When relay 103 is operated upon the closure of switch 101 and contact 114 is opened, battery is disconnected through contact 114 from the winding of relay 115 and relay 115 starts to release to operate start magnet 117 and set the transmitting distributor 138 in operation. Relay 115 however is a slow-to-release relay. During the interval while relay 115 is releasing, and before distributor 138 is set in operation, a train of at least six positive impulses is impressed, in a manner to be described hereunder, through cable 218 on the six-pulse selector 250 to perform the switching function.

When the path through the top winding of relay 209 is transferred from contact 224 to 234, the top winding of relay 209 is deenergized as each of the parallel branches connected to conductor 112 in Fig. 1 extends to an open circuit at this time. The armature of relay 208 therefore remains in engagement with contact 213 under the influence of its biasing winding while the six switching pulses are being transmitted. When cam 229 closes contact 223, with relay 230 operated, a circuit may be traced from battery 222 through contact 223, contact 233, conductor 111, top winding of relay 126, inner solid conducting ring 139 of distributor 138, conducting brushes 140 and 141 of rotatable arm 137, segment 3 of transmitter 138, conductor 136, contact 142, contact 143, contact 406, conductor 113, contact 235, top winding of relay 208 and resistance 227 to ground. The armature of relay 208 is actuated to close contact 216. The armature of polar relay 126 is actuated to the left but it is ineffectual at this time. When contact 216 is closed a positive pulse is impressed on conductor 217. The first positive pulse continues as long as contact 223 remains closed. When cam 229 has rotated so that its follower engages the depressed portion of cam 229, contact 223 opens, the top windings of relays 208 and 126 are deenergized, the armature of relay 208 is operated into engagement with contact 215. Ground is connected through contacts 213 and 215 to conductor 217. The release of relay 115 is slow enough to permit cam 229 to rotate through at least six complete revolutions before contact 116 is closed. Six successive pulses of positive battery each followed by a short grounded interval are transmitted through contacts 216 and 215 respectively. In response to six successive pulses of positive battery the six-pulse selector 250, which is well known in the art, closes contact 251. This establishes a circuit from positive battery through contact 251 and the winding of relay 252 to ground, operating relay 252. The closing of contact 253 establishes a circuit from battery through contact 264 in the six-space selector 270, contact 253 and the winding of relay 252 to ground to maintain relay 252 operated. Relay 252 will remain locked in the operated position until the transmission from Fig. 1 is terminated when the six-space selector will be operated by the transmission of a train of at least six-spacing or ground pulses to open contact 264. This will be described more fully hereunder.

Contacts 254 and 220 through which receiver 221 was connected to the cable circuit are now opened from the operation of relay 252 and contacts 255 and 256 are closed. A circuit may then be traced from the armature of relay 257 through contact 256, contact 255, and conductor 259 through the top winding of relay 301 to ground. A circuit may also be traced from contact 260 of relay 257 through contact 255, conductor 261, and the top winding of relay 302 to ground. The circuit is now in condition to direct impulses transmitted over cable 218 through regenerative repeater 219, and contacts 255 and 256 to polarized

receiving relays 301 and 302 of Fig. 3. The armatures of relays 301 and 302 are normally actuated to their right-hand positions under the influence of current flowing through their biasing circuits which may be traced from negative battery through the bottom winding of relay 301 and the bottom winding of relay 302 to positive battery. As positive battery is connected to contact 258 and contact 260 through the operation of polar relay 257 of regenerative repeater 219 in response to the positive and negative impulses received over the cable, the armatures of relays 301 and 302 will be actuated to their left-hand positions. In response to a ground signal element, as distinguished from curbing ground, contacts 258 and 260 will both be open and the armatures of relays 301 and 302 will both be actuated to the right. The cable code regenerative repeater which receives the cable code signals to perform these functions together with the six-pulse and six-space selectors are all well known in the art and will not therefore be described in detail herein.

To return now to Fig. 1. After the six or more switching pulses have been transmitted over cable 218, relay 115 will be sufficiently deenergized so that contact 116 will close. On the next closure of contact 127 when cam 229 causes an opening of contact 223, a circuit may then be traced from ground through contact 116, contact 127, armature of relay 126, winding of start magnet 117 and contact 123 to battery, energizing start magnet 117. The left-hand end of lever 118 is raised and clutch 134 operates to start the distributor.

The next step in the operation to be described is the manner in which the start pulse is transmitted to set the receiving retranslator distributor 304 in Fig. 3 and its associated transmitting distributor 306 in motion.

When brush 141, Fig. 1, moves onto segment 4 the circuit which has been traced from battery 222 in Fig. 2 to ring 139 is extended through brushes 140 and 141, segment 4, conductor 179, contact 188, conductor 112, contact 234, top winding of relay 209 and resistance 240 to ground operating the armature of relay 209 to the left. This transmits a negative battery pulse over cable 217 to start distributors 304 and 306 in a manner to be described below.

The transmitting and curbing cam 229 in the present embodiment is fork-driven at a speed of 140 revolutions per minute. The transmitting distributor 138 is driven at a speed of 150 revolutions per minute. The difference in operating speeds of the two transmitting mechanisms is adjusted by arresting the rotation of rotatable arm 137, once in each revolution. The stop cam is arranged so that arm 137 is stopped approximately in the position shown near the right-hand end of segment 3 of the distributor. Once start magnet 117 is energized and the right-hand end of lever 118 is disengaged from shoulder 120 of stop cam 121 shaft 122 cannot be arrested until shoulder 120 of stop cam 121 is in position to reengage the right-hand end of lever 118. To anticipate, the armature of relay 126 will be actuated to the left to disengage from contact 127 during the first three-quarters of each rotation of cam 229. This opens the circuit of magnet 117 and the right-hand end of lever 118 is interposed in the path of the shoulder 120 of cam 121 under the influence of spring 119 once for each signal element transmitted. However, this is ineffective until the shoulder 120 has rotated into the stop position near the end of the third pulse. When the third pulse is being transmitted

and the armature of relay 126 is actuated to the left, start magnet 117 will be deenergized and the raising of the right-hand end of the lever will be effective to arrest the rotation of the arm 137 of the transmitter distributor 138. As cam 229 continues its rotation contact 223 is opened, the top winding of relay 126 is deenergized, the operating path for start magnet 117 is reestablished, lever 118 is disengaged from shoulder 120, and the rotation of shaft 137 resumes. The rotation of the shaft will be arrested once in each revolution and the delay interposed will be just sufficient to compensate for the difference in operating speeds of the two mechanisms.

