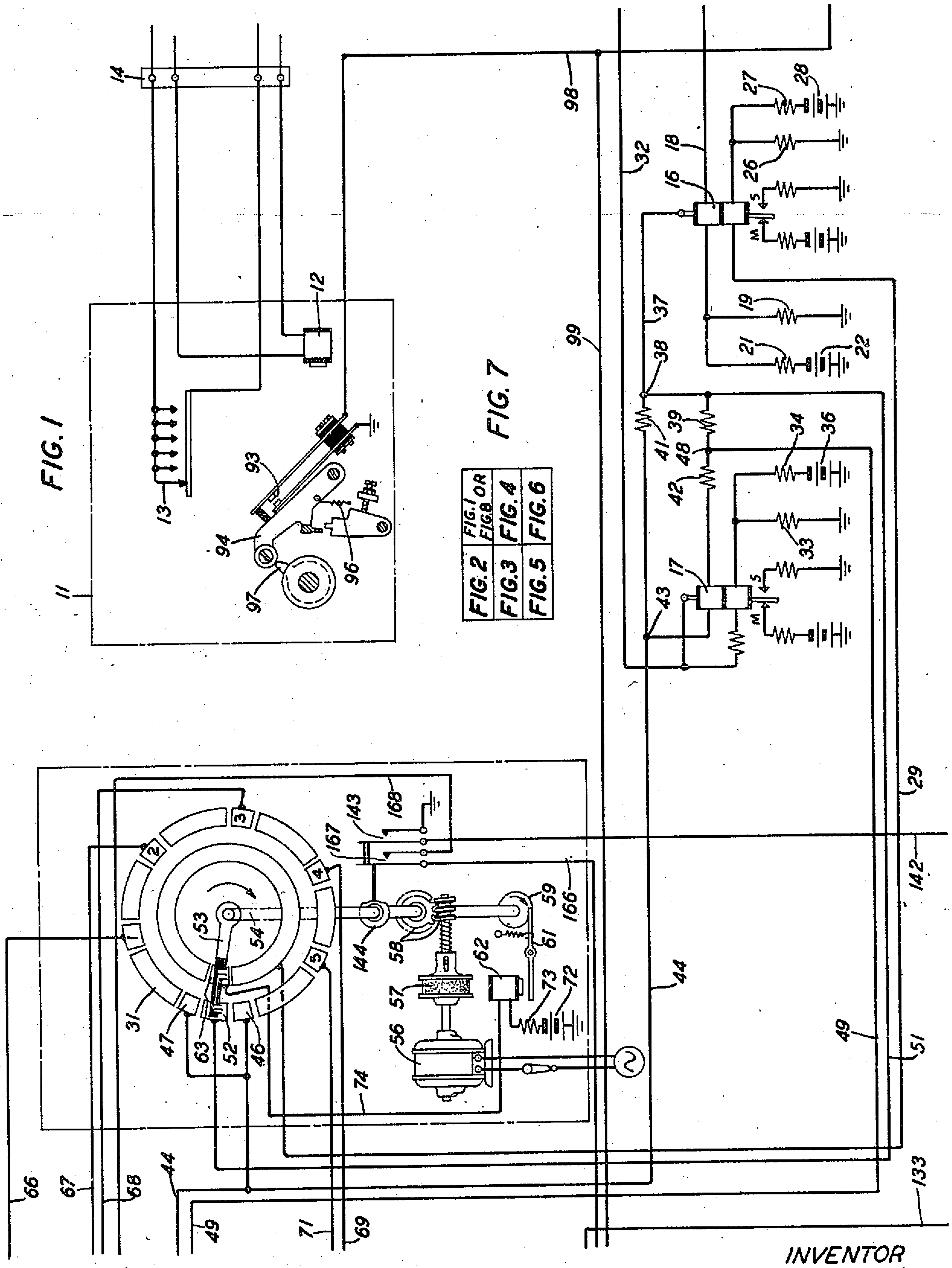
Aug. 13, 1946. J. W. DEHN 2,405,570

CRYPTOGRAPHIC TELEGRAPH SYSTEM

Filed Oct. 12, 1942 7 Sheets-Sheet 1



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CRYPTOGRAPHIC TELEGRAPH SYSTEM

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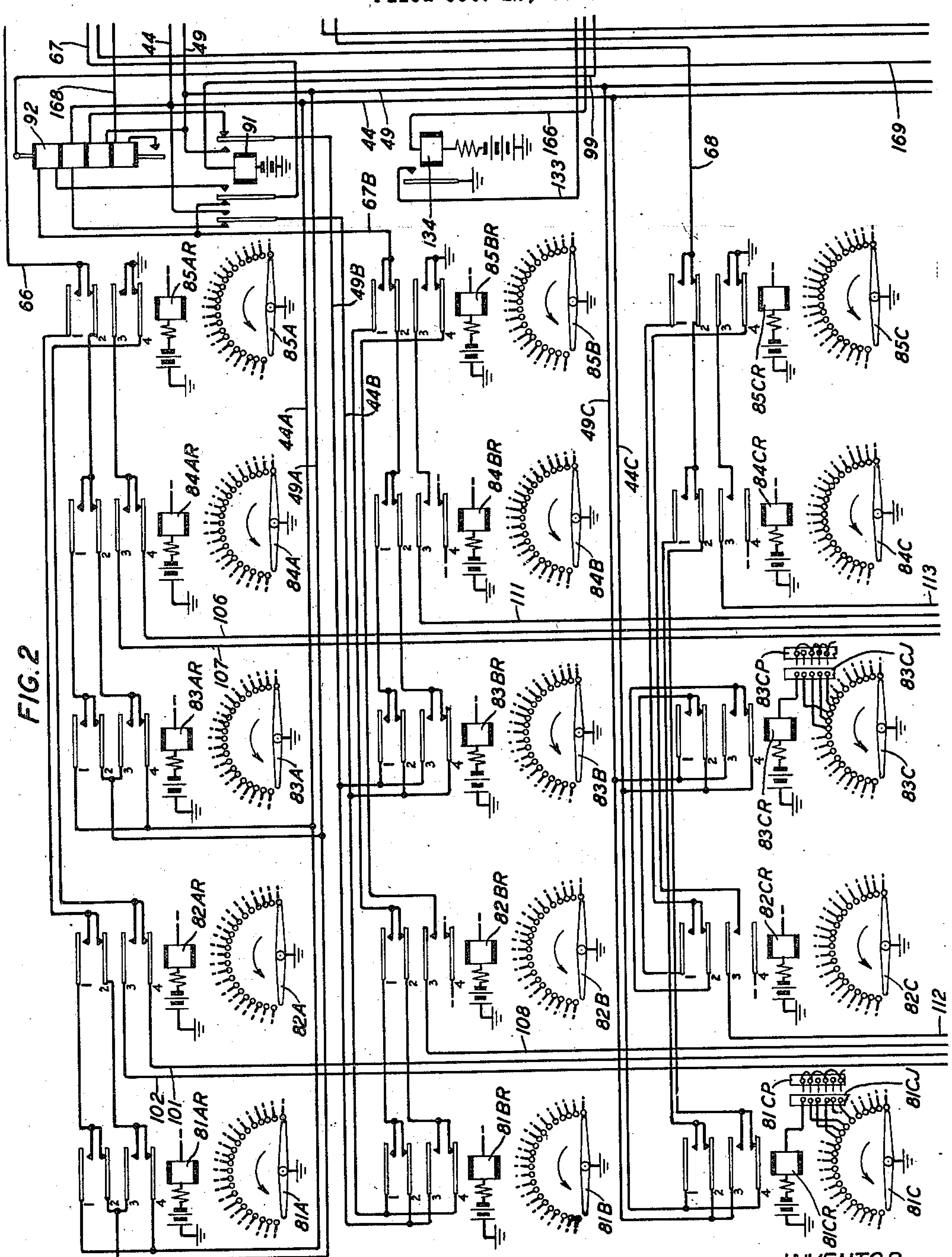

FIG. 2

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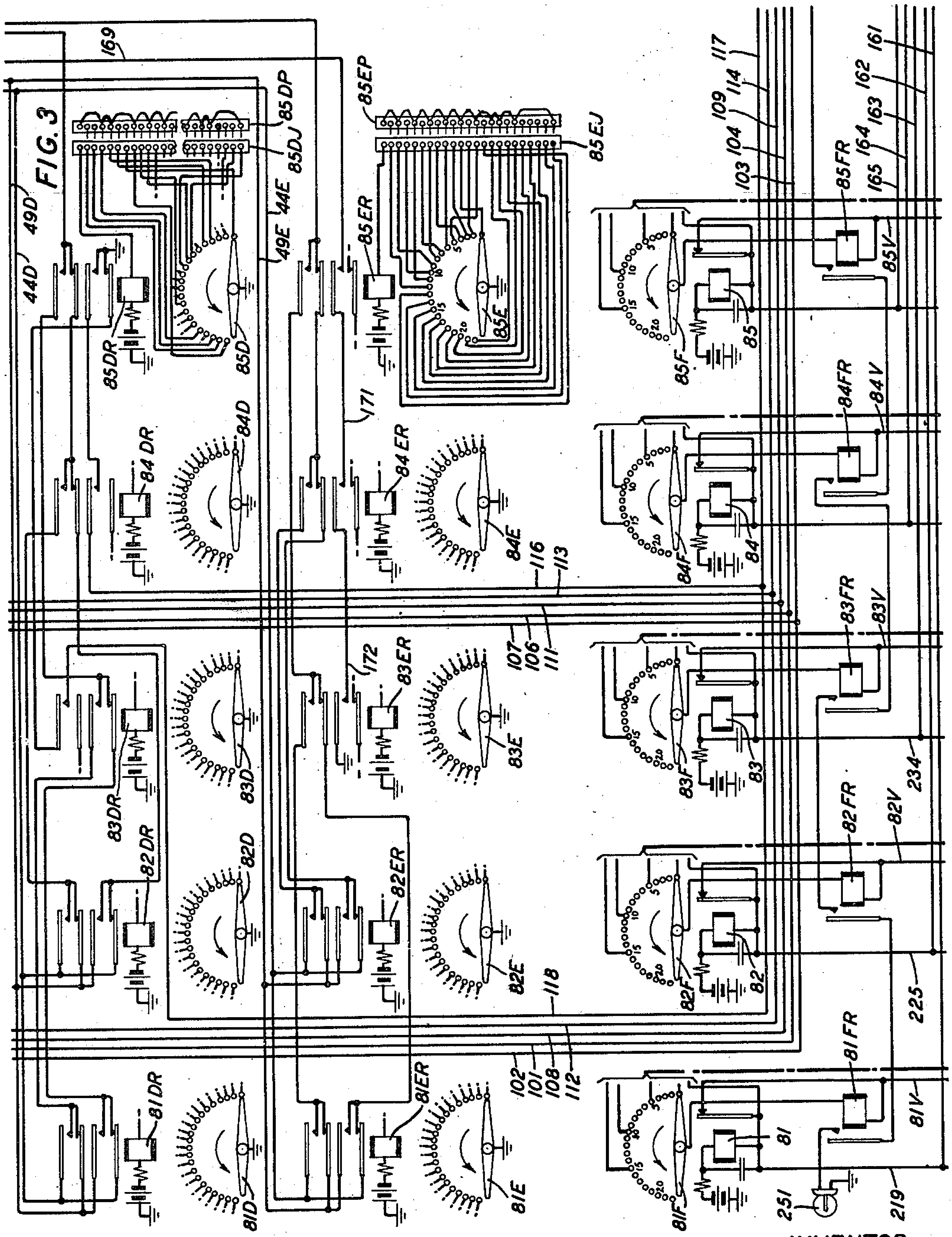

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CRYPTOGRAPHIC TELEGRAPH SYSTEM

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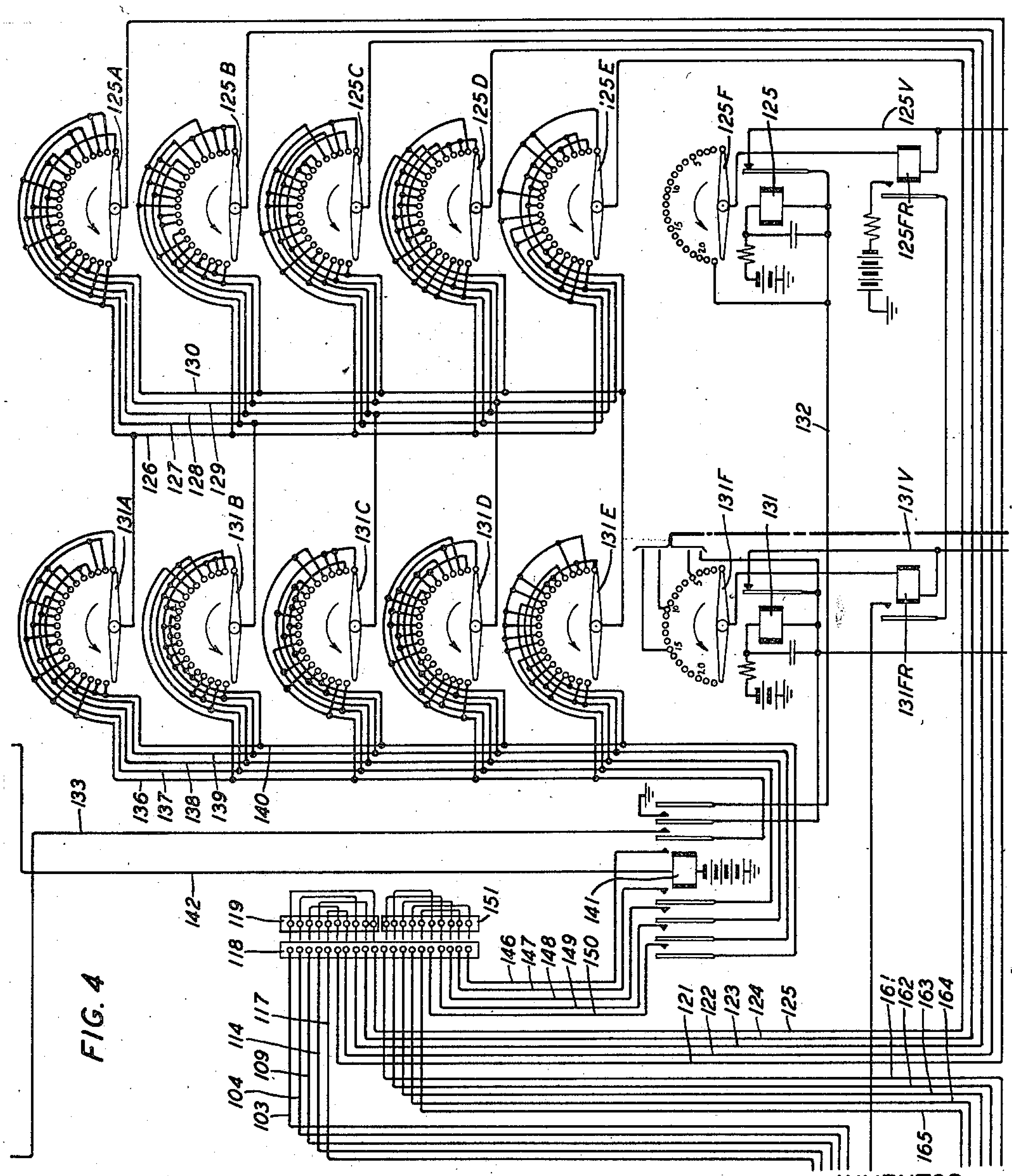

FIG. 4

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CRYPTOGRAPHIC TELEGRAPH SYSTEM