Teletypewriter station 150 which is remote from the transmitting code translator is connected by means of conductors 151 and 152 to the typing reperforator 108. As the teletypewriter contacts 153 are operated five-element current and no-current pulses are transmitted over a circuit which extends from the negative terminal of battery 154 through break key 155, teletypewriter transmitting contacts 153, receiving magnet 156, conductor 151, reperforator magnet 157 and conductor 152 to the positive terminal of battery 154. In the present embodiment of the invention the five-element current and no-current signals are transmitted from the teletypewriter to define each character at the rate of 60 words per minute. The transmitter distributor transmits the cable code combination at a speed of 23.4 words per minute. While the teletypewriter is operating, tape will accumulate. Each character is defined in the tape 107 as a combination of five perforated or unperforated elements arranged transversely in tape 107. The tape is fed into the transmitting distributor and interposed between pins 158 and 162 and their respective contacts 163 to 167, inclusive, in a well-known manner. Where an element in the tape is punched the corresponding contact is closed and where an element is unpunched the corresponding contact is open.

When contact 163 is closed a circuit may be traced from positive battery through sensing pin 158, contact 163, and the winding of relay 168, operating relay 168. When contact 164 is closed a circuit may be traced from positive battery through sensing pin 159, contact 164, and the winding of relay 169 to ground, operating relay 169. When contact 165 is closed a circuit may be traced from positive battery through sensing pin 160, contact 165, and the winding of relay 170 to ground, operating relay 170. When contact 166 is closed a circuit may be traced from positive battery through sensing pin 161, contact 166, left-hand winding of relay 172 and, when contact 173 is closed, to ground through contact 173, operating relay 172. When contact 167 is closed a circuit may be traced from positive battery through sensing pin 162, contact 167, left-hand winding of relay 171 and, when contact 173 is closed, through contact 173 to ground, operating relay 171. When contacts 163 to 167 are open the corresponding relay of the group 168 to 172 will not operate.

The tape is drawn into position so that all of the punched and unpunched areas in a particular transverse section representing a particular symbol are sensed simultaneously by pins 158 to 162. The pins are withdrawn while the third pulse is being transmitted and the succeeding transverse tape section identifying the next character is moved into position so that the elements may be sensed by the pins before rotata-

ble arm 137 sweeps onto segment 1. Elements 1, 2 and 3 in the tape control relays 168, 169 and 170. These relays cooperate as a group. It will be made apparent below that when the first element of the four-element code is transmitted the circuit extends from the transmitting cam 229 through segment 1 of transmitter 138 through a path which when closed extends through a combination of the contacts of relays 168, 169 and 170 to either conductor 112 or 113 which controls relays 208 or 209 so as to transmit either positive battery or negative battery. If the path through the contacts of relays 168, 169 or 170 is open relays 208 and 209 connect ground to the cable for the particular signal element. When rotatable arm 137 sweeps onto segment 2 of distributor 138 the path extends from transmitting cam 229 through segment 2 of distributor 138 and through a certain combination of the contacts of relays 168 to 170 to conductor 112 or 113 to control relays 208 and 209 so as to transmit either a positive or negative pulse or, if the path through the contacts is open, ground as the second element of the four-element cable code. Thus the first three elements of the five-element code control relays 168 to 170 in a manner to produce two signal elements each of which may be of any one of three conditions depending upon the settings of relays 168 to 170. The fourth and fifth elements of the five-element code set the armatures of relays 171 and 172 which cooperate also to establish various combinations of closed paths or open circuits through the contacts of these relays in tandem to conductors 112 and 113 and relays 208 and 209. When rotatable brush arm 137 sweeps onto distributor segment 3 the circuit from the transmitting cam 229 will be extended through various combinations of the contacts of relays 171 and 172 in tandem to conductor 112 or 113 to control the settings of relays 208 and 209. Positive or negative battery or ground will be transmitted for the third pulse of the four-element cable code. When rotatable brush arm 137 sweeps onto contact 4 of transmitting distributor 138 the circuit from transmitting cam 229 will be extended through various combinations of closed or open circuit paths through the contacts of relays 171 and 172 in tandem to conductors 112 or 113 to control relays 208 and 209 so as to transmit either positive or negative battery or ground as the fourth pulse of the cable code combination.

The transmitting tape as has been explained is presented to the sensing pins so that all five elements in the tape may be sensed at the same time. Relays 168, 169 and 170 corresponding to the first three elements of the five-element code are controlled substantially instantaneously, as soon as the pins are set in position and remain under direct control of the sensing pin contacts only, as the pins remain in their selected positions throughout the entire interval while the first two cable code elements, into which the first three elements of the five-element code are translated, are being transmitted. In tracing the operating circuits for relays 171 and 172 which cooperate to determine the nature of the third and fourth elements of the four-element code, it was pointed out that in order to operate relays 171 or 172 contact 173 must be closed. Relays 171 and 172 cannot be operated until relay 125 is released to close contact 173. After the No 4 pulse of the preceding four-element combination is sent, contact 123 is opened. Relay 125 releases and relays 171 and 172 are set in whatever position is necessary in accordance with the fourth and fifth elements of the tape code combination which is presently being transmitted. Contact 123 is opened after the fourth signal element of the four-element code for the preceding character is sent. Relay 125 releases closing contact 173. Relays 171 and 172 are operated or remain released in accordance with the fourth and fifth elements of the five-element code. The sensing pins are withdrawn while the third element of the four-element code is being transmitted. But before the pins are withdrawn, relay 125 is again operated to establish a locking circuit for relays 171 and 172. The locking path extends from battery through contact 176 and the right-hand windings of relays 171 and 172 in parallel to ground. Contact 176 closes before contact 173 opens. Thus even though the sensing pins are withdrawn before the transmission of the third element of the four-element code is completed, the paths through the translator circuit which determine the nature of the third and fourth pulse of the four-element code are maintained until the transmission of the third and fourth element is completed.