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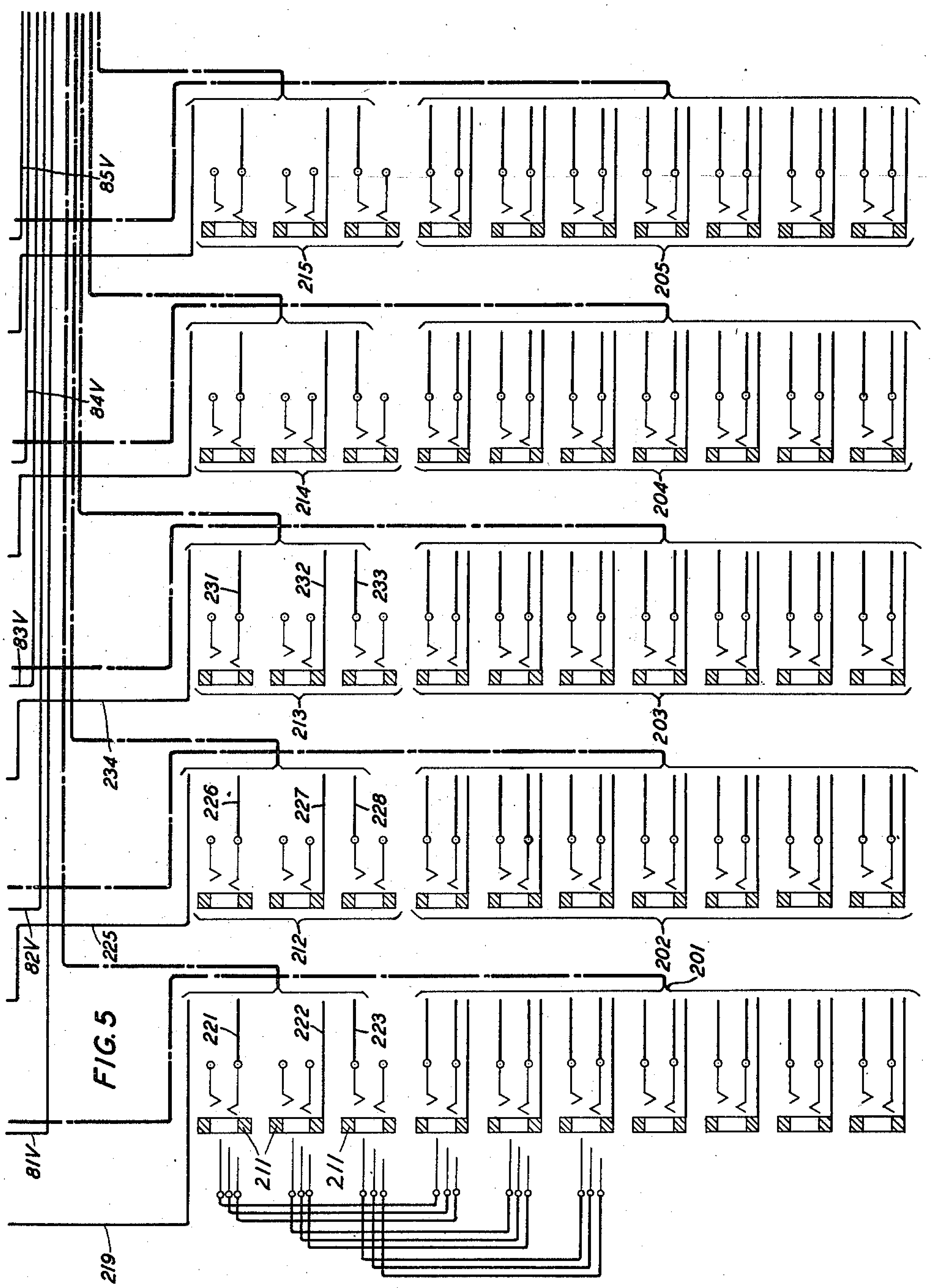

FIG. 5

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CRYPTOGRAPHIC TELEGRAPH SYSTEM

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FIG. 6

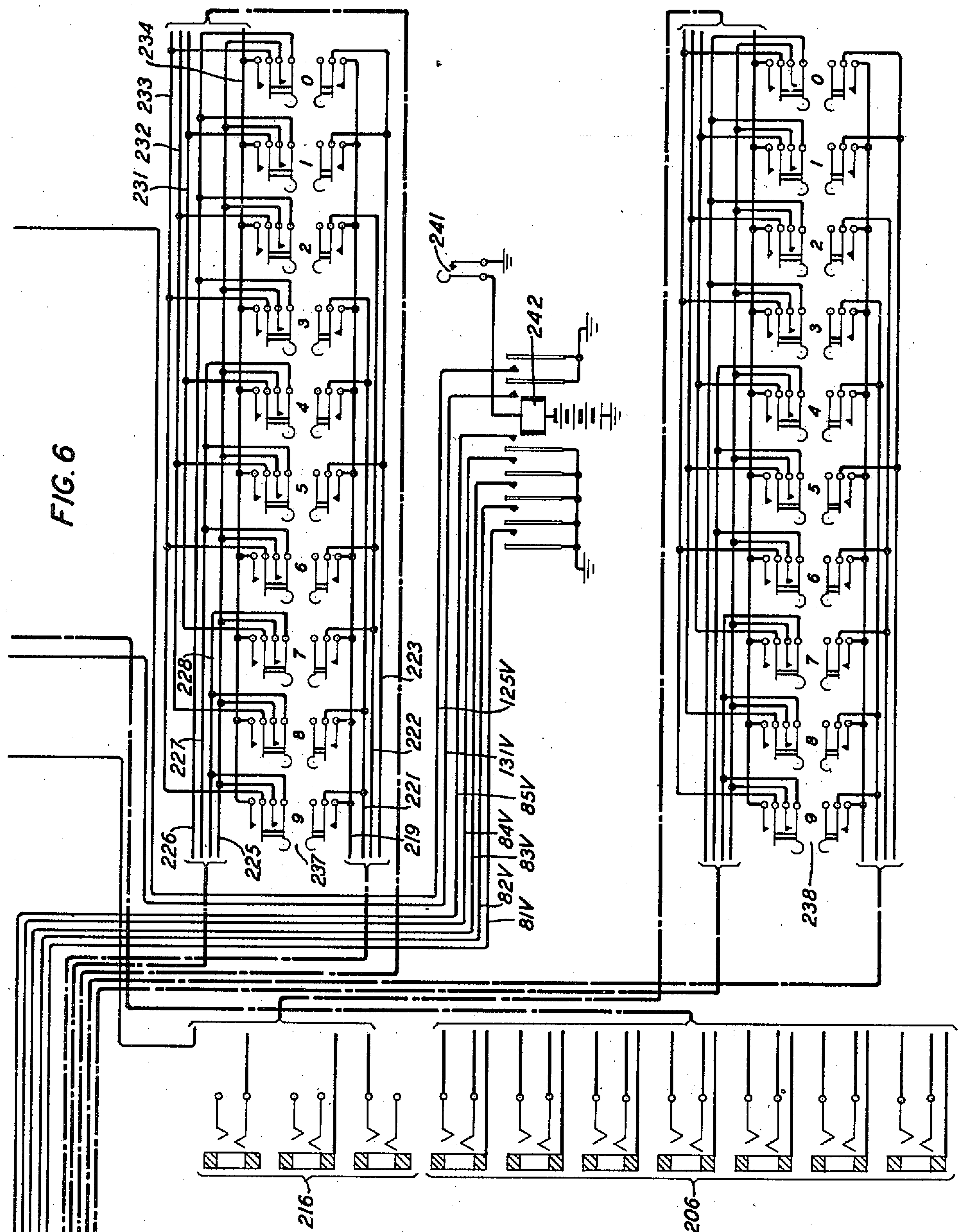

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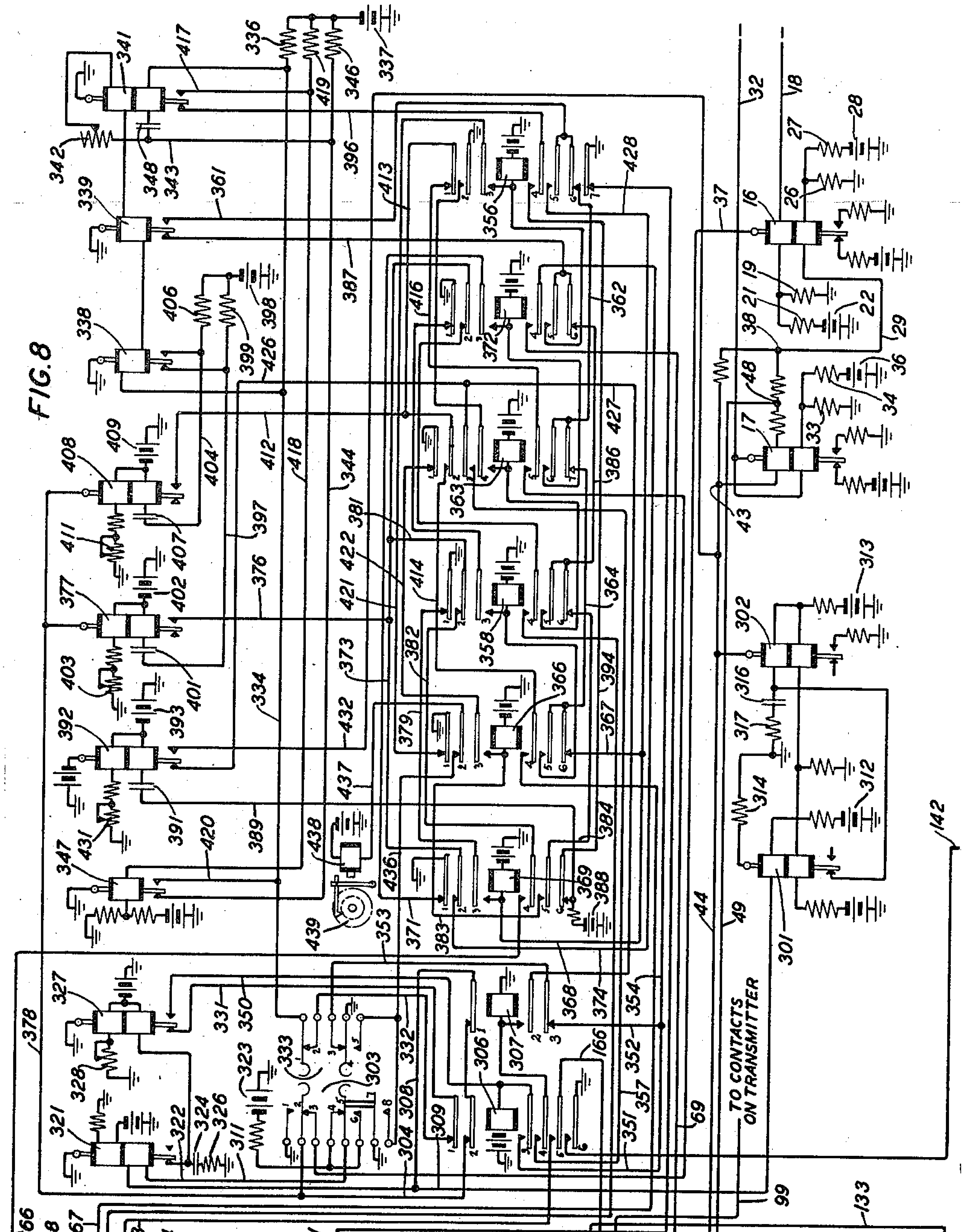
FIG. 8



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Patented Aug. 13, 1946

2,405,570

UNITED STATES PATENT OFFICE

2,405,570

CRYPTOGRAPHIC TELEGRAPH SYSTEM

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Application October 12, 1942, Serial No. 461,731

34 Claims. (Cl. 178—22)

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This invention relates to cryptographic telegraph systems and methods and particularly to apparatus for generating cipher codes to be used in ciphering text codes to be transmitted and in deciphering received codes to derive message text codes therefrom.

An object of the invention is to generate a random sequence of codes for ciphering and deciphering transmitted and received code signals.

Another object of the invention is to determine the character of each impulse of a cipher code combination in accordance with the operation of a plurality of selectively operable instrumentalities.

Another object of the invention is to control the operation of the selectively operable instrumentalities from multiple bank switching devices.

Another object of the invention is to control the operation of the switching devices from certain of the selectively operable instrumentalities.

Another object of the invention is to provide other switching devices for variously rearranging the operative relation between said certain selectively operable instrumentalities and the switching device operating means.

Another object of the invention is to control the operation of at least one of said other switching devices according to a predetermined characteristic of certain ones of the message text codes.

Another object of the invention is to provide means for quickly and easily rearranging the selective control of the selectively operable instrumentalities by their respective switching devices.

Another object of the invention is to provide means for adjusting the switching devices to any desired position to serve as starting points.

Another object of the invention is to provide a relay distributor for timing the generation of ciphered and deciphered signals.

The invention features a multiple contact jack or socket associated with the contacts of each bank of the multiple bank switching devices in different connective arrangements from each other bank and multiple contact jack or socket, and a plurality of multiple prong plugs having different combinations of prongs interconnected, any such plug being usable in any one of the jacks.

The invention also features a plurality of jacks and patching cords which in cooperation with selectively operable keys establish variable starting points for the switching devices.

In accordance with the preferred embodiment of the invention, an input relay receives plain text signals to be ciphered and transmitted or alternately receives ciphered signals to be deciphered and impressed upon a receiving printer.

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An output relay generates the ciphered signals to be transmitted or alternatively generates the deciphered signals to be recorded. The operating circuit of the output relay, which is polar, is completed from the marking or spacing contacts of the input relay, which have battery connections of opposite polarity, over either of two paths and through the segments of a transmitting distributor or through counting and distributing relays of a relay distributor. The operation of the output relay to its marking or spacing position will be dependent upon which of the two paths is completed to effect the energization of the relay, the paths entering the operating winding from opposite sides of the relay, and which of the two contacts the armature of the input relay engages at the time that the path is completed.

The completion of one or the other of the two paths is determined by a plurality of sets of cipher coding relays, there being a set for each selecting impulse of a permutation code signal combination. The armatures of the cipher coding relays control various chain circuits for completing connections from either of the output relay-operating path conductors to the segments of the distributor or to the counting and distributing relays. Each of the cipher coding relays is controlled from a switch bank which has approximately one half of its contacts connected to the associated relay through a multiple contact jack or socket and associated plug. There is a full set of connections from each switch bank to its jack and the selective extension of paths from about one half of the switch bank contacts to the relay is determined by the electrical interconnection of about half of the prongs of the plugs. Plugs having various arrangements of interconnection of their prongs are employed so that the selective control of the coding relay from its bank may be varied by the substitution of plugs.

The switch banks which control the cipher coding relays comprise multiple bank stepping switches so arranged that each switch has one contact bank assigned to control a relay in each of the sets of cipher coding relays, from which it follows that each of the relays in a set is controlled from a different stepping switch.

In addition to determining which of the two paths will be completed for operation of the output relay, certain of the cipher coding relays also selectively provide ground connections for a number of conductors equal to the number of stepping switches which control the cipher coding relays. These conductors extend to the contact brushes associated with an equal number of contact banks of another stepping switch. The conductive paths to the contact brushes of the last-mentioned stepping switch are completed through a mixing jack with which several different plugs may be employed for varying the connections between the conductors and the brushes. The contacts of the banks of the last-mentioned stepping switch are connected in various combinations to five conductors which extend to the brushes of still another stepping switch. The contacts of the banks of this stepping switch are connected in different combinations to five conductors which extend to the normally released armatures of a timing relay. From the front contacts of the timing relay conductors extend through another mixing jack and plug combination to the stepping magnets of the stepping switches which control the cipher coding relays, so that the operation of the stepping magnets for the stepping switches which control the cipher coding relays will depend upon the selective application of ground to the conductors extending to the brushes of the first transposing stepping switch and the manner in which the two transposing stepping switches transpose the conductive paths to the several stepping magnets.

One of the transposing stepping switches is advanced one step for each signal combination transmitted or received. The advancement of the other transposing stepping switch is dependent upon two factors. One is the preparation of a ground connection for the stepping magnet of the second transposing stepping switch through a chain circuit controlled by certain of the cipher coding relays. The other condition is the appearance of marking as the nature of a particular one of the impulses of the plain text codes. When these two conditions appear concurrently, the second transposing second switch is advanced one step.

The appearance of the marking condition for a particular impulse of the text code signals is detected by a relay which is controlled directly by the input relay in the case of signal transmission, because the plain text codes are impressed directly upon the input relay under those circumstances, and is controlled in accordance with the operation of the output relay in the case of the received signals since the input relay is then responding to ciphered signals and the output relay operates in accordance with the deciphered plain text signals.

Each of the stepping switches which control the cipher coding relays has one more bank of contacts than the number of sets of coding relays and each of the two transposing stepping relays has an extra contact bank. By means of a system of jacks, patching cords and manually operable keys, circuits may be prepared for energizing the stepping magnets of the stepping switches through the contact brush and any contact in the extra bank of contacts. After the circuits have been thus prepared, a manually controlled relay is operated to complete the circuits of the stepping magnets through their interrupter contacts whereby the switches will be advanced by interrupter or buzzer action. When each stepping switch reaches the contact to which a conductive path for energizing the stepping magnet has been extended, the stepping magnet will be held energized over a path in shunt relation to the path through the interrupter contacts whereby the automatic advancement of the stepping switch will be discontinued. When all of the switches have come to rest, the manually controlled relay may be released whereby the energizing circuit for the stepping magnet will be interrupted and the brushes of the stepping switches will be in starting positions as selected in accordance with the positions of the patching cords relative to the jacks and in accordance with the particular manually operable keys which had been operated.

For a complete understanding of the invention reference may be had to the following detailed description to be interpreted in the light of the accompanying drawings wherein:

Figs. 1 to 6, inclusive, are diagrammatic views showing parts of a cryptographic telegraph system in accordance with the present invention;

Fig. 7 is a diagrammatic view showing how Figs. 1 to 6, inclusive, are to be arranged to represent a complete telegraph station capable of ciphering and deciphering telegraph messages; and

Fig. 8 is a diagrammatic view showing an alternative embodiment of the portion of the system shown in Fig. 1.

Fig. 1 is largely similar to Fig. 1 of the patent concurrently granted on copending application, Serial No. 435,178, filed March 18, 1942, by K. E. Fitch et al. Fig. 2 of Fitch et al. discloses a special repeater which cooperates with the apparatus of Fig. 1 of that application and a repeater identical with that shown in Fig. 2 of the copending application is intended to cooperate similarly with Fig. 1 accompanying the present specification. For the purpose of simplifying the present specification and avoiding duplication of disclosure, the drawings accompanying the present specification do not include the repeater, nor does the specification contain detailed description of such repeater. In view of this the disclosure of the copending application and particularly Fig. 2 and the descriptive material pertaining thereto of the copending application is incorporated herein by reference as part of the present specification.

Referring now to the drawings and particularly to Fig. 1 the apparatus contained within the broken line rectangle **11** represents a combined receiving telegraph printer and keyboard transmitter which may be of the type shown in Patent 1,904,164, granted April 18, 1933, to S. Morton et al. The disclosure of the Morton patent is incorporated herein by reference as part of the present specification. In Fig. 1 the printer is indicated symbolically by the selector magnet **12** and the keyboard transmitter for transmitting start-stop permutation code signals is represented by the transmitting contacts **13**. The selector magnet **12** is connected to the sleeve terminals of a double plug **14** and the transmitting contacts **13** are connected to the tip terminals of the double plug **14**. The double plug **14** is adapted to be inserted into either of two pairs of jacks associated with the repeater circuit shown in Fig. 2 of the copending application, depending upon whether it is desired to transmit straight unciphered message text signals or ciphered signals.

A ciphering and deciphering relay system is shown in the lower right-hand portion of Fig. 1 comprising relays **16** and **17**. Relay **16** is adapted to receive signals from the repeater circuit (not shown) and has one terminal of its upper or operating winding connected to conductor **18** which extends into the repeater circuit and the other terminal of the operating winding is connected through resistor 19 to ground and through resistor 21 to the negative terminal of battery 22, the resistors 19 and 21 forming a potential divider. In the repeater, conductor 18 receives negative battery connection in the idle condition which causes current to flow in the operating winding of relay 16 in a direction to hold the armature on the marking contact, which has a negative battery connection. When the repeater receives a spacing signal either from the local transmitting contacts 13, which generate straight text signals, or from a remote station, a ground connection on conductor 18 is substituted for the negative battery connection, which causes current to flow in the opposite direction through the operating winding of relay 16 and drives its armature to spacing which has ground connection. Relay 16 has a holding or locking winding, one terminal of which is connected through resistor 26 to ground and through resistor 27 to negative battery 28, the resistors 26 and 27 comprising a potential divider, and the other terminal of the holding winding of relay 16 is connected over conductor 29 to the collector ring of a cipher code generating distributor 31 which will be described later.

The transmitting relay 17 has its armature connected to a conductor 32 which extends into the repeater, its marking contact connected to negative battery and its spacing contact connected to ground. When the armature of relay 17 is on the marking contact a marking signal is transmitted into the repeater and when the armature of relay 17 moves to the spacing contact a spacing signal is transmitted into the repeater. Relay 17 is operable under the joint control of receiving relay 16 and cipher code generating distributor 31. When relay 16 responds to a plain text code generated by transmitting contacts 13 and causes the operation of relay 17, the signal transmitted by relay 17 is a ciphered signal and is repeated by the repeater into a line extending to a remote station. When relay 16 responds to a ciphered code received from a remote station, the operation of relay 17 in response thereto is to decipher the code and the signal transmitted by relay 17 into the repeater is repeated to the selector magnet 12 of the receiving printer. The armature of relay 17 is also connected to one terminal of the holding or locking winding of that relay, the other terminal of which is connected through resistor 33 to ground and through resistor 34 to negative battery 36. The holding winding thus may be traversed by current in either direction from the marking and spacing contacts of relay 17 and serves to hold the armature in the position to which it is operated by the operating winding until the operating winding, which is paramount to the holding winding operates the armature to the opposite position.

The armature of input relay 16 is connected by conductor 37 to one corner 38 of a triangular bridge network which comprises one side or arm containing resistor 39, a second side or arm containing resistor 41, and a third side or arm containing the operating winding of output relay 17 and resistor 42 in series therewith. From the point of interconnection of the operating winding of relay 17 and resistor 41, designated as the bridge corner 43, conductor 44 extends to the stop segment 46 and to the start segment 47 of distributor 31 and into Fig. 2 where it has various connections as will be described later. From the point of interconnection of resistors 39 and 42, designated as bridge corner 48, conductor 49 extends into Fig. 2 and has various connections in that figure. From the bridge corner 38 conductor 51 extends to the rest segment 52 in the outer ring of distributor 31.

The distributor 31 is somewhat similar to a tape controlled transmitter distributor disclosed in Patent 2,055,567 granted September 29, 1936, to E. F. Watson, and the disclosure of the Watson patent is incorporated herein by reference as part of the present specification. However, the distributor has a considerably different arrangement of signal generating segments and there are no tape-controlled contacts, the segments receiving their potentials from other sources as will be described hereinafter.

The distributor 31 has a brush arm 53 which is carried by a rotatable shaft 54 to which rotation is imparted from motor 56 through friction clutch 57 and gears 58. A stop cam 59 is secured to shaft 54 and is arranged to be arrested by the armature lever 61 of electromagnet 62 when the magnet is deenergized. Upon the energization of magnet 62 the end of armature lever 61 presented toward cam 59 is rocked out of blocking relation to the cam whereby shaft 54 is released for rotation. Brush arm 53 carries two electrically interconnected brushes which bridge outer and inner segmented rings.

The inner ring of the distributor is electrically continuous except for a short conductive segment 63 insulated from the main body of the ring, and the inner brush carried by brush arm 53 is in engagement with the segment 63 when brush arm 53 is held at rest, the outer brush then engaging rest segment 52 which subtends the same angle as the segment 63. The stop segment 46 is traversed by the outer brush of arm 53 just before reaching rest segment 52 and the start segment 47 is traversed by the outer brush immediately after leaving segment 52. The remainder of the outer ring contains five uniformly spaced short conductive segments which correspond to the five code impulses of a permutation code combination and these segments are connected to conductors 66, 67, 68, 69 and 71 which extend into Fig. 2. The inner ring of the distributor, exclusive of the rest segment 63, has one end in registry with the beginning of start segment 47 and the other end in registry with the end of stop segment 46 and thus is arranged to complete conductive paths from the start segment, the five code segments and the stop segment over conductor 29 to the locking winding of input relay 16.

With distributor brush 53 in the rest position the two rest segments 52 and 63 are bridged by the brushes as previously stated and a circuit may be traced from ground on the positive terminal of a battery 72 through the battery, resistor 73, winding of start magnet 62, conductor 74, inner rest segment 63, brushes carried by distributor arm 53, outer rest segment 52, conductors 51 and 37, armature of input relay 16, and marking contact of that relay to negative battery, the positive terminal of which is connected to ground. The negative battery connected to the marking contact of relay 16 opposes the negative battery connected to start magnet 62 so that the magnet is deenergized. When input relay 16 goes to spacing in response to the start impulse of a signal combination received over conductor 18 the opposing negative battery connection on the marking contact of relay 16 is removed from the circuit of start magnet 62 and a ground connection on the spacing contact is substituted so that the magnet becomes energized and retracts armature lever 61 from blocking relation to start cam 59 thus permitting distributor shaft 54 and brush arm 53 to be rotated.

Referring now to Figs. 2 and 3 the apparatus for setting up cipher codes will be described. It may be stated generally that this involves selective determination of the completion of conductive paths over conductors 44 or 49 which extend from the bridge network corners 43 or 48 and thus from the opposite ends of the winding of output relay 17, to the five code segments of distributor 31. In the lower portion of Fig. 3 are shown the stepping magnets 81, 82, 83, 84 and 85 of five stepping switches each of which has six banks of contacts. The contact banks associated with the stepping switch operated by stepping magnet 81 are designated 81A to 81F, inclusive. Similarly, the banks of contacts associated with the stepping switches controlled by the stepping magnets 82 to 85, inclusive, are designated 82A to 85F, inclusive.

Associated with the stepping switch banks 81A to 81E are individual relays 81AR to 81ER. Similarly, the stepping switch banks 82A to 82E have relays 82AR to 82ER, respectively, the switch banks 83A to 83E have the individual relays 83AR to 83ER, the banks 84A to 84E have relays 84AR to 84ER, and the switch banks 85A to 85E have the relays 85AR to 85ER. The switch banks bearing designations A to E, inclusive, include uniform numbers of contacts, such as 22, and the brush associated with each of these banks is connected to ground. The association of a relay with its switch bank is shown in full detail in the case of bank 85E and relay 85ER in Fig. 3. The twenty-two contacts of switch bank 85E are connected to individual single contact spring jack elements of a multiple jack 85EJ which has a minimum of twenty-three individual jack spring elements. Successive contacts of bank 85E are not connected to successive jack spring elements of the multiple jack 85EJ but are scrambled or connected in purely random fashion. The uppermost jack spring element of jack 85EJ is connected to one terminal of relay 85ER the other terminal of which is connected to grounded battery. There is provided for cooperation with jack 85EJ a multiple plug 85EP having a minimum of twenty-three independent contact prongs. The uppermost prong is connected by conductive straps to about one half of the other twenty-two prongs, selected at random. With the plug 85EP inserted into jack 85EJ, when the brush associated with switch bank 85E comes into engagement with contacts of the bank from which conductive paths extend through springs of jack 85EJ to prongs of plug 85EP that are connected to the uppermost prong, the circuit of relay 85ER will be completed and the relay will be energized. With the specific arrangement of connections between switch bank 85E and jack 85EJ, and with the specific strapping of prongs of plug 85EP to the uppermost prong the circuit of relay 85ER will be completed when the stepping switch brush engages the first, fifth, sixth, eighth, ninth, eleventh, fourteenth, twentieth, twenty-first and twenty-second contacts of the bank.

Fragments of other multiple jack and multiple plug arrangements are indicated 85DJ and 85DP, respectively, in Fig. 3 and in Fig. 2 in association with switch bank 81C by the reference numerals 81CJ and 81CP, respectively, and in association

with the switch bank 83C by the reference numerals 83CJ and 83CP, respectively. Each of the twenty-five stepping switch banks which controls a relay has a set of connections from its twenty-two contacts to twenty-two jack springs of its multiple jack which differs from the arrangement of connections between the remaining twenty-four switch banks and their multiple jacks, and each of the multiple plugs of which there is a minimum of twenty-five has a different combination of strappings from the uppermost prong to about one half of the remaining twenty-two prongs of the plug. Any one of the plugs may be used in any one of the jacks to establish selectively variable paths for the energization of the relays. The multiple plugs, the number of which may considerably exceed twenty-five, because a large number of different strapping combinations may be made, may be marked with distinctive identifying symbols so that they may be placed in conductive association with the multiple jacks in predetermined arrangement according to charts or other instructions.

Each of the relays controlled by the stepping switch bank has a sufficient number of armatures and contacts to provide two normal paths and two off-normal paths, the normal paths being those that are established through back contacts and the off-normal paths being those that are established through front contacts. In the majority of instances this could be accomplished by providing relays having two armatures each operable between a back contact and a front contact. However, in Figs. 2 and 3 the relays have been shown as being provided with four armatures two of which cooperate only with a back contact and the other two of which cooperate only with a front contact. In some instances only one back contact is used and, accordingly, one of the armatures is not used. However, in systems of this type it is desirable to use similar relays throughout where they perform similar functions even though some of the armatures and contacts may not actually be used. The reason for this is that it may be desirable to rearrange some of the permanent connections from time to time and if all of the relays have full complements of armatures and contacts the rewiring may be done without the necessity of removing and substituting relays.

As previously stated the conductors 44 and 49 connected to the opposite ends of the winding of output relay 17 extend into Fig. 2. In branching relation to conductors 44 and 49 the conductors 44A and 49A extend to armatures of relays 81AR and 83AR. Conductor 44A is connected to armatures 1 and 4 of both relays, which have off-normal and normal relation respectively to their contacts. Conductor 49A extends to the armatures 2 and 3 of both relays 81AR and 83AR. Of these armatures the armature 2 has normal relation to its contact and the armature 3 has off-normal relation to its contact. The contacts of the armatures 1 and 2 of relay 81AR are connected to the armature 1 of relay 82AR. The contacts of the armatures 3 and 4 of relay 81AR are connected to the armature 2 of relay 82AR. The contacts associated with the armatures 1 and 2 of relay 82AR are connected to the armature 1 of relay 85AR. The contacts associated with the armatures 1 and 2 of relay 83AR are connected to the armature 1 of relay 84AR and the two contacts associated with the armatures 3 and 4 of relay 83AR are connected to the armature 2 of relay 84AR. The two contacts associated with the armatures 1 and 2 of relay 84AR are connected to the armature 2 of relay 85AR. The contacts associated with the armatures 1 and 2 of relay 85AR are connected over conductor 66 to the No. 1 code segment of distributor 31.

With relay armature and contact connections as described above, there are two chain circuits, one comprising the armatures and contacts of relay 81AR and the upper two armatures and contacts of relay 82AR and the other comprising the armatures and contacts of relay 83AR and the upper two armatures and contacts of the relay 84AR, these two chains leading into the upper two armatures of relay 85AR. Conductors 44A and 49A enter both of these chain circuits. When relay 85AR is deenergized the chain circuit comprising relays 83AR and 84AR will be effective to control connections from conductors 44A and 49A to conductor 66. With both of the relays 83AR and 84AR energized or both deenergized, conductor 44A will be connected to conductor 66. With either of these relays energized and the other deenergized conductor 49A will be connected to conductor 66. When relay 85AR is energized the chain circuit controlled by relays 81AR and 82AR will be effective. With both of these relays energized or both deenergized, conductor 44A will be connected to conductor 66 and with either of these relays energized and the other deenergized, conductor 49A will be connected to conductor 66. As the five relays are selectively operated singly or in combinations, they cooperate in sets of three, namely, 81AR, 82AR and 85AR, or 83AR, 84AR and 85AR to determine which of the two conductors 44A and 49A shall be connected to conductor 66. The chain circuits are so arranged that it is not possible for both of the conductors 44A and 49A to be connected to conductor 66 simultaneously.

The relays 81BR, 82BR, 83BR, 84BR and 85BR control chain circuits identical with those controlled by the relays 81AR to 85AR. It is not necessary that these two chain circuit systems be the same, as there are many ways in which the chain circuits may be arranged, and other sets of relays controlled by the stepping switches control different arrangements of chain circuits, as will be described later. The conductors entering the two chain circuits at the armatures of relays 81BR and 83BR have been designated by the reference numerals 44B and 49B. The conductors 44B and 49B do not connect directly to conductors 44 and 49, respectively, as do the conductors 44A and 49A, respectively, but connect instead to the outer left-hand armature and to the right-hand armature, respectively, of a relay 91. The back contact of the outer left-hand armature of relay 91 is connected through the second winding, counting from the top, of a relay 92 to conductor 44. Similarly, the back contact of the right-hand armature of relay 91 is connected through the third winding of relay 92 to conductor 49. The front contact of the outer left-hand armature of relay 91 is connected directly to conductor 44 and the front contact of the right-hand armature of relay 91 is connected directly to conductor 49. Thus when relay 91 is deenergized conductors 44 and 44B are interconnected through a winding of relay 92 and conductors 49 and 49B are interconnected through another winding of relay 92 whereas when relay 91 is energized conductors 44 and 44B are interconnected directly and conductors 49 and 49B are interconnected directly, the two windings of relay 92 being open.

Conductor 67B extending from the contacts of the armatures 1 and 2 of relay 85BR extends to the back contact of the inner left-hand armature of relay 91 and to one terminal of the uppermost winding of relay 92, the other terminal of which is connected to the front contact associated with the same armature. The armature is connected to conductor 67 which extends to the No. 2 code segment of distributor 31. When relay 91 is deenergized, conductors 67 and 67B are interconnected directly and the circuit of the uppermost winding of relay 92 is open. When relay 91 is energized, conductors 67 and 67B are interconnected through the uppermost winding of relay 92.

The operation of relay 91 is controlled by contacts 93 shown in Fig. 1. Contacts 93 are normally open but are closed by the operation of a locking bail arm 94 which is rocked in counterclockwise direction by a spring 96 under the control of a cam 97 associated with the cam assembly which controls the operation of transmitting contact 13. Cam 97 is shown in the rest position and is rotated one revolution for each code combination generated by transmitting contacts 13. This feature is more fully disclosed in Patent 2,018,368 granted October 22, 1935, to R. A. Lake and particularly in Fig. 5 of that patent. The disclosure of the Lake patent is incorporated herein by reference as part of the present specification. One of the contacts 93 is connected to ground and from the other contact a conductor 98 extends into the repeater circuit (not shown) for effecting a control fully disclosed in the copending application. A branching conductor 99 extends from conductor 98 to one terminal of relay 91 (Fig. 2) the other terminal of which is connected to grounded battery of the same polarity as the battery connected to conductor 98 in the repeater circuit, so that when contacts 93 are closed, relay 91 will be energized and when contacts 93 are open no energizing circuit for relay 91 will be completed through conductor 98 into the repeater circuit. From the foregoing it will be apparent that relay 91 will be energized only during the transmission of signals generated by transmitting contacts 13. When signals are being received from a distant station over conductor 18 the local transmitter will not be operated, contacts 93 will remain open and relay 91 will remain released.