Refer now to Fig. 4. In the code tabulation per Fig. 4 at the upper left is shown a code tabulation entitled 5 Unit and at the upper right a code tabulation entitled 4 Unit. In the 5 Unit tabulation there are three vertical columns of + and − symbols. In the 4 Unit tabulation there are two vertical columns of + and −0 symbols. The group of symbols in each horizontal line of the upper left-hand vertical tabulation corresponds to a different combination of the first three elements of a five-element code. There are eight possible combinations of + and − symbols that can be formed out of three elements each of which may be + or −. The 4 Unit tabulation shows, on a corresponding horizontal line, the two three-element symbols of the 4 Unit code into which the three two-element symbols of the 5 Unit code are translated in the invention herein. At the lower left of Fig. 4 is shown a code tabulation having a heading 4—5 and at the lower right is shown a code tabulation having a heading 3—4. The heading 4—5 represents the fourth and fifth elements of the five-element code. The heading 3—4 represents the third and fourth elements of the 4 Unit code. Under the heading 4—5 are shown the four possible different combinations of + and − elements corresponding to the fourth and fifth elements of the 5 Unit code. On a corresponding horizontal line under the heading 3—4 are shown the symbols in the 4 Unit code into which the fourth and fifth elements of the 5 Unit code are translated. Attention is called to the fact that in the 5 Unit code there are but two kinds of symbols, viz., + and −, representing the current and no-current condition of each of the five elements of the five-element code. Under the 4 Unit code there are three kinds of symbols, viz., +, − and 0. + stands for positive battery, − represents negative battery, and 0 represents ground on the 4 Unit cable code.

The various paths through the five to four-element relay translator shown in Fig. 1 for the code translations indicated in Fig. 4 will now be traced.

First, the translation indicated in the top horizontal line, that is, the translation from three + elements in the five-element two-condition code to a + and − element in the four-element three-condition code will be described.

For the three + elements relays 168, 169 and 170 are operated as described. When contact 223 is closed a circuit may be traced from battery 222, through contact 223, contact 233, conductor 111, top winding of relay 126, solid conducting ring 139 of distributor 138, conducting brushes 140 and 141 of rotatable arm 137 of distributor 138, conducting segment 1 of distributor 138, conductor 177, contact 181 of relay 168, contact 182 of relay 169, conductor 113, contact 235 of relay 230, top winding of relay 208 and resistance 227 to ground, operating the armature of relay 208 to close its contact 216. The path through the top winding of relay 209 is open. The armature of relay 209 is in engagement with contact 213 under the influence of current flowing through its bottom or biasing winding. When contact 215 is opened the position of the armature of relay 209 does not affect the signal element transmitted. Positive battery 228 is connected to cable conductor 217 by the armature of relay 208 as the first signal element of the four-element three-condition code. The positive pulse continues until transmitting and curbing cam 229 has rotated into position to open contact 223. Then the top winding of relay 208 is deenergized. The armature of relay 208 is actuated to close contact 215 under the influence of current flowing in the bottom or biasing winding of relay 208. Ground for curbing or discharging the cable conductor is connected to conductor 217 over a circuit which extends through contact 213, armature of relay 209, contact 215 and the armature of relay 208 to conductor 217.

It is pointed out that the portion of the transmitting circuit extending from battery 222 to the conducting brush 141 of distributor 138 remains unchanged for the transmission of each signal element of the four-element code. In the description below the transmission path between battery 222 and brush 141 will therefore not be retraced.

When brush 141 sweeps onto segment 2 of distributor 138 the transmission path is extended through conductor 178, contact 183 of relay 168, contact 184 of relay 169, contact 185 of relay 170, conductor 112, contact 234 of relay 230, top winding of relay 209 and resistance 240 to ground actuating the armature of relay 209 to engage contact 214. The position of the armature of relay 208 remains unchanged. A circuit may then be traced from negative battery 226, contact 214, armature of relay 209, contact 215 and the armature of relay 208 to cable conductor 217. Negative battery is thus connected to the cable as the second element of the four-element code.

Attention is called to the fact that when the transmission path from battery 222 extends through conductor 113, positive battery is connected to cable conductor 217 and when the transmission path from battery 222 extends through conductor 112 negative battery is connected to cable conductor 217. Attention is also called to the fact that if battery 222 is not connected to either conductor 112 or 113, the armatures of relays 208 and 209 are both actuated to engage their respective right-hand contacts, under the influence of their respective bottom or biasing windings. Under this condition ground is connected, as has been shown, to conductor 217. Ground as has been explained is connected to cable 217 for two conditions, namely for curbing and also for the transmission of the third of the three signaling conditions for any one of the four elements of the four-element cable code.

In the following description only that portion of the transmitting path extending between brush 141 and conductor 112 or 113 will be traced. When the path extends to conductor 113 a positive signal element will be transmitted over conductor 217. When the path extends to conductor 112 a negative signal element will be transmitted over conductor 217. When the path is not continuous to either conductor 112 or 113 the top windings of both relays 208 and 209 will be deenergized. The armatures of relays 208 and 209 will both be actuated to engage their right-hand contacts and ground will be connected through contacts 213 and 215 to conductor 217.

Now the translation indicated in the top horizontal line of the bottom left- and right-hand tabulation under the headings 4—5 and 3—4 will be explained. In this translation the fourth and fifth elements of the five-unit code are translated into the third and fourth elements of the four-unit code.

As explained above, the + symbol for the fourth element in the five-element code indicates the relay 172 is operated. The — symbol for the fifth element of the five-element code indicates that relay 171 is released.

For this condition when brush 141 sweeps onto segment 3 a circuit is established which extends through conductor 180, contact 142 of relay 171, contact 186 of relay 172 and contact 187 of relay 172 to conductor 113. This effects the transmission of a + pulse as the third element of the four-element code.

When brush 141 sweeps onto segment 4 a circuit is established which extends through conductor 179 and contact 188 of relay 171 to conductor 112. This effects the transmission of a — pulse for the fourth element of the four-element code.

Thus a five-element code consisting of the five elements + + + +— is translated into a four-element code consisting of the four elements + — + —.

The paths through the relay code translator of Fig. 1 for the translation of the seven other possible permutations of elements 1, 2 and 3 of the five-element two-condition code into corresponding elements 1 and 2 of the four-element three-condition code, indicated in horizontal lines two to eight in the upper portion of Fig. 4, under the headings 5 Unit 1—2—3 and 4 Unit 1—2 will now be traced. Thereafter the paths for the translation of the three other possible permutations of elements 3 and 4 of the five-element two-condition code into corresponding elements 3 and 4 of the four-element three-condition code shown in the bottom three horizontal lines in the lower portion of Fig. 4, under the headings 4—5 and 3—4 will be traced.

The second horizontal line in Fig. 4 shows a group of three elements, viz. + + —. In conformance with this grouping, relays 168 and 169 will be operated and relay 170 will be released. From segment 1 the path extends through conductor 177, contact 181 and contact 182 to conductor 113. The first element of the corresponding four-element code will therefore be +.

From segment 2 the path extends through conductor 178, contact 183, contact 184 and contact 190 to conductor 113. The second element of the corresponding four-element code will therefore be + also.

The three-element combination shown on the

third line is + − +. For this condition relays 168 and 170 will be operated and relay 169 will be released.

From segment 1 the path extends through conductor 177, contact 181 and contact 191 to conductor 112. The first four-element pulse is −.

From segment 2 the path extends through conductor 178, contact 183, contact 192 and contact 193 to conductor 112. The second four-element pulse is − also.

The combination shown on the fourth line is + − −. For this condition relay 168 will be operated. Relays 169 and 170 will be released. The circuit extends from segment 1 through conductor 177, contact 181 and contact 191 to conductor 112. The first impulse of the four-element code is therefore −.

From segment 2 the circuit extends through conductor 178, contact 183 and contact 192 to an open circuit at contact 193. This, as has been explained, results in the transmission of ground, represented by the symbol 0 as the second impulse of the four-element code.

The fifth line shows the symbols − + + for the five-element code. Relay 168 is released and relays 169 and 170 are operated. The circuit extends from segment 1 through conductor 177, contact 194, contact 195, and contact 196 to conductor 112. The first element of the four-element code is therefore −.

From segment 2 the circuit extends through conductor 178, contact 197, contact 198 and contact 199 to conductor 113. A + pulse is transmitted as the second element of the four-element code.

In accordance with the code for − + − on the sixth line relays 168 and 170 are released and relay 169 is operated. From segment 1 the path extends through conductor 177, contact 194, contact 195, and contact 411 to conductor 113 transmitting a + pulse as the first element of the corresponding four-element code.

From segment 2 the circuit extends through conductor 178, contact 197 and contact 198 to an open circuit at contact 199. Accordingly, ground represented by the symbol 0 is connected to cable conductor 217 for the second element of the four-element code.

In accordance with the code for − − + shown on the seventh line, relays 168 and 169 are released and relay 170 is operated. From segment 1 the path extends through conductor 177 and contact 194 to open contact 195. This connects ground, represented by the symbol 0, to cable conductor 217 as the first four-element pulse.

From segment 2 the circuit extends through conductor 178, contact 197, contact 400 and contact 401 to conductor 113. The second four-element pulse is therefore +.

In accordance with the code for − − − shown on the eighth line relays 168, 169 and 170 are released. From segment 1 the circuit extends through conductor 177 and contact 194 to open contact 195. Ground is therefore connected to cable 217 represented by the symbol 0 as the first element of the four-element code.

From segment 2 the path extends through conductor 178, contact 197, contact 400 and contact 402 to conductor 112. The second four-element pulse is therefore −.

On the second line under the heading 4—5 the code − + appears. Relay 172 is released and relay 171 is operated. From segment 3 the circuit extends through conductor 180, contact 403, contact 404 and contact 144 to conductor 112. The third element of the four-element code is therefore −.

From segment 4 the circuit extends through contact 405 to conductor 113. The corresponding fourth element of the four-element code is therefore +.

On the third line under the heading 4—5 the symbols − − appear. Relays 171 and 172 are both released for this condition. From segment 3 the circuit extends through conductor 180, contact 142, contact 143, contact 407 and resistance 408 to ground. Contact 406 is open. This results in the connection of ground to cable 217 represented by the symbol 0 under the heading 3—4 as the third element of the four-element code.

From the fourth segment the circuit extends through conductor 179 and contact 180 to conductor 112. The fourth element of the four-element code is therefore −.

One the bottom line under the heading 4—5 the symbols + + appear. Relays 171 and 172 are both operated for this condition. From segment 3 the circuit extends through conductor 180, contact 403, contact 410, contact 407 and resistance 408 to ground. Contact 406 is open. This results in the connection of ground to cable 217 represented by the symbol 0 under heading 304 as the third element of the four-element code.

From segment 4 the circuit extends through conductor 179 and contact 405 to conductor 113. The fourth element of the corresponding four-element code is therefore +.

Refer now to Fig. 3.

The four-element receiving distributor 304 in the four-to-five-element retranslator and the associated relay circuit, together with the transmitting distributor 306 for the five-element code made be assumed to be in the condition indicated when the apparatus is idle. Switch 307 of motor 308 of receiving distributor 304 and switch 325 of motor 326 of transmitting distributor 306 are closed manually preparatory to operating the mechanism of Fig. 3. Whenever the system per Fig. 1 may be operated switches 307 and 325 will be closed. Motor 308 rotates, driving shaft 309. Driven shaft 310 is restrained from rotating through friction clutch 311, by the right-hand end of stop lever 312 of start magnet 313, which engages a raised shoulder 314 on the periphery of stop cam 315 which is rigidly secured to transmitter-distributor shaft 316. Rigidly secured to distributor shaft 316 is rotatable distributor arm 317. Secured in arm 317 are conducting brush 318 which engages the inner segmented distributor ring and conducting brush 319 which engages the outer segmented distributor ring. Driven shaft 310 is coupled to transmitter shaft 316 by worm 320 which is rigidly secured to shaft 310 and spur gear 321 which is rigidly secured to shaft 316.

The rotating arm 317 is arranged to be arrested in the position indicated with brush 318 engaging segment 327 and brush 319 engaging segment 328.

The operation of the driving mechanism of transmitting distributor 306 is substantially the same as that of receiving distributor 303 except that the outer conducting brush 330 is always arrested when it engages stop segment 331.

Attention is called to the fact that the outer ring of distributor 303 has four segments spaced and of a size to receive the center portion only of the four signal elements of the four-element code. These four segments 362, 368, 396 and 502 are relatively short.