Before proceeding with the description of further features and elements of the apparatus, the operation of the apparatus heretofore described in ciphering signals to be transmitted to a distant station and in deciphering signals received from a distant station, will be described. The ciphering of a signal to be transmitted will first be considered. Upon the operation of transmitting contacts 13 to transmit a signal, the first impulse is the start signal which is of spacing nature and this causes the relay 16 to go to spacing, thus completing the energizing circuit for start magnet 62 over a circuit previously traced. The start magnet permits brush arm 53 to be driven and the brushes first encounter start segment 47. This segment is connected to conductor 44 so that conductor 44 becomes connected to conductor 29 through the brushes of the distributor while the outer brush is traversing the start segment 47. Conductor 49 has no direct connection to any segment of the distributor 31 but extends directly to the cipher coding relay system in Figs. 2 and 3, the return leads of which are to the code segments of the distributor, so that no circuits can be completed over conductor 49 while the brushes are traversing the start segment. Accordingly, a circuit is traced from ground on the spacing contact of relay 16 through the armature of the relay and conductor 37 to the bridge corner 38. At this point the conductive path divides, part of the current flowing over resistor 41 to the bridge corner 43 and the remainder flowing through resistors 39, 42 and operating winding of relay 17 from right to left to the bridge corner 43. The path reunites at the bridge corner 43 and continues over conductor 44 to the start segment 47 then to the inner ring of the distributor, conductor 29, locking winding of relay 16 and the resistor 27 through battery 28 to ground. Output relay 17 is polar and with ground on the armature of relay 16 and the circuit of the operating winding of relay 17 extended over conductor 44, current flows through the operating winding of relay 17 in the direction to drive the armature of that relay to spacing. The current through the locking winding of relay 16 is in the direction to hold relay 16 in the spacing condition even though the start impulse of spacing nature received over conductor 18 should cease and a marking impulse should be substituted before the brushes have left start segment 47. From this it follows that the locking winding of relay 16 is paramount to the operating winding. With relay 17 in the spacing condition a spacing impulse is transmitted over conductor 32 to the repeater, wherein it is repeated to the line extending to the distant station, and current is supplied from the spacing contact of relay 17 through the locking winding of that relay in the direction to hold the relay in the spacing condition. As soon as the brushes leave the start segment 47 the circuit through the operating winding of output relay 17 and through the locking winding of input relay 16 is interrupted but the circuit through the locking winding of relay 17 remains. Relay 16 is now free to be operated in response to the first code impulse of the signal but the locking winding of relay 17 assures that the start signal shall endure until a circuit through the operating winding of relay 17 is again completed, which cannot occur until the brushes reach the No. 1 code segment of the distributor. The operating winding of relay 17 is paramount to the locking winding and can move the armature of the relay whenever the operating winding becomes energized, although the locking winding is seeking to hold the armature in the position to which it had last been moved.

Assume that the first code impulse of the signal generated by contacts 13 is of marking nature, as a result of which a marking signal will be received by relay 16 over conductor 18 and the armature will be restored to the marking position. Assume also that the relays 81AR to 85AR are energized in such combination that a conductive path will be extended over conductors 44 and 44A to conductor 66. For this condition there are four possibilities. If relay 85AR is deenergized the connection will be established with both of the relays 83AR and 84AR also deenergized or with both of the relays 83AR and 84AR energized, the relays 81AR and 82AR having no effect. If, on the other hand the relay 85AR is energized, the connection will be established with both of the relays 81AR and 82AR also energized or with the relays 81AR and 82AR both deenergized, the relays 83AR and 84AR having no effect. The circuit is traced from ground through the battery on the marking contact of relay 16 through the armature of that relay, conductor 37 through the branching paths of the bridge network including the operating winding of relay 17 then through conductors 44 and 44A, armatures and contacts of relays 81AR to 85AR, conductor 66, the No. 1 contact of distributor 31, the brushes and inner ring of that distributor, conductor 29, locking winding of relay 16 and resistor 26 to ground. Except for the addition of conductor 44A, contacts and armatures of relays 81AR to 85AR and conductor 66, this is the same path that was traced in connection with the transmission of the start signal. However, the polarities have been reversed because the armature of relay 16 now receives battery connection instead of ground connection. The reversal of polarity on the bridge network and through the operating winding of relay 17 causes the armature of that relay to be moved to its marking contact to effect the transmission of a marking signal over conductor 32 and to complete a circuit from the marking contact through the locking winding of relay 17 to hold the armature on the marking contact. If the first impulse of the code combination had been spacing the polarity applied to the bridge circuit network would have been the same as that applied in response to the start signal and with the circuit completed to conductor 29 over conductor 44, the armature of relay 17 would have remained on the spacing contact.

Assume now that the No. 1 impulse of the code combination is marking, which was the condition originally assumed, but that the relays 81AR to 85AR are energized in such combination that they complete a conductive path to conductor 66 over conductor 49A from conductor 49. There are four conditions of the relays under which this can occur. If relay 85AR is deenergized the connection will be made if either of the relays 83AR or 84AR is energized and the other is deenergized, the relays 81AR and 82AR having no effect. On the other hand, if the relay 85AR is energized, the circuit will be completed if either of the relays 81AR or 82AR is energized and the other is deenergized, the relays 83AR and 84AR having no effect. The circuit is traced from ground through the battery on the marking contact of relay 16 through the armature and conductor 37 to the bridge corner 38. The current now divides in a different manner, one path being traced through resistor 39 to bridge corner 48 and the other being traced through resistor 41, operating winding of relay 17 from left to right and resistor 42 to bridge corner 48. From this point the circuit continues over conductors 49 and 49A, the armatures and contacts of relays 81AR to 85AR, conductor 66, the No. 1 code segment, brushes and inner ring of distributor 31, conductor 29, locking winding of relay 16 and resistor 26 to ground. With the circuit completed from bridge corner 48 instead of bridge corner 43 the current through the operating winding of relay 17 is in the reverse of the direction in which it flowed when with the armature of relay 16 on the marking contact the circuit was completed through conductor 44, so that the armature of relay 17 is driven to the spacing contact to transmit a spacing signal over conductor 32 and the current through the locking winding of relay 17 holds the armature on the spacing contact. There has been no reversal of the direction of current through the locking winding of relay 16 so that its armature remains on the marking contact. If instead of being of marking nature the first code impulse generated by transmitting contacts 13 had been of spacing nature, with the path to the locking winding of relay 16 extended over conductor 49 as just described there would have been a reversal of the polarity on the operating winding of relay 17 which over the same conductive path would have caused the armature of the relay to assume the marking position.

By way of recapitulation there are four possible conditions of signal transmission. When relay 16 responds to a spacing signal and the circuit is completed over conductor 44 a spacing signal will be transmitted over conductor 32. When relay 16 responds to a marking signal and the circuit is completed over conductor 49, a spacing signal will be transmitted over conductor 32. When relay 16 responds to a spacing signal and the circuit is completed over conductor 49 relay 17 will be operated to marking to cause the transmission of a marking signal over conductor 32. When relay 16 responds to a marking signal and the circuit is extended over conductor 44, relay 17 will be operated to marking and a marking signal will be transmitted over conductor 32. The further summarizing statement may be made that relay 17 operates in correspondence with relay 16 when the circuit is completed over conductor 44, and operates in reverse relation to relay 16 when the circuit is completed over conductor 49.

After the brushes have traversed the five code segments and the ciphered impulses have been transmitted, the brushes traverse the stop segment 46. At this time the relay 16 receives the stop pulse, of marking nature, generated by contacts 13. The circuit is completed from the marking contact of relay 16 through the bridge network including the operating winding of relay 17, over conductor 44, stop segment 46, inner ring of the distributor, and conductor 29 to the locking winding of relay 16. This corresponds to the fourth condition recited in the preceding paragraph of recapitulation and relay 17 will be operated to the marking condition to transmit a marking signal, which is the true stop impulse.

It is to be noted that the cipher coding relays 81AR to 85ER in Figs. 2 and 3 have no effect upon the transmission of the start and stop signals. The circuit through the operating winding of relay 17 is completed through conductor 44 in both cases, but relay 16 is spacing for the start signal and marking for the stop signal, and relay 17 is correspondingly driven spacing for the start signal and marking for the stop signal.

After the brushes leave the stop segment they encounter the rest segments and are arrested, since the start magnet 62 was released when the brushes left the rest segment and presumably the relay 16 will still be responding to the stop signal when the brushes reach the rest segments, so that the start magnet will remain released. When the relay 16 responds to the start signal of the next code combination, magnet 62 will again be energized and will release the shaft 54 for another cycle of rotation.

There will now be described the operation of deciphering received code combinations. The code combinations are transmitted from a distant station having ciphering apparatus of the same type as that disclosed in the drawings accompanying the present specification and it is a characteristic of the system that when ciphered messages are being transmitted identical arrangements of connections between the cipher coding relays and the stepping switch banks are established at both stations and the brushes of the stepping switches are adjusted to the same starting points and are advanced together by local control individual to the stations, so that the cipher coding relays at the receiving station establish the same connections from the conductors 44 and 49 to the distributor code segments as are established at the transmitting station. It has been shown that the cipher coding relays have no effect upon the output relay 17 when the input relay 16 responds to the start signal of spacing nature and therefore that the output relay follows the input relay to spacing condition. When the start signal of spacing nature is received from the distant station it is repeated by the repeater to the input relay 16 which completes a circuit over conductor 44 and the start segment of the receiving distributor, which was released for rotation when the start signal was received, to the locking winding of input relay 16 and the output relay 17 goes to spacing.

The first message code impulse was previously assumed to be of marking nature with the cipher code circuit established over conductor 44 and it was found that the output relay transmitted a marking signal. Accordingly, the input relay of a receiving station would go to marking condition and would complete a circuit over conductor 44 identical with that which was described when the first impulse of text code was assumed to be marking. The polarity on this circuit is such that the output relay 17 is operated to the marking condition and impresses a marking signal on conductor 32 which is repeated to the selector magnet 12. In this way the original text marking signal, which was treated in such a way by the cipher code relays that it was transmitted unchanged as a marking signal, is received and similarly treated through an identical arrangement of the cipher code relays and is repeated unchanged as a marking signal which is used to control the receiving printer. Corresponding deciphering operations occur with reference to the other three possible conditions. Thus with a text code impulse of spacing nature controlling output relay 17 over conductor 44 and causing the relay to transmit a spacing signal, the received spacing signal, controlling relay 17 over conductor 44 causes the output relay 17 to generate a spacing signal which is repeated to the printer magnet 12. A text code marking impulse, controlling the output relay 17 over conductor 49 to cause the relay to transmit a spacing signal, is received in cipher as a spacing signal which, controlling output relay 17 over conductor 49 causes the relay to generate a marking signal which is repeated to the selector magnet 12. Finally a text code signal of spacing nature controlling the output relay 17 over conductor 49 to cause the relay to transmit a marking signal is received as a marking signal by the input relay 16 and, controlling output relay 17 over conductor 49, causes the relay to generate a spacing signal which is repeated to the selector magnet 12. From this it will be apparent that the deciphering of received signals in order to derive the plain text codes therefrom is accomplished by ciphering received codes under the same conditions that were employed at the transmitting station to convert the text code signals into ciphered signals.

Reference has been made previously to the fact that the chain circuit arrangements of armatures and contacts of the cipher coding relays may differ from the arrangement of the contacts and armatures of relays 81AR to 85AR and of the relays 81BR to 85BR. The relays 81CR to 85CR show a different arrangement. The conductors 44C and 49C which enter the chain circuit of these relays connect directly to the conductors 44 and 49, which is comparable with the arrangement of the conductors 44A and 49A, but differs from the arrangement of conductors 44B and 49B. Conductors 44C and 49C enter the chain circuit at the armatures 1 and 4, 2 and 3, respectively, of relay 81CR from the contacts of which conductors extend to armatures 1 and 2 of relay 84CR from the contacts of which a conductor extends to the armature 2 of relay 85CR and the contacts associated with this armature and also the armature 1 are connected to conductor 68 which extends to the No. 3 segment of distributor 31. Thus one of the chains includes armatures and contacts of relays 81CR, 84CR and 85CR in that order from conductors 44C and 49C to conductor 68. Conductors 44C and 49C also enter another chain at the armatures 2 and 4, 1 and 3, respectively, of relay 83CR and from the contacts of those relays conductors extend to armatures 1 and 2 of the relay 82CR from the contacts of which a conductor extends to armature 1 of relay 85CR. Thus this chain consists of armatures and contacts of relays 83CR, 82CR and 85CR in that order from conductors 44C and 49C to conductor 68. In connection with the chain circuits established by each of the first two sets of relays, namely, 81AR to 85AR and 81BR to 85BR, it was noted that when both of the first two relays of any one of the chains were energized or were deenergized the connection was from conductor 44 to the distributor code segment conductor, and that when either of the first two relays of any chain is energized and the other is deenergized the connection is from conductor 49 to the distributor code segment conductor. This arrangement is also true of the chain comprising armatures and contacts of relays 81CR, 84CR and 85CR but is not true of the chain comprising armatures and contacts of relays 83CR, 82CR and 85CR. In the latter chain the connection from conductor 44 to conductor 68 is established only when relay 83CR is deenergized, with relay 82CR either energized or deenergized and is established from conductor 49 to conductor 68 only when relay 83CR is energized with relay 82CR either energized or deenergized. The relays 81DR to 85DR and 81ER to 85ER provide still other arrangements of chain circuits for establishing connections between both of the conductors 44 and 49 and the distributor code segment conductors 69 and 71. These will not be described in detail except to identify the conductors 44D and 49D which enter the chains provided by the relays 81DR to 85DR and the conductors 44E and 49E which enter the chain circuit provided by the relays 81ER to 85ER.

Referring again to the relays 81AR to 85AR, it will be noted that the contacts associated with the armatures 3 and 4 of relay 85AR are connected to ground. The armature 4 is connected to the contacts associated with armatures 3 and 4 of relay 82AR. The armature 3 of relay 85AR is connected to the contacts associated with the armatures 3 and 4 of relay 84AR. The armatures 4 and 3 of relay 82AR are connected to conductors 101 and 102, respectively, which extend into Fig. 3 and connect with conductors 103 and 104. Conductors 106 and 107 extend from the armatures 4 and 3, respectively, of relay 84AR into Fig. 3 and connect with the same conductors 103 and 104. With relay 85AR deenergized ground will be connected through conductor 101 to conductor 103 when relay 82AR is also deenergized and will be connected through conductor 102 to conductor 104 when relay 82AR is energized. With relay 85AR energized ground will be connected through conductor 106 to conductor 103 when relay 84AR is deenergized and will be connected over conductor 106 to conductor 104 when relay 84AR is energized.

The contacts associated with the armatures 3 and 4 of relay 85BR are connected to ground and conductors extend from these armatures to the front contact associated with armature 3 of relay 84BR and to the front contact associated with armature 3 of relay 82BR, respectively. From armature 3 of relay 82BR, conductor 108 extends into Fig. 3 and connects with a conductor 109. From armature 3 of relay 84BR conductor 111 extends into Fig. 3 and connects with the conductor 109. By means of a similar arrangement ground may be supplied through either of the armatures 3 and 4 of relay 85CR and through an armature of relay 84CR or an armature of relay 82AR to conductors 112 and 113 which extend into Fig. 3 and connect with a conductor 114. Similarly ground may be supplied from the armatures 3 and 4 of relay 85DR through a front contact and armature of relay 84DR to conductor 116 which connects to conductor 117 and through the outermost armature and front contact of relay 83DR to conductor 118 which also connects to conductor 117.

Conductors 103, 104, 109, 114 and 117 extend into Fig. 4 and connect to the uppermost five single circuit jack spring elements of a multiple jack 118 which has twenty such single circuit jack spring elements. The uppermost ten of the jack elements of multiple jack 118 are arranged to receive the ten single circuit prongs of a multiple plug 119 which has each of the prongs of the uppermost five prongs connected to one of the prongs in the lowermost group of five. Several of the plugs 119 having different arrangements of interconnection between the upper and lower groups of five prongs may be employed for varying the connections extended from conductors 103, 104, 109, 114 and 117 to the second group of five jack spring elements of multiple jack 118. The jack spring elements of the second group of five counting from the top are connected by conductors 121, 122, 123, 124 and 125 to the brushes associated with contact banks 125A to 125E of a stepping switch which is operated by stepping magnet 125. The stepping switch has a sixth bank designated 125F. The stepping switch comprising contact banks 125A to 125F may be of the same type as the stepping switches shown in Figs. 2 and 3, the contact banks consisting of twenty-two contacts. Each contact of each of the contact banks 125A to 125E is connected to one of five conductors designated 126, 127, 128, 129 and 130. The arrangement of connections from the contacts to the five conductors is different for each contact bank and it is not necessary for each bank to have the same number of contacts connected to any one conductor and in fact it will be found by reference to Fig. 4 that the number of connections from any one bank to any one of the five conductors varies from one bank to another. However, it is preferable that the distribution of connections of contacts to the five conductors be equal from which it will follow that each conductor will be connected to twenty-two contacts.