In response to the reception of the negative

starting impulse, the armature of relay 361 is actuated to engage contact 369. A circuit may now be traced from negative battery through contact 369, resistance 334, conductor 335, segment 327, brush 318, brush 319, segment 328, conductor 336, winding of relay 337, contact 338 of relay 339 and contact 340 of relay 341 to ground operating relay 337. The operation of relay 337 establishes a circuit from battery through contact 342 of relay 337, conductor 343 and the winding of start magnet 313 to ground. The left-hand end of stop lever 312 is raised against the influence of spring 344 attached to the right-hand end of lever 312. The right-hand end of lever 312 is disengaged from shoulder 314. Rotatable brush arm 317 of distributor 303 starts to rotate in a clockwise direction. The closing of contact 345 of relay 337 establishes a circuit from battery through contact 345 and the winding of start magnet 346 of the five-element transmitting distributor 306. Rotatable brush arm 347 starts to rotate in a clockwise direction.

As brush 319 engages segment 502 corresponding to the fourth element of the four-element code, relay 393 will not be operated, since contact 369 of relay 361 will remain closed and negative battery connected to contact 369 will oppose negative battery connected to the right-hand winding of relay 393.

After the start pulse is received, let it be assumed that the four-element cable code combination comprising the two elements shown on the first line of Fig. 4 under the heading 1—2, viz., + — and the two elements shown on the first line under the heading 3—4, viz., + — are first to be received over the cable. The first two elements + — of the four-element code are to be translated into the elements + + + as the first three elements of the five-element code and the second pair of elements + — which are the third and fourth elements of the four-element code are to be translated into the elements + — as the fourth and fifth elements of the five-element code. In other words, the four-element combination + — + — is to be translated into the five-element combination + + + + —.

When brush 319 engages segment 350, a circuit may be traced from positive battery through resistance 349, segment 348, brushes 318 and 319, segment 350, conductor 351 and the winding of relay 352 to ground operating relay 352. Relay 352 is a locking relay. When relay 352 is released battery is supplied through contact 353 to the left-hand locking windings of relays 354, 355, 356 and 357. Such of these relays as have been operated on the preceding cycle of operations, in accordance with the first two elements of the four-element cable code, in a manner to be described hereunder, will be locked through contact 358, 359, 360 or 361. The opening of contact 353 releases such of these relays as have been locked in the previous cycle so that relays 354 to 357 are conditioned to receive and register the nature of the first two symbols of the four-element code. When brush 319 engages segment 362 the first positive element of the four-element code will be impressed on the translating circuit. The circuit extends from positive battery through contact 332, contact 333, resistance 334, conductor 335, segment 327, conductor 363, segment 364, brushes 318 and 319, segment 362 and conductor 365, which connects in parallel to the right-hand windings of relays 354 and 355 through rectifiers 366 and 367, which are oppositely poled. Rectifier 366 presents a low resistance to current of positive polarity so that substantial current flows through rectifier 366 and the right-hand winding of relay 354 to ground operating relay 354. Rectifier 367 presents an exceedingly high resistance to current of positive polarity so that the resistance of the circuit extending through rectifier 367 and the right-hand winding of relay 355 to ground is too great to permit relay 355 to be energized. Contact 358 therefore closes and contact 359 remains open. When brush arm 317 has rotated into position so that brush 319 engages segment 368 the second element of the four-element cable code will be impressed on the retranslator mechanism. The second element is a negative element. In response to this the armature of relay 361 will be actuated to close contact 369. A circuit may then be traced from negative battery through contact 369, resistance 334, conductor 335, segment 327, conductor 545, segment 364, brushes 318 and 319, segment 368 and conductor 369 from which parallel branches extend. One of the parallel branches extends through rectifier 370 and the right-hand winding of relay 356 to ground. The other parallel branch extends through rectifier 371 and the right-hand winding of relay 357 to ground. Rectifier 370 presents a very high resistance to current of negative polarity so that relay 356 remains unoperated. Rectifier 371 presents a low resistance to current of negative polarity so that the right-hand winding of relay 357 is energized closing contact 361.

Relay 352 was released when brush arm 317 swept beyond segment 350. Contact 353 was closed. When relay 354 operated a circuit was established from battery through contact 353, contact 356 and the left-hand winding of relay 354 to ground locking relay 354. When relay 357 was operated a circuit was established from battery through contact 353, contact 361 and the left-hand winding of relay 357 to ground locking relay 357. Relays 355 and 356 remained in the released condition.

The distant five-element teletypewriter station arranged to receive five-element two-condition signals is connected to transmitting distributor 305 at the cable receiving retranslating station by means of a pair of conductors 552 and 554. While distributor 305 is in the stop position shown, printer magnet 374 is energized by current flowing over a circuit which extends from the right-hand terminal of battery 375, conductor 552, winding of printer magnet 374, conductor 545, ring 373, brushes 329 and 330, stop segment 331 and conductor 515 to the left-hand terminal of battery 375.

When brush arm 347 of distributor 305 sweeps into position so that brushes 329 and 330 bridge the gap between inner continuous conducting ring 373 and start segment 372 the circuit extending through printer receiving magnet 374 is opened and a start pulse, which is always an open pulse, is transmitted to printer magnet 374.

When brush arm 347 is rotated into position so that the gap between inner ring 373 and segment 376 of the transmitting distributor is bridged by brushes 329 and 330, a circuit may be traced from the right-hand terminal of battery 375 through conductor 552, winding of printer magnet 374, conductor 554, inner ring 373, segment 376, conductor 377, contact 378, contact 373, and conductor 380 to the left-hand terminal of battery 375 which sends a current impulse to the printer corresponding to the + symbol shown in the top line under the heading 1—2—3 in Fig. 4 as the first element of the five-element code.

When brush arm **347** has rotated into position so that brushes **329** and **330** bridge the gap between inner ring **373** and segment **381** of the distributor a circuit may be traced from the right-hand terminal of battery **375** through conductor **552**, winding of printer magnet **374**, conductor **554**, ring **373**, brushes **329** and **330**, segment **381**, conductor **382**, contact **383**, contact **384**, and conductor **380** to the left-hand terminal of battery **375**. This transmits another current impulse, represented by the symbol +, as the second impulse of the five-element code.

When brush **330** engages segment **385** a circuit may be traced from the right-hand terminal of battery **375** through conductor **552**, winding of printer magnet **374**, conductor **554**, ring **373**, brushes **329** and **330**, segment **385**, conductor **386**, contact **387**, contact **388**, and conductor **380** to the left-hand terminal of battery **375**. This transmits a third positive pulse, represented by the symbol +, as the third element of the five-element code.

Attention is called to the fact that the first two elements of the four-element code, namely the + − elements, have been translated into the first three elements of the five-element code, namely, the + + + elements.

When brush arm **317** of distributor **303** rotates into position so that brush **319** engages segment **389** a circuit may be traced from battery through resistance **399**, segment **390**, brushes **318** and **319**, segment **389**, conductor **390** and the winding of relay **391** to ground operating relay **391**. When contact **392** of relay **391** is opened the locking circuit, which has been maintaining relays **393**, **394** and **395** in positions in accordance with the third and fourth elements of the preceding four-element code transmitted over the circuit, is opened and relays **393**, **394** and **395** are released to assume positions in accordance with the third and fourth elements of the four-element code presently being transmitted.

The third element of the four-element code is a + element. In accordance with this the armature of relay **302** will be operated to close contact **332**. The armature of relay **301** will be in engagement with contact **333**. A circuit may then be traced from positive battery through contact **332**, contact **333**, resistance **334**, conductor **335**, segment **327**, brushes **318** and **319**, segment **396**, and conductor **397** to parallel branches. One parallel branch extends through rectifier **398** and the right-hand winding of relay **394** to ground. The other parallel branch extends through rectifier **500** and the right-hand winding of relay **395** to ground. Rectifier **398** is poled so as to present low resistance to current of positive polarity. Rectifier **500** is poled so as to present exceedingly high resistance to current of positive polarity. Relay **394** is operated. Relay **395** remains released. When brush **319** sweeps off segment **389** the operating circuit of relay **391** is opened. Contact **392** therefore closes. When relay **394** operates, therefore, a circuit is established from battery through contact **392**, contact **501**, and the left-hand winding of relay **394** to ground locking relay **394** in the operation position.

The fourth element of the four-element code is a − element. In response to this the armature of relay **301** is actuated to close contact **369**. A circuit may then be traced from negative battery through contact **369**, resistance **334**, conductor **335**, segment **327**, segment **502**, conductor **503** and the right-hand winding of relay **393** to negative battery. Attention is called to the fact that negative battery is connected to both ends of this circuit. Relay **393** therefore remains in the released condition as shown. Relays **393**, **394** and **395** cooperate to determine the nature of the last two elements or the fourth and fifth elements of the five-element code.

When brush **330** of transmitting distributor **305** engages segment **505** a circuit may be traced from the right-hand terminal of battery **375** through conductor **552**, winding of printer magnet **374**, conductor **554**, ring **373**, brushes **329** and **330**, segment **505**, conductor **506**, contact **507**, contact **508** and conductor **509** to the left-hand terminal of battery **375**. This transmits a current pulse, represented by a + symbol, as the fourth element of the five-element code.

When brush **330** engages segment **510** a circuit may be traced from the right-hand terminal of battery **375** through conductor **552**, winding of the printer magnet **374**, conductor **554**, ring **373**, brushes **329** and **330**, segment **510** and conductor **511** to contact **512** which is open. As a result of this negative current pulse, represented by the symbol −, is transmitted to the printer as the fifth element of the five-element code.

When brush **330** engages segment **331**, the rotation of the distributor arm **347** is stopped. For this condition, the circuit through the winding of the printer magnet is again closed over a circuit heretofore traced.

From the foregoing it should be apparent that when the first element of the four-element cable code is positive, relay **354** is operated and relay **355** is released. When the first element is negative, relay **355** is operated and relay **354** is released. When the second element of the four-element cable code is positive, relay **356** is operated and relay **357** is released. When the second element is negative, relay **357** is operated and relay **356** is released. When the third element of the four-element cable code is positive, relay **394** is operated and relay **395** is released. When the third element is negative, relay **395** is operated and relay **394** is released. When the fourth element of the four-element cable code is positive, relay **393** is operated. When it is negative, relay **393** is released.

The manner in which the first and second elements of the four-element cable code shown on lines 2 to 8 under the heading 1—2 in Fig. 4 are translated into the three symbols for the first, second and third elements of the five-element code shown on the corresponding lines under the heading 1—2—3 of Fig. 4 will now be described.

Elements **1** and **2** of the four-element code shown on the second line are + +. For this condition relays **354** and **356** will now be operated. Relays **355** and **357** will be released. For the first element of the five-element code, a circuit extends from the right-hand terminal of battery **375** through conductor **552**, winding of printer magnet **374**, conductor **554**, solid conducting ring **373**, brushes **329** and **330**, segment **376**, conductor **377**, contact **518**, contact **384** and conductor **380** to the left-hand terminal of battery **375**. The circuit is continuous. A current pulse represented by the symbol + will, therefore, be transmitted as the first element of the five-element code. For the second element, a circuit may be traced from the right-hand terminal of battery **375** through conductor **552**, winding of printer magnet **374**, conductor **554**, ring **373**, brushes **329** and **330**, segment **381**, conductor **382**, contact **519**, contact **388** and conductor **380** to the left-hand terminal of

battery 375. The second symbol will, therefore, be +. For the third element, a circuit extends from the right-hand terminal of battery 375 through conductor 552, winding of printer magnet 374, conductor 554, ring 373, brushes 329 and 330, segment 385, conductor 386, contact 520 and contact 521 to contact 522 which is open. Since the circuit to the left-hand terminal of battery 375 is not continuous, a no-current pulse represented by the symbol — will be transmitted as the third element of the five-element code.

On the third line under heading 1—2 of the four-element code the symbols — — appear. For this condition relays 355 and 357 will be operated. Relays 354 and 356 will be released. Attention is called to the fact that the circuit for the printer magnet extends always from the right-hand terminal of battery 375 through conductor 552, winding of printer magnet 374, conductor 554, solid conducting ring 373, and brushes 329 and 330 to some one of the segments on the outer ring of distributor 305. In tracing the circuits for the remainder of the translations, in order to avoid unnecessary repetition in the description hereunder, only that portion of the circuit beyond the particular segment engaged by brush 330 will be traced. When brush 330 engages segment 376, the circuit extends through conductor 377, contact 516, contact 517 and conductor 380 to the left-hand terminal of battery 375. A + pulse will, therefore, be transmitted to the first element. From segment 381 a circuit extends through conductor 382 and contact 383 to contact 384 which is open at this time. A no-current pulse, represented by the symbol —, will, therefore, be transmitted as the second element of the five-element code. From contact 385 a circuit extends through conductor 386, contact 522, contact 523 and conductor 380 to the left-hand terminal of battery 375. A + pulse will, therefore, be transmitted as a third element of the five-element code.