Conductors 126, 127, 128, 129 and 130 are connected to the brushes associated with contact banks 131A to 131E, respectively, of a stepping switch which is operable by stepping magnet 131 and which has a sixth contact bank designated 131F. The contacts of the five stepping switch banks 131A to 131E are connected in a manner similar to the contacts of stepping switch banks 125A to 125E, but in different combinations, to five conductors 136, 137, 138, 139 and 140 which extend to the inner right-hand armature and to the four left-hand armatures of a relay 141. These five armatures cooperate with front contacts from which five conductors 146, 147, 148, 149 and 150 extend to the lowermost group of five single circuit jack spring elements of multiple jack 118. A multiple plug 151 has ten prongs which enter the ten lower jack elements of multiple jack 118 and each of the lower five prongs of plug 151 is connected to one of the upper five prongs of that plug. Several plugs having different connections as between the lower five and the upper five prongs may be employed for varying the connections between conductors 146 to 150 and the third group of five jack elements of multiple jack 18, counting the groups from the top. From these five jack elements conductors 161, 162, 163, 164 and 165 extend into Fig. 3 and connect individually to one terminal of each of the stepping magnets 81 to 85, the other terminal of which is connected to battery. It will be apparent that as conductors 103, 104, 109, 114 and 117 receive ground connection selectively under the control of certain of the relays controlled by the stepping switch banks in Figs. 2 and 3, such ground connections will be extended to certain ones of the conductors 121, 122, 123, 124 and 125 depending upon the arrangement of interconnection of the prongs of plug 119, then to certain ones of the conductors 126, 127, 128, 129 and 130, depending upon the position of the brushes associated with stepping switch banks 125A to 125E, then to certain ones of the conductors 136, 137, 138, 139 and 140, depending upon the position of the brushes associated with the stepping switch banks 131A to 131E, through the inner right-hand and the four left-hand armatures of relay 141 when that relay is energized, through conductors 146, 147, 148, 149 and 150 to certain ones of the conductors 161, 162, 163, 164 and 165, depending upon the arrangement of interconnection of the prongs of multiple plug 151, through the windings of certain ones of the stepping magnets 81 to 85 (Fig. 3), to battery to cause the energization of the stepping magnets. The energization of the stepping magnets will occur upon the energization of relay 141, and the release of the stepping magnets upon the release of relay 141 will cause the stepping switch brushes controlled thereby to advance one step, since these stepping switches are of the type which advance the brushes on the back stroke or release of the stepping magnet.

One terminal of relay 141 is connected to grounded battery and the other terminal is connected to conductor 142 extending into Fig. 1 and there connected to one contact of a normally open contact pair 143, the other contact of which is connected to ground. Contacts 143 are operable by a cam 144 carried by the driving shaft 54 of distributor 31 and the cam 144 is arranged to close contacts 143 after the brushes have traversed the start segment 47 and to permit the contacts 143 to open just before the brushes encounter the stop segment 46. From this it will be apparent that the stepping magnet in Fig. 3 will be energized prior to the transmission of the first code impulse of a code combination and will be released to effect the advancement of the stepping switch brushes after the transmission of the last code impulse of a code combination has been initiated, so that the cipher coding relays will not be disturbed during the ciphering or deciphering of a code.

The outer right-hand armature of relay 141 cooperates with a front contact which is connected to ground and the armature is connected by conductor 132 to one terminal of the winding of stepping magnet 125 the other terminal of which is connected to grounded battery. Thus each time the relay 141 is energized the energizing circuit of stepping magnet 125 will be completed and upon the release of relay 141 stepping magnet 125 will be released to effect the advancement of the brushes associated with stepping switch banks 125A to 125F, concurrently with the advancement of the brushes of the stepping switches shown in Figs. 2 and 3.

The stepping magnet 131 has one terminal connected to grounded battery and the other terminal connected to the middle right-hand armature of relay 141. From the front contact with which this armature cooperates conductor 133 extends through Fig. 1 into Fig. 2 to the front contact of a relay 134, the armature of which is connected to ground. One terminal of the winding of relay 134 is connected to grounded battery and the other terminal is connected by conductor 166 extending into Fig. 1 to one contact of a normally open pair of contacts 167. Contacts 167 are closed at the same time as contacts 143 by cam 144. The other contact of the contact pair 167 is connected by conductor 168 extending into Fig. 2 to one terminal of the lower winding of relay 92, the other terminal of which is connected to the single contact with which the armature of the relay cooperates. The armature of relay 92 is connected by conductor 169 extending into Fig. 3 to the front contact associated with an armature of relay 85ER. This armature is connected by conductor 171 to the front contact associated with an armature of relay 84ER. This armature is connected by conductor 172 to the front contact associated with an armature of relay 83ER which is connected to ground.

From the foregoing it will be apparent that when relays 83ER, 84ER and 85ER are energized, ground connection will be extended over conductor 169 to the armature of relay 92. If the armature of relay 92 is operated into engagement with the right-hand contact, the ground connection will be extended through the lower winding of relay 92 and over conductor 168, through the contacts 167 when closed and over conductor 166 and the winding of relay 134 to grounded battery so that relay 134 will be energized in series with the lower winding of relay 92, which is a holding winding. With relay 134 energized ground connection is extended over conductor 133 to the middle right-hand front contact of relay 141 which will be energized since when contacts 167 are closed, contacts 143 are also closed, and through the middle right-hand armature of relay 141 and the winding of stepping magnet 131 to grounded battery. When contacts 143 reopen and relay 141 is released the energizing circuit for stepping magnet 131 is opened and the magnet advances the brushes associated with the stepping switch banks 131A to 131F to the next contacts. The operation of stepping magnet 131 to effect the advancement of its associated brushes is thus observed to be dependent upon two factors which do not have cyclic occurrence, namely, the operation of the armature of relay 92 into engagement with its right-hand contact and the energization of relays 83ER, 84ER and 85ER. Other factors also involved which do have cyclic occurrence and are introduced for timing purposes are the preparation of the energizing circuit of relay 134 at the cam-operated contacts 167 and the completion of the energizing circuit of relay 141 at the contacts 143.

The operation of relay 92 to complete the energizing circuit for relay 134 is dependent upon the occurrence of a marking impulse as the second code impulse of plain text code signals, by which is meant code signals before being ciphered or after being deciphered. The requirement that relays 83ER, 84ER and 85ER be energized in order to extend a ground connection through to the armature of relay 92 provides that relay 134 shall be energized only in response to some of the occurrences of a marking impulse as the second impulse of text code. The reason for this is that in a permutation code, one-half of the total number of available codes will have the second impulse of marking nature so that if the stepping magnet 131 were controlled solely in accordance with the operation of relay 92 the average frequency of operation of the stepping magnet would be once for each two codes received or transmitted. It is preferable that the stepping magnet 131 shall operate less frequently than this since the stepping magnet 125 operates to advance its associated brushes once for each code combination received or transmitted. By supplying the ground connection for operating stepping magnet 131 through armatures and front contact of the three relays 83ER, 84ER and 85ER, the average frequency of operation of stepping magnet 131 will be once for every eight characters received or transmitted.

The operation of relay 92 will now be described and the situation involved in the transmission of signals to a distant station will first be considered, this involving signals generated by the transmitting contacts 13. Two facts are to be noted with reference to signal transmission. One is that the input relay 16 directly follows text code signals generated by the transmitting contact 13. When a marking signal is generated, relay 16 goes to marking in response thereto. The other is that each time the transmitting contacts 13 are operated to generate a signal contacts 93 are closed and complete the energizing circuit for relay 91 (Fig. 2), so that its armatures engage their front contacts. Assume that relay 16 is in marking condition for the second impulse of a code signal and that the relays 81BR to 85BR are energized in combination to interconnect conductors 44 and 44B. The circuit is traced from negative battery on the marking contact of relay 16 through conductor 37 to the bridge corner 38, through the branching paths of the bridge network rejoining at bridge corner 43 through conductor 44, front contact and outer left-hand armature of relay 91, conductor 44B, armatures and contacts of certain of the relays 81BR to 85BR, conductor 67B, uppermost winding of relay 92 entering at the top of the winding and leaving at the bottom of the winding, front contact and inner left-hand armature of relay 91, conductor 67, No. 2 code segment and inner ring of distributor 31, conductor 29, locking winding of relay 16 and resistor 26 to ground. The windings of relay 92 are polar and when the circuit is as traced with the upper terminal of the upper winding of relay 92 at the marking battery potential and the lower terminal connected to the path to ground, the winding is energized in the direction to drive the armature to the single right-hand contact to complete the energizing circuit for relay 134. The circuit includes the lower or locking winding of relay 92 which becomes energized to hold the armature on the right-hand contact. The locking winding of relay 92 is subordinate to each of the other three windings so that upon the energization of one of them in the direction to restore the armature to its left-hand position, the locking winding will not prevent such restoration. It merely holds the armature on the right-hand contact to hold relay 134 energized until that relay is released by the opening of contacts 167 so that the circuit of stepping magnet 131 will not be interrupted and the brushes associated therewith stepped until after the transmission of the last code impulse of a code combination has been initiated. Relay 92 preferably has bias which may be either mechanical or electrical but which should, however, be subordinated to all of the four windings shown, including the holding winding, tending to restore the armature to its left-hand position so that after being operated to the right-hand position and held there until after the last impulse of a code has been initiated, the armature will be restored to the left-hand position upon the interruption of the holding circuit and will not remain in the right-hand position until one of the upper three windings becomes energized in the direction to drive the armature to its left-hand position. Thus the armature of relay 92 will remain in the right-hand position only during the remainder of a cycle of distributor 31 in which it was operated to that position due to the occurrence of the marking impulse as the second impulse of a text code combination.

If at the time that the relay 16 was operated to marking in response to the second impulse of the code signal being generated the relays 81BR to 85BR had been energized in such combinations as to connect conductor 67B to conductor 49B, the circuit would be traced from the armature of relay 16 through the branching paths of the bridge network from the bridge corner 38 to the bridge corner 48 and then over conductor 49, the front contact and right-hand armature of relay 91 to conductor 49B then to conductor 67B through the armatures and contacts of the second row of cipher coding relays in Fig. 2 and then to the upper terminal of the upper winding of relay 92 the same as before. It makes no difference whether the circuit from the marking contact of relay 16 is completed over conductor 44 or over conductor 49 the battery polarity applied to the upper winding of relay 92 will be such as to drive the armature to the right-hand position. When the second impulse of the code generated by transmitting contact 13 is of spacing nature, the circuits, traced over conductor 44 or conductor 49, depending upon the condition of the second row of cipher coding relays in Fig. 2 will be the same but the polarity applied to the upper winding of relay 92 will be reversed, ground being connected to the upper terminal of the winding and negative battery being connected to the lower terminal of the upper winding through the locking winding of relay 16. The upper winding of relay 92 will thus be energized in the opposite direction, tending to drive the armature to its left-hand position to which it has already been operated by its mechanical or electrical bias.

The operation of relay 92 in response to received signals involves a different problem. Relay 16 is not now responding to text code signals but is responding to ciphered signals and these signals are deciphered so that the plain text signals appear at relay 17. Accordingly, it is necessary to operate the armature of relay 92 to its right-hand position when relay 17 is driven to marking for the second impulse of a received code combination. This is accomplished by the two middle windings of relay 92.

When signals are being received, contacts 93 are not operated so that relay 91 remains deenergized. For an understanding of the operation of relay 92 by its two middle windings it is necessary to remember that when the circuit of the operating winding of relay 17 is completed from the marking contact of relay 16 over conductor 49, the armature of relay 17 goes to spacing, that when the circuit is completed from the spacing contact of relay 16 over conductor 44 the armature of relay 17 goes to spacing, that when the circuit is completed from the spacing contact of relay 16 over conductor 49 the armature of relay 17 goes to marking, and that when the circuit is completed from the marking contact of relay 16 over conductor 44 the armature of relay 17 goes to marking.

Taking the first of these four conditions the circuit is traced from the marking contact of relay 16 over conductor 37 to the bridge corner 38, through the two branches of the bridge network rejoining at the bridge corner 48, then over conductor 49 to the lower terminal of the third winding of relay 92 counting from the top, then from the upper terminal of this winding through the back contact and right-hand armature of relay 91 to conductor 49B, through armatures and contacts of the second row of cipher coding relays of Fig. 2, conductor 67B to the back contact and inner left-hand armature of relay 91 where the circuit of the uppermost winding of relay 92 is now open, conductor 67, No. 2 code segment and inner ring of distributor 31, conductor 29, locking winding of relay 16 through resistor 26 to ground. The armature of relay 17 is caused to go to spacing when the circuit and battery polarity is as thus traced, from which it follows that the second impulse of the deciphered text code is of spacing nature and the armature of relay 92 should not be operated to the right-hand position. Accordingly, the third winding of relay 92 is so polarized that with negative battery connected to the lower terminal of that winding and ground connected to the upper terminal the magnetic field produced by the winding tends to drive the armature to its left-hand position, which position it already occupies.

For the second condition the circuit is traced from ground on the spacing contact of relay 16 through conductor 37 to the bridge corner 38, then through the branching paths of the bridge network to bridge corner 43, then over conductor 44 to the second winding of relay 92 entering at the right-hand terminal and leaving at the left-hand terminal thereof, through the back contact and outer left-hand armature of relay 91 to conductor 44B, to conductor 67B through armatures and contacts of relays 81BR to 85BR and from this point over the path traced in the preceding paragraph to ground through the locking winding of relay 16 and resistor 27 to the negative terminal of battery 28, the positive of which is grounded. The circuit arrangement and battery polarity are such that the armature of relay 17 is driven to spacing from which it follows that the armature of relay 92 should not be operated to its right-hand position. Accordingly, it may be stated that with ground on the right-hand terminal of the second winding of relay 92 and negative battery on the left-hand terminal the magnetic field generated is in the direction tending to drive the armature to the left-hand position.

For the third condition the circuit path is identical with that described for the first condition but the battery polarity is reversed so that ground is connected to the lower terminal of the third winding of relay 92 counting from the top and negative battery is connected through the locking winding of relay 16 to the upper terminal of the third winding of relay 92. This causes the armature of relay 92 to be driven to the right-hand position which prepares or completes the energizing circuit for relay 134 as the case may be. The circuit arrangement and battery polarity is such that the armature of relay 17 is driven to the marking contact.

For the fourth condition the circuit connections are the same as those described in connection with the second condition but the battery polarity is reversed, negative battery being connected to the right-hand terminal of the second winding of relay 92 and ground being connected through the locking winding of relay 16 to the left-hand terminal of the second winding of relay 92. This causes the armature of relay 92 to be driven to the right-hand position and the armature of relay 17 to be driven to the marking contact.

Figs. 5 and 6 show apparatus which in cooperation with the stepping magnets 81 to 85, 131 and 125 and with the sixth contact bank of each of the stepping switches, designated 81F to 85F, 131F and 125F, provides for selectively adjusting the stepping switches shown in Figs. 2 and 3 and the left-hand stepping switch in Fig. 4 to any of a plurality of starting points and for adjusting the brushes of the stepping switch at the right of Fig. 4 to the No. 1 contact as a starting point. Referring first to Fig. 5 a group of seven jacks 201 each having tip, ring and sleeve contacts have those contacts connected to twenty-one of the twenty-two contacts of stepping switch bank 81F. These connections may be made to contacts 1 to 21, inclusive, of the stepping switch bank or they may be made to contacts 2 to 22. It is of no consequence which one of the contacts of bank 81F is left unconnected but at all stations it should be the corresponding contact. Similarly twenty-one of the contacts of bank 82F are connected to the twenty-one contacts of seven jacks 202, twenty-one contacts of bank 83F are connected to the twenty-one contacts of seven jacks 203, twenty-one of the contacts of bank 84F are connected to the twenty-one contacts of seven jacks 204, twenty-one of the contacts of bank 85F are connected to the twenty-one contacts of seven jacks 205 and twenty-one contacts of the stepping switch bank 131F (Fig. 4) are connected to the twenty-one contacts of seven jacks 206 (Fig. 6).

By means of three patching cords, each having three conductors and provided at both ends with three-circuit plugs, connection may be made from any selected three of the jacks 201 to three jacks 211. From the ring contact of the uppermost jack 211, from the sleeve contact of the middle one of jacks 211 and from the tip contact of the lowermost jack 211, individual connections extend to conductors 221, 222 and 223, respectively, in Fig. 6. In addition, a connection is extended from the lower or ground terminal of stepping magnet 81 over conductor 219 into Fig. 6. Other sets of three jacks are designated by the reference numerals 212, 213, 214, 215 and 216. The ring contact of the upper, sleeve contact of the middle, and tip contact of the lower of jacks 212 are connected to conductors 226, 227 and 228, respectively, in Fig. 6. The lower or ground terminal of stepping magnet 82 is connected to conductor 225 which extends into Fig. 6. Similarly, the ring contact of the uppermost jack 213, the sleeve contact of the middle jack 213 and the tip contact of the lower jack 213 are connected to conductors 231, 232 and 233, respectively, in Fig. 6. The ground terminal of stepping magnet 83 is connected to conductor 234 which extends into Fig. 6.

Ten manually operable keys 237 are associated with the conductors 219, 221, 222, 223, 225, 226, 227, 228, 231, 232, 233 and 234 in Fig. 6. Each of the keys 237 has three pairs of normally open contacts. Considering first the lower pairs of contacts, one contact of each pair is connected to conductor 219 and the other contact of each pair is connected to one of the three conductors 221, 222 and 223. In the specific arrangement shown in Fig. 6 four of the other contact springs are connected to conductor 221, three are connected to conductor 222 and three are connected to conductor 223. Of the middle pairs of contacts one contact of each pair is connected to conductor 225 and the other contact of each pair is connected to one of the conductors 226, 227 and 228. Of the upper pairs of contacts, one contact of each pair is connected to conductor 234 and the other contact of each of the pairs is connected to one of the conductors 231, 232 and 233.