On the fourth line under the heading 1—2 of the four-unit code, the symbols — 0 appear. Relay 355 will be operated by the — pulse. The armatures of relays 391 and 392 are both actuated toward the right for the zero pulse. Relays 356 and 357 will, therefore, both be released. From segment 376 the circuit extends through conductor 377, contact 524, contact 525, contact 526 and conductor 380 to the left-hand terminal of battery 375. This results in a current pulse, represented by the symbol + as the first element of the five-element code. From segment 381 a circuit extends through conductor 382 to open circuits at contacts 383, 519, 527 and 528. A no-current pulse represented by the symbol — will be transmitted as the second element of the five-element code. From segment 385 a circuit extends through conductor 386 to open circuits at contacts 387, 522, 520 and 529. A no-current pulse represented by the symbol — will be transmitted as the third element of the five-element code.

On the fifth line under the heading 1—2 of the four-unit code the symbols — + appear. For this condition, relays 355 and 356 will be operated. Relays 354 and 357 will be released. From segment 376 a circuit extends through conductor 377 and contact 516 to open contact 384. The first element of the five-element code is therefore a no-current pulse represented by the symbol —. From contact 381 a circuit extends through conductor 382, contact 527, contact 517 and conductor 380 to the left-hand terminal of battery 375. A current pulse represented by the symbol + will be transmitted as the second element of the five-element code. From segment 385 a circuit extends through conductor 386, contact 529, contact 523 and conductor 380 to the left-hand terminal of battery 375. A current pulse represented by the symbol + will be transmitted as the third element of the five-element code.

The sixth line under the heading 1—2 for the four-unit code shows the combination +0. For this condition, relay 354 will be operated and relays 355, 356 and 357 will be released. From segment 376 a circuit extends through conductor 377 to open contacts on relays 357, 356 and 355. A no-current pulse represented by the symbol — will be transmitted as the first element of the corresponding five-element code. From segment 381 a circuit extends through conductor 382, contact 528, contact 525, contact 526 and conductor 380 to the left-hand terminal of battery 375. A current pulse represented by the symbol + will be transmitted as the second element of the five-element code. From segment 385 a circuit extends through conductor 386 to open contacts on relays 357 and 356. A no-current pulse represented by the symbol — will, therefore, be transmitted as the third element of the five-element code.

The seventh line under the heading 1—2 of the four-element code shows the symbols 0 + as the first and second elements of the four-element code. For this condition, relay 356 will be operated. Relays 354, 355 and 357 will be released. From segment 376 a circuit extends through conductor 377 and contact 518 to open contact 384. A no-current pulse represented by the symbol — will be transmitted as the first element of the five-element code. From segment 381 a circuit extends through conductor 382 and contact 519 to open contact 388. A no-current pulse represented by the symbol — will be transmitted as the second element of the three-element code. From segment 385 a circuit extends through conductor 386, contact 520, contact 521, contact 522 and conductor 380 to the left-hand terminal of battery 375. A current pulse represented by the symbol + will be transmitted as the third element of the five-element code.

On the eighth line under the heading 1—2 of the four-element code the symbols 0 — appear. For this condition, relay 357 will be operated and relays 354, 355 and 356 will be released. From segment 376 a circuit extends through conductor 377 to contacts 516 and 378 in parallel both of which lead to open circuits. A no-current pulse represented by the symbol — will be transmitted as the first element of the five-element code. From segment 381 a circuit extends through conductor 382 and contact 383 to open contacts 518 and 384. A no-current pulse represented by the symbol — will be transmitted as the second element of the five-element code. From segment 385 a circuit extends through conductor 386, through contacts 387 and 522 in parallel. The branch which extends through contact 387 terminates in open contacts 519 and 388. The branch which extends from contact 522 terminates at open contacts 529 and 523. A no-current pulse represented by the symbol — will, therefore, be transmitted as the third element of the five-element code.

The manner in which relays 393, 394 and 395 cooperate to translate the third and fourth elements, of the four-element code into the fourth and fifth elements of the five-element code as indicated in the second, third and fourth lines

under the headings 3—4 and 4—5 of Fig. 4 will now be described.

The second line under the heading 3—4 shows the symbols — + as the third and fourth elements of the four-element code. For this condition, relays **395** and **393** will be operated. Relay **394** will be released. From segment **505** a circuit extends through conductor **506** and contact **530** to open contact **531**. A no-current pulse represented by the symbol — will be transmitted as the corresponding fourth element of the five-element code. From segment **510** a circuit extends through conductor **511**, contact **512** and conductor **509** to the left-hand terminal of battery **375**. A current pulse represented by the symbol + will be transmitted as the fifth element of the five-element code.

The third line under the heading 3—4 shows the symbols 0 — as the third and fourth elements of the four-element code. For this condition, relays **393**, **394** and **395** will all be released. From segment **505** a circuit extends through conductor **506**, contact **530** and contact **531** to open contact **532**. A no-current pulse represented by the symbol — will be transmitted as the fourth element of the five-element code. From segment **510** the circuit extends through conductor **511** to open contact **512**. A no-current pulse represented by the symbol — will be transmitted for the corresponding fifth element of the five-element code.

The last line under the heading 3—4 of the four-element code shows the symbols 0 + as the third and fourth elements of the four-element code. For this condition, relays **394** and **395** will both be released and relay **393** will be operated. From segment **505** a circuit extends through conductor **506**, contact **530**, contact **531**, contact **532** and conductor **509** to the left-hand terminal of battery **375**. A current pulse represented by the symbol + will be transmitted as the fourth element of the five-element code. From segment **510** a circuit extends through conductor **511**, contact **512** and conductor **509** to the left-hand terminal of battery **375**. A current pulse represented by the symbol + will be transmitted as the corresponding element of the five-element code.

Each one of the eight combinations of the first two elements of the four-element code may be combined with each one of the four combinations of the second two elements of the four-element code to provide thirty-two different four-element combinations. Each one of the thirty-two different combinations of the four-element code may be translated into a different one of the thirty-two different possible combinations of the five-element start-stop code as indicated.