A second set of ten keys 238 is similarly associated with twelve conductors, nine of which extend from contacts of jacks 214, 215 and 216 and the remaining three of which extend from the ground terminals of stepping magnets 84, 85 and 131. The connections from the contact pairs of keys 238 to the twelve conductors with which the keys are associated have been shown as corresponding to the connections from the contacts of keys 237 to the twelve conductors with which they are associated. It is necessary that the connections be alike only as regards the three conductors extending from the ground terminals of stepping magnets 84, 85 and 131 but as to the connections to the conductors extending from the jacks 214, 215 and 216 the arrangement may be different and in actual practice would probably be different. It should be noted also that the recitation of connections from conductors 221, 222, 223, 226, 227, 228, 231, 232 and 233 to specific contacts of jacks 211, 212 and 213 is solely by way of example in order to enable circuits to be traced over which the keys 237 effect a control, and that in practice the connections between any one set of conductors, such as the conductors 221, 222 and 223, and the contacts of the jacks to which they are connected, in this case the jacks 211, may be transposed.

As shown in Fig. 6, a normally open key 241 has one contact connected to ground and the other contact connected to one terminal of a relay 242, the other terminal of which is connected to grounded battery. Relay 242 has seven armatures all connected to ground and seven front contacts from which conductors 81V, 82V, 83V, 84V, 85V, 131V and 125V extend through the interrupter contacts of stepping magnets 81, 82, 83, 84, 85, 131 and 125, respectively, to the ground terminals of those magnets.

A relay 81FR has one terminal connected to the conductor 81V and the other terminal connected to the brush associated with stepping switch bank 81F. Relays 82FR, 83FR, 84FR, 85FR, 131FR and 125FR are similarly connected between the conductors 82V, 83V, 84V, 85V, 131V and 125V, respectively, and the brushes associated with stepping switch banks 82F, 83F, 84F, 85F, 131F and 125F, respectively. Each of these relays has a single armature and front contact. The front contact of relay 81FR is connected to one terminal of lamp 251, the other terminal of which is connected to ground. From the armature of relay 81FR a series or chain circuit, open at the armature and front contact of each of the other relays, extends through to the front contact of relay 125FR which is connected to grounded battery. The last contact in stepping switch bank 125F is connected to the ground side of stepping magnet 125 and no other contact in that bank has any connection.

For the purpose of describing the operation of establishing starting points for the stepping switches, several assumptions will be made. It will be assumed that patching cords are connected from the three jacks 211 to the uppermost three of the jacks 201, that patching cords are connected from the jacks 212, to the middle three of the jacks 202, which would be the third, fourth and fifth of those jacks counting from the top and that patching cords are connected from jacks 213 to the lower three jacks of the group 203. Patching cords will also be connected from the jacks 214, 215 and 216 to three jacks in each of the sets 204, 205 and 206 but the conductive paths established thereby will not be traced in detail since the mode of operation will be fully exemplified by the description relative to the jacks for which specific connections have been assumed. It will also be assumed that the extreme left-hand one of the keys 237 is operated, these being locking keys, and that some one of the keys 238 is operated.

A control circuit may now be traced from the lower or ground terminal of stepping magnet 81 over conductor 219 through the lower pair of contacts of key 237, now closed, conductor 221 to the ring contact of the uppermost one of the jacks 211, through the patching cord assumed to be connected from the uppermost jack 211 to the uppermost jack 201 and through the ring contact of the last-mentioned jack to the twentieth contact of bank 81F, assuming that the tip contact of the uppermost jack 201 is connected to the twenty-first contact of bank 81F and the sleeve contact of the lowermost one of jacks 201 is connected to the No. 1 contact of bank 81F, the other contacts of the jack 201 being connected in order from bottom to top around the stepping switch bank 81F in the direction of rotation of the brush as indicated. Since the brush associated with stepping switch bank 81F is probably not engaging contact No. 20 at this time, no circuit will be completed over this path as a direct result of the operation of the extreme left-hand key 237.

A second conductive path may be traced from the ground terminal of stepping switch 82 over conductor 225 through the middle pair of closed contacts of the left-hand key 237 to conductor

228 which, as previously stated, is connected to the tip contact of the lowermost jack of group 212. The path is extended over the patching cord which is connected to the fifth jack in group 202 and as the tip contact of this jack is the ninth jack contact counting from the bottom, it is assumed that the path extends to the No. 9 contact of stepping switch bank 82F.

A third conductive path is traced from the ground terminal of stepping switch 83 over conductor 234 through the uppermost pair of contacts of the left-hand key 237 to conductor 233 to which the tip contact of the lowermost jack in group 213 is connected. The patching cord extends to the lowermost jack in group 203 and the path is extended over the tip contact of this jack to the No. 3 contact of stepping switch bank 83F since the tip contact of the lowermost jack is the third contact counting from the bottom.

The particular one of the keys 238 which has been operated completes similar conductive paths from the ground terminals of stepping magnets 84, 85 and 131 to a contact in each of the stepping switch banks 84F, 85F and 131F. When one key in each group in Fig. 6 has been operated, the advancement of the stepping switch brushes to their start positions as selectively determined by the particular ones of the keys that are operated and by the arrangement of the patching cord is initiated by the operation of key 241 which completes the energizing circuit for relay 242, and which must be held while the brushes are being advanced. Ground is applied through the armatures and front contacts of relay 242 and over the conductors 81V to 85V, 131V and 125V, to energize the several stepping magnets through their interrupter contacts. As each stepping magnet is energized, it opens the interrupter contact to open its own energizing circuit thus permitting the stepping magnet to advance its associated brushes and to release its interrupter armature which recompletes the energizing circuit so that the stepping switch brushes are advanced by buzzer operation of their stepping magnets. Assuming that the brush associated with bank 81F is the first to reach the contact to which a conductive path has been extended by the left-hand key 237, namely, the contact No. 20 of that bank, a circuit may be traced from grounded battery through the winding of stepping magnet 81 over conductors 219, lower contact of the left-hand key 237, conductor 221, ring contact of the uppermost jack of group 211, patching cord, ring contact of the uppermost jack in group 201, contact No. 20 and brush of stepping switch bank 81F, winding of relay 81FR, conductor 81V and front contact and armature of relay 242 to ground. Over this circuit the winding of relay 81FR is placed in series with the winding of stepping magnet 81 in shunt relation to the interrupter contacts of stepping magnet 81 so that the energizing circuit for stepping magnet 81 is not interrupted as a result of the opening of the interrupter contacts and the brushes controlled by stepping switch 81 remain in engagement with the No. 20 contacts of their respective banks. The relay 81FR becoming energized prepares the circuit of lamp 251.

As the brush associated with each of the stepping switch banks 82F to 85F, and 131F reaches contacts to which a conductive path has been extended by contacts of keys 237 or 238, substitute energizing circuits for the stepping magnets are established in shunt relation to the interrupter contacts and including the relays 82FR to 85FR, and 131FR so that the stepping switch brushes are arrested and the circuit of lamp 251 is further prepared for completion. The brushes controlled by stepping magnet 125 advance until they reach the last contact whereupon a substitute energizing circuit for stepping magnet 125 is completed to the last contact and brush of bank 125F in shunt relation to the interrupter contacts and including the winding of relay 125FR which becomes energized. Thus the brushes controlled by stepping switch 125 are invariably stopped on their last contacts.

The order in which the several sets of stepping switch brushes will be stopped and the relays 81FR to 85FR, 131FR and 125FR become energized will depend upon the distance the brushes must travel from the random positions which they occupied before key 241 was closed to the positions at which they complete substitute energizing circuits for their stepping magnets. When the last of the relays has been energized the circuit of lamp 251 will be completed and the lamp will be lighted. This serves as an indication that the brushes have reached rest positions as selectively determined by the operated ones of the keys 237 and 238, whereupon key 241 may be released to permit the release of relay 242. Relay 244 upon release removes the ground connections from the energizing circuits of the stepping magnets and of the lamp controlling relays so that the magnets and relays release, the magnets advancing the stepping switch brushes one step on the release stroke. This advances the stepping switch brushes to the next step beyond the one at which they were arrested and in the case of the brushes controlled by stepping magnet 125F the brushes are brought into engagement with the No. 1 contact as the starting point.

From the standpoint of operating routines, the changing of connections where there is provision for such changes may be made once each day, such as upon the starting of the day's business in the morning, or more frequently if it is thought that greater assurance of secrecy is needed. Such changes may involve changing the locations of plugs such as the plugs 81CP, 85DP and 85EP through which connections from the stepping switch banks to the cipher coding relays are established, substitution of other plugs for the plugs 119 and 151 in Fig. 4, and in connection with the establishment of new starting points for the stepping switches, the rearrangement of the patching cords with reference to the jacks shown in Figs. 5 and 6. New starting points for the stepping switches may be established as frequently as is desired under the control of the keys 237 and 238 and must be established before intercommunication can be had in cipher between any two stations where a system involves a plurality of stations of the type shown in Figs. 1 to 6, inclusive, any two of which may be interconnected through a central switching station. With the two stations that are interconnected for intercommunication having their stepping switch systems out of phase there can be no cipher transmission between them and it is necessary to transmit in plain text such information as will enable them to adjust their stepping switch systems to the same starting points. If the keys 237 and 238 have preestablished identifying symbols, the necessary stepping switch phasing information may be transmitted in plain text without fear of its being used by an unauthorized person to condition deciphering apparatus to intercept ciphered message transmission. All elements which may be involved in interchange and substitution of apparatus, such as jacks and plugs, may have preestablished identifying symbols so that all information necessary to condition all stations in the system to intercommunicate in cipher may be transmitted to and between all stations in plain text code.

Fig. 8, which as indicated in the diagram of arrangement of the sheet of drawings in Fig. 7, may be substituted for Fig. 1, discloses a modified form of transmitting distributor which may be employed instead of the mechanically driven distributor 31 of Fig. 1 and which is entirely electrical, consisting of relays. In Fig. 8 the transmitting and receiving printing telegraph set identified by the reference numeral 11, Fig. 1, has been omitted solely because of lack of space in which to show it, but it will be understood that it is required for initiating and receiving signals in the same manner as in the system shown in Fig. 1.

The signal responsive relay 16 and signal generating relay 17 are shown in the lower right-hand corner of Fig. 8 and operate in the same manner to cipher and decipher telegraph signals. Where elements identical with those in Fig. 1 appear in Fig. 8 the same reference numerals have been employed. Thus the potential dividers for the operating and locking windings of signal responsive relay 16, the elements of the bridge network with which the operating winding of relay 17 is associated and the bridge corners of that network, the potential divider for the locking winding of signal generating relay 17 and the conductors extending from the two ends of the operating winding of relay 17 to the cipher relay circuit in Figs. 2 and 3 have been so identified. The conductors 66, 67, 68, 69 and 71 which extend from the cipher relay chain circuits in Figs. 2 and 3 are shown in Fig. 8 extending into the relay distributor as will be specifically described hereinafter. A minor difference in the relation of signal responsive relay 16 to the bridge network associated with relay 17 will be noted in Fig. 8. Whereas in Fig. 1 conductor 37 from the armature of relay 16 extends to the bridge corner 38 and the return circuit is over conductor 29 to the locking winding of relay 16, in Fig. 8 conductor 29 of the locking winding of relay 16 extends to the bridge corner 38 and, as will be described later, the return circuit is over conductor 37 to the armature of relay 16. Thus the bridge network has merely been located in a different point in the circuit from the armature of relay 16 to its locking winding and in reverse relation to the sources of operating current. This necessitates employment of a signal generating relay 17 polarized oppositely in both windings from the polarity of the relay 17 in Fig. 1.

A relay circuit for effecting the transmission of the start signal by relay 17 independently of the distributor is shown at the left of relay 17 in Fig. 8, consisting of relays 301 and 302. This circuit corresponds to the circuit of relays 201 and 202 in Fig. 4 of the copending application of K. A. Fitch et al. hereinbefore identified. The operation of this circuit will now be described. When relay 16 is driven to spacing in response to the start pulse of a signal generated locally and to be ciphered, or received from a remote station and to be deciphered, ground is connected from the spacing contact through the armature of relay 16 over conductor 37 to contact 3 of a test key 303, then through contact 2 which normally engages contact 3, conductor 304, back contact and armature 2 of a relay 306 which at this time is deenergized, back contact and armature 1 of a relay 307 which is also deenergized at this time, conductor 308 and over branching parallel paths 309 and 311. Conductor 309 extends to one terminal of the operating winding of relay 301, the other terminal of which is connected to the negative terminal of battery 312, the positive terminal of which is grounded. Before the relay 16 moved to its spacing contact the negative battery on its marking contact was in oposition to the battery 312 so that the operating winding of relay 301 was not energized. The battery connection on the end of the conductor 311 which is in parallel with conductor 309 is negative, as will appear later, so that the operating winding of relay 301 is not energizable over conductor 311 but only over conductor 309 from the spacing contact of relay 16. The energizing current in the operating winding of relay 301 overcomes the opposing biasing winding and moves the armature of the relay to its right-hand contact, which has no circuit connection.

The left-hand contact of relay 301, which the armature normally engages, is connected to one terminal of the operating winding of relay 302, the other terminal of which is connected to negative battery 313. The armature of relay 301 is connected through resistor 314 to ground, so that the operating winding of relay 302 is normally energized and holds its armature in engagement with the left-hand contact, which has no circuit connection. The terminal of the operating winding of relay 302 to which the left-hand contact of relay 301 is connected is also connected through condenser 316 and resistor 317 to ground. Condenser 316 is normally discharged but when relay 301 operates its armature to the right-hand contact, charging current for condenser 316 flows through the operating winding of relay 302 for an interval determined by the capacity of condenser 316 and the resistance of resistor 317. When the charging current for condenser 316 dies out the operating winding of relay 302 ceases to hold the armature on its left-hand contact and the biasing winding moves the armature to the right-hand contact which has ground connection.

The armature of relay 302 is connected to conductor 44 which enters the bridge network associated with signal generating relay 17 at the bridge corner 43. The direct grounding of conductor 44 has the same effect as the previously described completion of the circuit of the operating winding of relay 17 from the grounded spacing contact of relay 16 over conductor 44, namely, to drive the armature of relay 17 to the spacing contact whereby a spacing signal will be transmitted over conductor 32, and the circuit of the holding winding of relay 17 is completed in such direction and polarity as to hold the armature on the spacing contact upon the removal of the ground from conductor 44. The charging of condenser 316 delays the operation of the armature of relay 302 to its right-hand contact and accordingly the initiation of the start impulse by relay 17. The delay interval may be varied by providing condenser 316 of different value and also by varying the value of resistance 317. There is a limit to the delay in initiating the transmission of the start signal since selecting impulses will follow the start impulse into the relay 16 in regular order but it may be desirable to delay the initiation of the start impulse slightly in order to afford time in which to start the sequence of operations in the relay distributor circuit.

Besides completing the circuit of the operating winding of relay 301 the relay 16 in its spacing condition completes a circuit over the parallel conductor 311 through the lower or operating winding of the start relay 321 of the distributor circuit, conductor 322, springs 4 and 5 of key 303 which are normally engaged, to negative battery 323. The operating winding of relay 321 becomes energized and overcomes the opposing effect of the biasing winding, thus moving the grounded armature of the relay from the left-hand contact to the right-hand contact which has no circuit connection.

The left-hand contact of relay 321 is connected through condenser 324 and resistor 326 to ground and is also connected through the lower or operating winding of an orientation relay 327. The circuit of the biasing winding of relay 327 includes a variable resistor 328 by means of which the current in the biasing winding may be varied to change the relative effectiveness of the biasing winding, which urges the grounded armature of the relay to its right-hand position and of the operating winding which urges the armature to its left-hand position.

Before the armature of relay 321 becomes disengaged from its left-hand contact the circuit of the operating winding of relay 327 is completed directly to ground on the armature of relay 321, and the operating winding of relay 327 is fully energized to hold the armature on its left-hand contact. In this condition a circuit is completed over conductor 331, armature 1 and back contact of relay 306, conductor 332, contacts 1 and 2 of a key 333 to a conductor 334. Conductor 334 is connected through resistor 336 to the negative terminal of battery 337, the positive terminal of which is grounded. Conductor 334 is also connected to the left-hand end of a series circuit including the single windings of polar relays 338 and 339 and the upper winding of polar relay 341. The right-hand end of the series circuit is connected through variable resistor 342 and conductor 343 to conductor 344. Conductor 344 is connected through resistor 346 to battery 337 and is also connected to the left-hand contact of a polar relay 347 which is normally engaged by its grounded armature so that conductor 344 is at ground potential. Thus both ends of the series circuit including relays 338, 339 and the upper winding of relay 341 are grounded and no current flows through this circuit. The lower winding of relay 341 has one terminal connected to grounded conductor 334 and the other terminal connected through condenser 348 and conductor 343 to grounded terminal 344 so that no current flows through the lower winding of relay 341 and condenser 348 is discharged.