It was explained above that when the cable relay transmitter was seized for the transmission of signals generated in the system per Fig. 1, red lamp **242** was lighted and the cable code tape transmitter **201** was stopped. The cable code tape transmitter is arranged so that when the start key **101** in Fig. 1 is opened, releasing relay **230** of Fig. 2 and reconnecting the tape transmitter **201** to the cable relay transmitter, one or more groups of six successive ground pulses will be transmitted over the cable before the cable code transmitter is restarted manually. Such a combination never occurs in the four-element cable code. In response to this, the six-space selector **270** opens contact **264** in a well-known manner. This releases relay **252** and the circuit of Figs. 1, 2 and 3 are restored to their original condition.

What is claimed is:

1. In a telegraph system, a source of thirty-two, five-element, two-condition, permutation code, telegraph signal combinations connected to an electromechanical translator and means in said translator, said means comprising two individual multielement selectors each including a plurality of selectively operable relays, the relays of one of said selectors actuable by a given number of the five elements of said code and the relays of the other actuable by the remaining elements, said means responsive to the reception of any one of said signal combinations, for translating said received combinations into a corresponding particular one of thirty-two four-element, three-condition, permutation code telegraph signal combinations.

2. In a telegraph system, a source of five-element, two-condition, permutation code, telegraph signals connected to an electromechanical translating device, means in said device for translating said signals into four-element, three-condition signals said means comprising two individual multielement selectors each including a plurality of selectively operable relays, the relays of one of said selectors actuable by a given number of the five elements of said code and the relays of the other actuable by the remaining elements, and means in said system for retranslating said signals into their original form.

3. A five-element, two condition, start-stop permutation code, telegraph signal transmitting station, a four-element, three-condition, cable code, telegraph signal transmitting station, a telegraph channel, automatic means for effectively connecting said channel through said four-element station to said five-element station in tandem, a code conversion device connected to said channel for converting signal combinations in accordance with said five-element code into corresponding signal combinations in accordance with said four-element code, means connected to said channel to control the time consumed in the act of code conversion of each individual combination and means in said control means for making each of said converted combinations of the same duration as each of said four-element combinations.

4. In a telegraph system, a telegraph channel, a first transmitting means connected to a first end of said channel and a first receiving means connected to a second end of said channel for transmitting and receiving telegraph signals in accordance with a first code over said channel, a second transmitting means connected to said first end of said channel and a second receiving means connected to said second end of said channel for transmitting and receiving telegraph signals in accordance with a second code, different from said first code, over said channel and switching means responsive to particular signals transmitted over said channel for switching said second end of said channel from one to another of said receiving means, so as to connect the proper receiver to said channel to receive signals of a particular code.

5. In a telegraph system, in combination, a telegraph channel, a first and a second telegraph signal receiving device, a telegraph signal code retranslator intermediate said channel and said second device, means for directing telegraph communication signals over said channel to said first receiving device at a first time, and means responsive to the transmission of switching signals over said channel for switching said channel from said first receiving device through said retrans-

lator to said second receiving device at a second time.

6. In a telegraph system, a telegraph signal code translator for translating four-element, three-condition, permutation code signal combinations into five-element, two-condition, permutation code signal combinations and means in said translator for translating a subgroup of two signal elements of each of said four-element signal combinations into a subgroup of three signal elements of each of said five-element signal combinations.

7. In a telegraph system, a telegraph signal code translator for translating five-element, two-condition, permutation code, signal combinations into four-element, three-condition, permutation code, signal combinations, a first means in said translator for translating three of the five elements of said five-element signals into two of the elements of said four-element signals and a second means in said translator for translating two of the elements of said five-element signals into two of the elements of said four-element signals.

8. In a telegraph system, a telegraph code translator for translating four-element, three-condition, permutation code signals into five-element, two-condition, permutation code signals, a first means in said translator for translating two of the elements of said four-element signals into three of the elements of said five-element signals and a second means in said translator for translating two of the elements of said four-element signals into two of the elements of said five-element signals.

9. In a telegraph system, a first telegraph transmitter, means in said transmitter for generating telegraph signals in accordance with a first code, a timing mechanism connected to said transmitter, means connected to said timing mechanism for controlling the duration of signal elements in said code, a telegraph channel, means for impressing said timed signal elements on said channel, a second telegraph transmitter, means in said second transmitter for generating signals in accordance with a second code, different from said first code, means for impressing signals in accordance with said second code on said channel and means for timing the duration of the signal elements of said second code with said timing mechanism so that they may be transmitted through facilities connected to said channel adaptable to the duration of signal elements of said first code.

10. In a telegraph system, a telegraph transmitter, means in said transmitter for transmitting a train of four signal elements to form a four-element, start-stop permutation code signal combination, each of said elements being of any one of three conditions, a telegraph receiver, means in said receiver for receiving a train of seven signal elements consisting of a starting element, five permutation code signal elements, each of which may be of any one of two conditions and a stop element, a translator intermediate said transmitter and receiver, a telegraph channel interconnecting said transmitter and receiver through said translator and means in said translator for translating said four-element train into said seven-element train.

11. A code signal transmission system comprising means for producing a two-element, five-unit code, means for converting three chosen units thereof to produce eight combinations of two units of a three-element, four-unit code, means for converting two other units thereof to produce four combinations of two units of the three-element, four-unit code, means for combining the eight combinations of two units permutatively with the four combinations of the two other units to produce thirty-two possible combinations and means for utilizing codes of the thirty-two combinations of the three-element, four-unit code to control signaling apparatus.

12. A code signal transmission system comprising means for producing a two-element, n-unit code, means for converting $(n-p)$ chosen units thereof to produce $(n-p)^2$ combinations of two units of a three-element m-unit code, means for converting p other units thereof to produce x (where x does not exceed p^2) combinations of two units of the three-element m-unit code, means for combining the $(n-p)^2$ combinations of two units permutatively with the x combinations of the two other units to produce a given number of possible combinations and means for utilizing the given number of combinations of the three-element, m-unit code for signaling.

13. In a telegraph system, a five-element permutation code telegraph signal transmitter, connected to a telegraph signal code translator, means in said translator for translating three of said five elements into two elements of a four-element code and means in said translator for translating the two remaining elements of said five-element code into the two remaining elements of said four-element code.

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