Upon the operation of the armature of relay 321 to its right-hand contact as a result of response of relay 16 to the start signal, the direct ground connection for relay 327 is removed but energizing current for the operating winding of that relay continues to flow, charging condenser 324, and the magnitude and duration of this current are determined by the constants of condenser 324 and resistor 326. When the charging current has dropped to such value that the magnetic field produced by it in the lower winding of relay 327 no longer successfully opposes the magnetic field produced by the current in the upper winding, the armature of relay 327 is moved to its right-hand contact. The interval between the operation of relay 321 and the operation of relay 327 may be lengthened by increasing the value of variable resistor 328, thereby reducing the current through the upper winding of relay 327 or may be shortened by decreasing the resistance 328, thereby increasing the current through the upper winding of relay 327. Varying this interval represents orientation of the distributor cycle with reference to the response of relay 16 to signals.

When the armature of relay 327 moves out of engagement with its left-hand contact it removes ground potential from conductor 334. This permits relays 338, 339 and the upper winding of relay 341 to become energized in a circuit from battery 337 through resistor 336, conductor 334, the series circuit of relays 338, 339 and the upper winding of relay 341 from left to right, resistor 342, conductor 343, conductor 344, left-hand contact and armature of relay 347 to ground. It also permits the lower winding of relay 341 to become energized from battery 337 through resistor 336, lower winding of relay 341 from right to left, condenser 348, conductors 343 and 344, left-hand contact and armature of relay 347 to ground. Relays 338 and 339 operate at once, moving their armatures to their right-hand contacts, but the operation of the armature of relay 341 is delayed because current through the lower winding, charging condenser 348 opposes the operation of the armature to the right-hand contact under the control of the current in the upper winding. The current in the upper winding may be varied by means of the variable resistor 342 to vary the interval during which the charging current for condenser 348 effectively opposes movement of the armature to the right-hand contact in the same manner that varying the resistance 328 varies the time of movement of the armature of relay 327 to its right-hand contact following the operation of the armature of relay 321 to its right-hand contact.

Before the armature of relay 341 has operated to its right-hand contact, the relay 327 will have completed a circuit from its grounded armature through its right-hand contact, conductor 350 and winding of relay 306 to grounded battery. Relay 306 completes a holding circuit for itself from the right-hand terminal of its winding through its armature 3 and front contact, conductors 351 and 352, back contact and armature 3 of relay 307, conductor 353 and contacts 3 and 4 of key 333 to ground. Another ground circuit for holding relay 306 energized may be traced from conductor 351 through conductor 354 and armature 7 and back contact of a relay 356. Relay 356 is the last of a series of six counting and distributing relays and may or may not be energized at the instant that relay 306 becomes energized. In setting the apparatus in operation preparatory to message transmission and reception after an interval during which the system has been shut down and power has been disconnected from the relays, relay 356 will be deenergized at the time relay 306 becomes energized. At the end of the first signal combination transmitted or received, relay 356 becomes energized as will be described later and remains energized as will also be described later until after the relay 306 has become energized in response to the start impulse of the next signal combination received or transmitted, so that ground will be disconnected from conductor 354 and only one holding circuit for relay 306 will be established initially, namely, that provided on contact 4 of key 333. For the present it will be assumed that relay 356 is not energized, the apparatus just having been conditioned for operation after an idle period during which power was disconnected from the relay.

At its armature 1 and back contact the relay 306 interrupts the conductive path from the left-hand contact of relay 327 to conductor 334. Relay 327 will thus be prevented from grounding conductor 334, upon return of its armature to its left-hand contact, as long as relay 306 remains energized. At its armature 2 and back contact, relay 306 interrupts the path from conductor 304, which is an extension of the armature conductor 37 of relay 16, to the operating windings of relays 301 and 321. Relay 301 restores the steady energizing circuit for relay 302 and discharges condenser 316, thus removing the ground connection from conductor 44, relay 17 remaining in its spacing condition under the control of its locking winding. Relay 321 restores the steady energizing circuit for the lower winding of relay 327 and discharges condenser 324. Relay 327 removes ground potential from the energizing circuit of relay 306 which is now held over its locking circuit, and restores ground connection to conductor 331 which connection extends only to the armature 1 of relay 306, now disengaged from its back contact. Armature 4 of relay 306, cooperating with its front contact, prepares an energizing circuit for relay 307, the path from the front contact extending over conductor 357 to the front contact associated with the armature 3 of counting relay 363 which is deenergized at this time whether or not the distributor has been in operation or is being started after a shut-down period. Armature 5 and its front contact interconnect conductors 166 and 168. This operation is comparable with closure of the cam-controlled contacts 167 in Fig. 1 and prepares for the operation of relay 134 in Fig. 2 under the control of relay 92 and relays 83ER, 84ER and 85ER. Armature 6 of relay 306 connects ground over conductor 142 which operation is comparable with the closure of cam-controlled contacts 143 in Fig. 1 for the purpose of completing the energizing circuit of relay 141 in Fig. 4.

Relay 339, having operated its armature from its left-hand to its right-hand contact substantially immediately after the armature of relay 327 left its left-hand contact, completes a circuit from ground on its armature over conductor 361, armature 6 and back contact of counting relay 356, conductor 362, armature 7 and back contact of counting relay 363, conductor 364, armature 6 and back contact of counting relay 366, conductors 367 and 368 and winding of counting relay 369 to grounded battery, the relay 369 becoming energized over this circuit. At its armature 1 and back contact relay 369 removes ground potential from conductor 371 which extends to the armature 3 of counting relay 372, this being a potential holding circuit for relay 372 which is not effective at this time because the relay has been assumed to be released. At its armature 2 the relay 369 interrupts a path from conductor 373 over conductor 374 to armature 4 of relay 372 which, upon the assumption that relay 372 is at this time deenergized, is out of engagement with its front contact. Conductor 373 is connected by conductor 376 to the right-hand contact of a biased polar relay 377 the armature of which is connected over conductor 378, contacts 2 and 3 of key 303, and conductor 37 to the armature of signal responsive relay 16. Conductor 373 is a feeder conductor for supplying positive or negative potentials from the armature of signal responsive relay 16 through distribution paths established by certain of the counting relays, and relay 377 is a timing relay for determining the length of the interval during which the positive or negative potentials are applied to the feeder conductor 373.

Armature 3 of relay 369 establishes a holding circuit for the relay over conductor 379 and the front contact and armature 1 of counting relay 358 to ground. It will be apparent from this that when relay 358 subsequently becomes energized the holding circuit for relay 369 will be interrupted and that relay will be released. Armature 4 of relay 369 establishes a conductive path from feeder conductor 373 over conductor 381, armature 2 and back contact of relay 358, conductor 382, armature 4 and front contact of relay 369 to conductor 66 associated with the first chain of counting relays in Fig. 2. The completion of the connection from conductor 66 to feeder conductor 373 represents one of two steps which, together correspond with the passage of the brushes of distributor 31 in Fig. 1 over the No. 1 code segment in the outer ring. The other operation which must occur is the movement of the armature of timing relay 377 into engagement with its right-hand contact. The armature 4 of relay 369 thus completes a path from the locking winding of relay 16, through the bridge network associated with signal generating relay 17, over one or the other of the conductors 44 and 49 to conductor 66 as determined by the first set of cipher coding relays in Fig. 2, and on through feeder conductor 373 to the right-hand contact of relay 377. The relay 377, when operated, will extend this path over conductor 378 and conductor 37 to negative or ground (positive) potential on the armature of signal responsive relay 16, to cause the operation of relay 17 in accordance with the polarity received by the armature of relay 16 and the path 44 or 49 over which the circuit is completed under the control of the cipher coding relays.

At the armature 5 and front contact of relay 369 a path is extended from the winding of relay 366 over conductor 383, front contact and armature 5 of relay 369, conductor 384, back contact and armature 6 of relay 358, conductor 386, back contact and armature 6 of relay 372, and conductor 387 to the left-hand contact of relay 339. As the armature of relay 339 is still in engagement with its right-hand contact, the current for condenser 348 still being assumed to be flowing in the lower winding of relay 341 so that the upper winding has not yet assumed control of that relay, a circuit from ground on the armature of relay 339 will not yet be completed over the path just traced. The back contact associated with the armature 6 of relay 369 is connected to the negative terminal of battery 388, the positive terminal of which is connected to ground, and is also connected over conductor 389, condenser 391, lower winding of a biased polar relay 392 to the negative terminal of battery 393, the positive terminal of which is connected to ground. The armature 6 of relay 369 is connected by conductor 394 to the front contact for the armature 4 of relay 356 and this armature is connected by conductor 396 to the left-hand contact of relay 341, the armature of which is grounded. Since relay

356 has been assumed to be deenergized, the ground at the armature of relay 341 has not been extended to the armature 6 of relay 369 and batteries 386 and 393 are in opposition at the ends of the circuit including condenser 391 and the lower winding of relay 392, so that no current flows through the lower winding of the relay and the disengagement of the armature 6 of relay 369 from its back contact has no effect on relay 392 at this time.

At the same time that relay 339 operated to its right-hand contact, relay 338 also operated to its right-hand contact. The left-hand contact of relay 338 is connected to a conductor 397 which extends a conductive path from the negative terminal of battery 398, the positive terminal of which is grounded, through resistor 399, condenser 401 and the lower winding of relay 377 to the negative terminal of battery 402, the positive terminal of which is grounded. The biasing circuit of relay 377 includes a variable resistance 403 which determines the magnitude of the current flowing in the biasing winding. When the armature of relay 338 is on its left-hand contact the ground connection thereby established on conductor 397 permits current to flow through the lower winding of relay 377 to charge condenser 401. Initially this current is sufficient to overcome the effect of current in the biasing winding of relay 377 and to move its armature to the right-hand contact to interconnect conductors 376 and 378. As soon as this current drops below the value of current in the biasing winding the latter winding assumes control and restores the armature to the left-hand contact. The magnitude of the current in the biasing winding controlled by the variable resistor 403 determines the interval during which the armature of relay 377 engages its right-hand contact and this interval is preferably of the order of five thousandths of a second which is sufficient to effect the operation of relay 17, the circuit of which relay 377 completes upon being operated to its right-hand contact.

The right-hand contact of relay 338 is connected to a conductor 404 which provides a circuit from battery 398 through resistor 406, condenser 407 and lower winding of relay 408 to negative battery 409. The biasing circuit of relay 408 includes a variable resistor 411 which serves the same purpose as variable resistor 403, namely, to limit the interval during which the armature of relay 408 engages its right-hand contact after relay 338 grounds conductor 404 to about five thousandths of a second. The armature of relay 408 is connected to conductor 378 for extending a conductive path from the armature of relay 16 and the right-hand contact of relay 408 is connected by conductor 412 to a feeder conductor 413 which provides for the extension of conductive paths through armatures and contacts of certain of the counting relays 369, 366, 358, 363, 372 and 356.

The operation of the armature of relay 338 to its right-hand contact causes the momentary operation of relay 408 to its right-hand contact thus extending a conductive path from the armature of relay 16, which at this time is responsive to the start signal, to feeder conductor 413. One path from this feeder conductor is traced through the armature 2 and back contact of relay 363, conductor 414 to the armature 4 of relay 366 which is out of engagement with its front contact because relay 366 is released. Another path is traced from feeder conductor 413 through the armature 1 and back contact of relay 356, conductor 416 to the armature 4 of relay 363 which is out of engagement with its front contact because relay 363 is released. With relay 338 operated to its right-hand contact relay 377 has its armature operated to the left-hand contact because batteries 398 and 402 are in opposition and conductor 397 is not grounded. Thus, no conductive path is established from the armature of relay 16 through armatures and contacts of any counting relays when relay 16 is responding to the start impulse.

When the charging current for condenser 348 through the lower winding of 341 decreases to a value less than the current through the upper winding, the armature of relay 341 is operated to its right-hand contact. The variable resistor 342 is preferably so adjusted that the interval elapsing between the completion of the charging circuit for condenser 348 and the operation of the armature to the right-hand contact is of the order of twenty-two thousandths of a second, which is the impulse interval of a five-unit permutation code combination. The right-hand contact of relay 341 is connected by conductor 417 to conductor 418 which extends a path from the negative terminal of battery 337 through resistor 419 to one terminal of the winding of polar relay 347 the other terminal of which is connected to a potential divider having negative battery potential at one end and ground (positive) potential at the other end. When conductor 418 is not grounded through the armature and right-hand contact of relay 341 current through relay 347 is in the direction to hold its armature on the left-hand contact. With conductor 418 grounded the current in relay 347 is reversed and the armature moves to the right-hand contact which is connected by conductor 420 to conductor 334. In so operating relay 347 removes ground connection from conductor 344 and grounds conductor 334. This reverses the polarities applied to the ends of the series circuit comprising relays 338, 339 and the upper winding of relay 341 and also reverses the polarities applied to the lower winding of relay 341. Relays 338 and 339 immediately restore their armatures to their left-hand contacts. The upper winding of relay 341 also seeks to restore the armature of that relay to its left-hand contact but current for discharging condenser 348 and for recharging it in the opposite direction flows through the lower winding of relay 341 and opposes movement of the armature back to the left-hand contact. The delay in movement of the armature will be the same as the delay previously mentioned, preferably twenty-two thousandths of a second.

Relays 338 and 339 immediately moved their armatures to their left-hand contacts. Relay 338 removes ground potential from conductor 404 thus permitting condenser 407 to discharge but the relay 408 had already returned its armature to its left-hand contact at the end of the short interval during which the charging current for condenser 407 held the armature on the right-hand contact, which is of the order of five thousandths of a second. Relay 338 grounds conductor 397 thus permitting condenser 401 to charge through the lower winding of relay 377 which operates its armature to the right-hand contact for the same interval of time. While the armature of relay 377 is engaging the right-hand contact a conductive path from the armature of relay 16 is extended over conductors 37, 378, 376, 373 and 381, armature 2 and back contact of relay 358, conductor 382, armature 4, and front contact of relay 369 and conductor 66 into the chain circuit established by the cipher coding relays of the first set in Fig. 2. Over this circuit the relay 17 is operated through one of the conductors 44 and 49 in accordance with the operation of relay 16 and the cipher coding relays. The armature of relay 377 remains on its right-hand contact only momentarily but the interval is of sufficient length to permit relay 17 to operate.

Relay 339 completes a circuit from ground on its armature over conductor 387, armature 6 and back contact of relay 372, conductor 386, armature 6 and back contact of relay 358, conductor 384, armature 5 and front contact of relay 369 and conductor 383 to the winding of relay 366 which becomes energized. At its armature 1 relay 366 removes ground potential from a path traced through conductor 421 to the armature 3 of relay 356. This armature is engageable with a front contact when relay 356 is energized for establishing a holding circuit for the relay 356, but since this relay is assumed to be deenergized the removal of ground potential from conductor 421 has no effect at this time. Armature 2 of relay 366 controls a circuit for checking and adjusting the timing of condenser controlled relays, particularly the relays 327 and 341, and the operation of this circuit will be described later. At the front contact and armature 3 of relay 366 a holding circuit for the relay is extended over conductor 422 through the back contact and armature 1 of relay 363 to ground.

It has previously been set forth that a conductive path is extended to the armature 4 of relay 366 from feeder conductor 413. The front contact with which this armature cooperates is connected to conductor 67 over which the circuit of relay 17 will be completed for the second selective impulse of the permutation code signal, the circuit for the first impulse having been completed through the armature 4 and front contact of relay 369 to conductor 66. At the fifth armature and front contact of relay 366 a circuit is prepared for the energization of counting relay 358 through armature 7 and back contact of relay 356 and armature 6 and back contact of relay 363 in series. At armature 6 and back contact of relay 366 the previously described circuit for energizing relay 369 is interrupted, this relay being held energized at this time over its holding circuit.

At the end of an interval equal to the length of an impulse of a permutation code combination the armature of relay 341 is again operated to its left-hand contact and operates relay 347 to its left-hand contact. Relay 347 again reverses the polarity on relays 338, 339 and 341 and the armatures of relays 338 and 339 immediately operate to their right-hand contacts. Relay 338 operates relay 408 momentarily to extend a path from the armature of relay 16 to the feeder conductor 413 from which the path is extended over the armature 2 and back contact of relay 363, conductor 414, armature 4 and front contact of relay 366 to conductor 67 for operation of relay 17 to generate the second impulse of the permutation code combination. Relay 339 operates relay 358 over the previously prepared path.

At its armature 1, relay 358 interrupts the holding circuit for relay 369 which releases. At its armature 2 relay 358 interrupts the path from feeder conductor 373 to conductor 66, this path also being interrupted at the armature 4 of relay 369 upon the release of that relay. At its armature 3 relay 358 completes its own holding circuit to the grounded armature 1 of relay 372 which engages its back contact. At armature 4 relay 358 connects the third distributor conductor 68 to feeder conductor 373 through the back contact and armature 2 of relay 372. At armature 5 the relay 358 prepares an energizing circuit for relay 363 through conductor 386, the back contact and armature 6 of relay 372 to conductor 387, and at armature 6 the energizing circuit for relay 366 is interrupted this relay being now held energized over its holding circuit.

At the end of its timing interval relay 341 operates its armature to the right-hand contact thereby operating relay 347 to its right-hand contact and reversing the polarities on relays 338, 339 and 341 whereby the relays 338 and 339 are at once operated to their left-hand contacts. Relay 338 operates relay 377 momentarily and this relay completes the circuit of relay 17 through the armature 2 and back contact of unoperated relay 372 and through the armature 4 and front contact of operated relay 358 to conductor 68. Relay 339 operates relay 363 over the circuit prepared by relay 358 to the left-hand contact of relay 339. Relay 363 performs operations comparable with those of the counting relays which preceded it, namely releasing relay 366 at its armature 1 and back contact, interrupting the path to conductor 67 at its armature 2 and back contact, completing its own holding circuit at armature 4 and front contact to the grounded armature 2 of relay 356, extending a connection from feeder conductor 413 to the fourth distributor conductor 69 at its armature 4, preparing an energizing circuit from the right-hand contact of relay 339 for relay 372 through the armature 5 and front contact of relay 363, and interrupting the energizing circuit for relay 358 at the armature 6 and back contact.

As an additional operation performed by relay 363, its armature 3 and front contact complete a circuit from grounded battery on the armature of relay 392 through the left-hand contact of that relay, conductor 426, armature 3 and front contact of relay 363, conductor 357, front contact and armature 4 of relay 306 and winding of relay 307 to ground, the relay 307 becoming energized over this circuit. Relay 307 completes a holding circuit for itself through its front contact and armature 2 and over conductor 427 to conductor 426. At its armature 1 the relay 307 interrupts the circuit for the lower winding of relay 321 but as this circuit is already interrupted at the armature 2 and back contact of relay 306 which is energized, this operation has no immediate effect. At the armature 3 and back contact of relay 307, the ground potential supplied through contacts 3 and 4 of key 333 is disconnected from the holding circuit for relay 306 but this relay remains held by the ground connection on the armature 7 of relay 356 supplied over conductor 354.

Upon the second return of the armature of relay 341 to its left-hand contact relay 347 is controlled to reverse the polarity on relays 338, 339 and 341 and relays 338 and 339 operate to their right-hand contacts for the third time. Relay 338 operates relay 408 momentarily to complete the circuit of signal generating relay 17 through feeder conductor 413 and armature 5 and front contact of relay 363 and over the fourth distributor conductor 69. Relay 339 completes the energizing circuit for relay 372 which releases relay 358 and prepares the energizing circuit for relay 356. Other operations performed by relay 372 are comparable with those performed by relays ahead of it in the counting circuit, excluding the operation of relay

307 by relay 363 which is a special operation assigned to relay 363, but including the extension of a path from feeder conductor 373 to distributor conductor 71, this path including armature 4 and front contact of relay 372 and back contact and armature 2 of relay 369.

Upon the third operation of the armature of relay 341 to its right-hand contact under the timing control of condenser 348, relay 347 is operated to its right-hand contact to restore the armature of relays 338 and 339 to their left-hand contacts for the third time. Relay 338 operates relay 377 momentarily which completes the circuit of relay 17 over feeder conductor 373 and over the path through the armature 4 of relay 372, traced in the foregoing paragraph, including the fifth distributor conductor 71, to cause relay 17 to generate the fifth impulse of the code combination. Relay 339 completes the energizing circuit for relay 356 through the armature 5 and front contact of relay 372. At its armature 1 the relay 356 interrupts the circuit to the fourth distributor conductor 69 through the armature 5 and front contact of relay 363. At its armature 2 relay 356 interrupts the holding circuit for relay 363 which is released. At its armature 3 relay 356 completes its own holding circuit over conductor 421 to the grounded armature 1 of relay 366 which is at this time released and engages its back contacts. At the armature 4 of relay 356 a conductive path is completed from the left-hand contact of relay 341 over conductor 396, the armature 4 and front contact of relay 356, conductor 394 to the armature 6 of relay 369. This armature is now released and engages its back contact which is connected to battery 388 and through conductor 389, condenser 391 and lower winding of relay 392 to battery 393 which is in opposition to battery 388 so that relay 392 remains in the condition shown with its armature engaging the left-hand contact. At armature 5 of relay 356 a path is prepared from the right-hand contact of relay 339 over conductor 361, armature 5 and front contact of relay 356, conductors 428 and 368 directly to the winding of relay 369. At armature 6 of relay 356 the circuit over which relay 369 was previously energized, including armature 7 and back contact of relay 363 and armature 6 and back contact of relay 366, is interrupted. The armature 7 of relay 356 removes the remaining ground from the holding circuit of relay 306 so that that relay is released.

The armature 1 of relay 306 restores to conductor 334 the ground connection supplied from the armature of relay 327. At this time relay 347 is operated to its right-hand contact, through which ground is also supplied to conductor 334 so that the release of relay 306 does not interfere with the timing operation controlled by condenser 348. Armature 2 of relay 306 prepares for the restoration of the operating winding of relay 301 and the lower winding of relay 321 to control by relay 16 but this path is still open at the armature 1 of relay 307 which has remained energized. Relay 306 opens its own holding circuit contacts, disconnects conductor 166 from conductor 168 to release relay 134 if that relay had been energized, and interrupts the circuit of relay 141 (Fig. 4) which releases.

At the end of the interval determined by condenser 348 the armature of relay 341 returns to its left-hand contact for the third time and restores the armature of relay 347 to its left-hand contact. Relay 347 grounds conductor 344, and as conductor 334 has already been grounded by the armature of relay 327 through the armature 1 and back contact of relay 306 both ends of the series circuit comprising relays 338 and 339 and the upper winding of relay 341 are at ground potential and both terminals of the lower winding of relay 341 are at ground potential so that these three relays have been restored to the original condition in which they remain until relay 321 responds to the start impulse of the next signal combination and operates relay 327 to remove ground from conductor 334.

As the armature of relay 341 returns to its left-hand contact it completes a circuit over conductor 396, armature 4 and front contact of relay 356, conductor 394, armature 6 and back contact of relay 369 to battery 388 from which current flows, and in parallel with battery 388 over conductor 389, condenser 391, lower winding of relay 392 to battery 393 from which current flows to energize the lower winding of relay 392 and charge condenser 391. The operation of relay 392 is comparable with the operation of relays 377 and 408, the lower winding immediately overcoming the effect of the biasing current in the upper winding and moving the armature to the right-hand contact momentarily. Current in the upper winding of relay 392 is regulated by variable resistor 431 to determine the interval during which the current in the lower winding exceeds that in the upper winding and this interval is preferably of the same duration as the operating intervals for relays 377 and 408, namely, of the order of five thousandths of a second. When the armature of relay 392 leaves its left-hand contact it interrupts the holding circuit for relay 307 which releases.

At its armature 1 relay 307 reestablishes a conductive path from the armature of relay 16 to the lower winding of start relay 321. The five selecting impulses of the code combination have been distributed through the five cipher coding relay systems to relay 17 and relay 16 is now responding to the stop impulse of the code combination, of marking nature, so that the lower winding of relay 321 does not become energized. At its armature 2 the relay 307 releases its holding circuit so that the relay will not be reenergized when the armature of relay 392 returns to its left-hand contact. At its armature 3 and back contact relay 307 restores the ground connection to conductor 351 for holding relay 306 when that relay again becomes energized.

Relay 392 completes a circuit from negative battery on its armature through its right-hand contact and conductor 432 to bridge network corner 43, through the bridge network, conductor 29 and locking winding of relay 16 to the potential divider comprising resistors 26, 27 and grounded battery 28. The polarity applied to bridge corner 43 by relay 392 is the opposite of that which was applied to that bridge corner by relay 302 for driving relay 17 to the spacing condition for transmitting the start impulse, so that relay 392 drives relay 17 to the marking position for the transmission of the stop impulse, it being understood that the relay 17 is actually operated to marking position only if the last selecting impulse of the code combination was of spacing nature, because otherwise relay 17 will be in the marking condition at the time relay 392 is operated.

When the charging current for condenser 391 has dropped below its effective value with respect to the biasing current of relay 392 the relay is restored to initial condition with its armature engaging the left-hand contact, and this completes restoration of all of the apparatus in Fig. 8 to the condition which was assumed to be the initial condition, with the exception that relays 372 and 356 have remained energized. Since the holding circuit for relay 372 is controlled by the armature 1 of relay 369, relay 372 will remain energized until relay 369 is operated in consequence of reception of the start impulse of the next code combination and preparatory to distribution of the first selecting impulse of that code combination to the cipher relay system.

Relay 356 has remained energized through a holding circuit to ground on the armature 1 of relay 366, and provides a path for energizing relay 369 which differs from that over which relay 369 was energized when relay 356 was in released condition, this path being directly through conductor 428 and not including armature 6 of relay 366 and armature 7 of relay 363. The reason for providing the alternate path for energization of relay 369 is that relay 356 may be energized or may be deenergized at the time that a start signal is received by relay 16 depending, as previously stated, upon whether relay 356 has been released by removal of battery connection therefrom for conversation of power during an idle period. The reason for providing that the energizing path for relay 369 when relay 356 is released shall include armatures and back contacts of others of the counting relays, namely, the relays 366 and 363, is to prevent the erroneous energization of relay 369 with one of the other counting relays which is energizable through the armature 6 and back contact of relay 356, such as the relay 372, after relay 369 has been released by relay 358.

Key 333 is operable manually to establish circuit conditions for checking and adjusting the timing of relay 341. When key 333 is operated contacts 1 and 2 open and remove ground from conductor 334. Contacts 3 and 4 open, removing ground from the holding circuit path of relay 306, which has no effect as relay 306 is at this time released, and contacts 4 and 5 close to connect ground over conductor 436, back contact and armature 2 of relay 366, conductor 437 and winding of magnet 438 to battery. The armature of magnet 438 controls an operation counting register 439, to advance the counting dials thereof one step for each complete cycle of energization and release of magnet 438.

The removal of ground from conductor 334 causes relays 338, 339 and 341 to operate in the same manner as if they had been set in operation in response to a signal combination. Relay 347 is operated by relay 341 and in turn reverses the polarities on relays 338, 339 and 341. Relay 338 operates relays 377 and 408 alternately and relay 339 operates the counting relays 369, 366, 358, 363, 372 and 356 in sequence. Relay 17 may be operated as the distributor operation proceeds because, although relay 16 is not responding to signals the energizing circuit of relay 17 may be completed over either of the conductors 44 and 49 in accordance with the condition of the cipher coding relays in Figs. 2 and 3. The stepping switches which control the cipher coding relays will not be advanced because none of the relays 321, 327, 306 and 307 is operated and the relays which control the advancement of the stepping switches are energized through armatures and front contacts of relay 306.

The counting relays will go through repeated cycles because ground remains disconnected from conductor 334 except when it is applied by relay 347, and relay 341 will oscillate continuously at the rate controlled by the adjustment of variable resistor 342, operating the counting relays successively on each half cycle of relay 341 at uniform rate. Each time that relay 366 of the counting relays is energized it will interrupt the energizing circuit for magnet 438, which circuit will be reclosed when relay 363 becomes energized and releases relay 366. Upon being released and reenergized magnet 438 will advance the counting dials of counter 439 one step to register a complete cycle of operation of the six counting relays which correspond to six half cycles of relay 341.

As stated previously, each half cycle of relay 341 preferably has a duration of twenty-two thousandths of a second. Six half cycles of relay 341 required to complete a cycle of the six counting relays will occupy one hundred and thirty-two thousandths of a second. In an easily measurable interval of time such as one minute, there are four hundred fifty-four and a fraction intervals of a length of one hundred and thirty-two thousandths of a second, or in sixty-six seconds which could, without difficulty be measured with an ordinary timepiece or very accurately with a stop-water, there are exactly five hundred intervals of one hundred and thirty-two thousands second length. The test is made by operating key 333 at the beginning of the time interval to be measured and opening it at the end of the time interval. If the counting register 439 does not show a reading of four hundred fifty-four at the end of a time interval of one minute or five hundred at the end of a time interval of sixty-six seconds, resistor 342 may be adjusted to vary the timing of relay 341 and the test repeated until the proper number of cycles of the counting relays has been registered in the time interval. When this adjustment has been reached it will be known that the timing of each half cycle of relay 341 is twenty-two thousandths of a second.

Key 303 controls circuits for timing and adjusting the over-all interval occupied by a cycle of the distributor from the time of operation of the start relay 321 until the armature of relay 341 has made its third return to the left-hand contact and has operated relay 392 to release relay 307. Since the mid-point of a telegraph impulse is likely to be the most reliable and effective part of the impulse, the ideal operating condition is to delay the starting of the distributor by operation of relay 327 until one-half of the start impulse interval has elapsed and, accordingly, the ideal operating condition would be for relay 327 to operate its armature to the right-hand contact eleven thousandths of a second after relay 321 operates and this interval added to the interval of one hundred thirty-two thousandths of a second for six half cycles of relay 341 gives a total interval of one hundred forty-three thousands of a second. There are four hundred twenty such intervals in one minute and a negligible fraction of a second thereover, so that one minute may be employed as a counting time and four hundred twenty cycles of the distributor may be considered as the standard for one minute of continuous operation.

When key 303 is operated contacts 2 and 3 open, thereby disconnecting the armature of relay 16 from the winding of relay 321 and contacts 1 and 2 close to substitute ground potential on one terminal of the lower winding of relay 321 through the back contact and armature 2 of relay 306 and through the back contact and armature 1 of relay 307. Contacts 4 and 6, from the former to the latter of which contact 5 moves when key 303 is operated, both have negative polarity which continues to be extended to the other terminal of the lower winding of relay 321 after key 303 is operated. Contacts 7 and 8 extend ground connection to magnet 438 through the back contact and armature 2 of relay 366 as in the previously described testing and adjusting operation.

The technique of conducting the test is the same, namely, key 303 is operated at the instant that time starts to run and is restored at the end of one minute. At the instant that key 303 is operated the armature of relay 321 moves out of engagement with its left-hand contact and initiates a complete cycle of the distributor such as has been described herein in detail. Relay 327 operates its armature to its right-hand contact a timed interval thereafter, depending upon the adjustment of resistor 328, and operates relay 306. It also starts the oscillatory relay system comprising relays 338, 339, 341 and 347. Relay 306 interrupts the circuit of the lower winding of relay 321 which restores its armature to its left-hand contact and causes the relay 327 to restore its armature to its left-hand contact. Relays 369, 366, 358, 363, 372 and 356 operate in succession in timed relation and when relay 363 operates it completes the energizing circuit for relay 307. Relay 307 provides a second interruption in the energizing circuit for the lower winding of relay 321 and releases relay 306 which removes the first interruption in that circuit. Thereafter relays 372 and 356 operate which completes the counting relay sequence. It is to be noted that this is not the conclusion of the distributor interval for the reason that relay 369 became operated substantially simultaneously with the operation of the relay 327 when relay 341 began to time the first or start impulse interval. Thereafter the remaining five counting relays are operated as the relay 341 begins to time the impulse interval for each of the five selecting impulses of the code combination. Accordingly, the third return of the armature of relay 341 to its left-hand contact occurs substantially a full impulse interval after the operation of relay 356, such return denoting the end of the fifth selecting impulse and the end of the sixth impulse timed by relay 341, the start impulse being counted along with the selecting impulse.

The armature of relay 341, returned to its left-hand contact for the third time, operates relay 392 which releases relay 307. The latter relay recloses the circuit of the lower winding of relay 321 which operates to initiate another cycle of the distributor. At the end of the timing interval of one minute key 303 is restored to normal which causes the distributor to stop at the end of the cycle then in progress. If the counting register 439 reads more or less than four hundred twenty operations, variable resistor 328 is adjusted and the testing operation is repeated until an adjustment has been attained which will produce four hundred twenty operations of the distributor in one minute.

With regard to the timing of relay 341 and of relay 327, a feature of the operation of relay 341 should be noted. When the system is at rest, both of the conductors 334 and 344 are at ground potential so that condenser 348 is discharged. Upon the removal of the ground connection from conductor 334, by relay 327 in response to the start impulse of a code combination, condenser 348 charges from the discharged condition and a certain interval elapses before the charging current has decreased to the point where the current through the upper winding of relay 341 will take control and move the armature to the right-hand contact. When relay 347 transfers ground potential from conductor 344 to conductor 334 upon movement of the armature of relay 341 to the right-hand contact, the polarity applied to the lower winding of relay 341 is the opposite of that previously applied and is in series-aiding relation to the charge accumulated on condenser 348. Accordingly, condenser 348 first discharges, passing through the condition of zero charge and then charges in the opposite direction. A slightly longer interval is required to discharge the condenser and charge it in the opposite direction until the charging current decreases to a value which permits the upper winding of the relay 341 to operate the armature then is required to charge the condenser from a condition of no charge, so that the second impulse interval is slightly longer than the first. Each succeeding interval timed by relay 341 within one code combination is the same as the second interval because discharging and recharging of the condenser must occur. When ground potential is applied to conductor 344 upon the third return of the armature of relay 347 to its left-hand contacts, which occurs at the end of the last impulse of the code, condenser 348 is again discharged.

In the operation of testing and adjusting the timing of relay 341, by the operation of key 333, condenser 348 starts from the condition of no charge and the interval before the first transit of the armature of relay 341 is a short interval. Thereafter as long as key 333 remains operated, condenser 348 swings from the condition of charge in one direction to equal charge in the opposite direction, since at no time are conductors 334 and 344 grounded simultaneously. Thus all the half cycles of relay 341 except the first half cycle are equal during the one minute or sixty-six second timing interval but relay 341 goes through three thousand half cycles in sixty-six seconds and the effect of one half cycle of slightly less than twenty-two thousandths second duration is negligible when averaged out over the remaining two thousand nine hundred ninety-nine half cycles so that each half cycle will not differ from twenty-two thousandths second by a significant amount.

The second timing and adjusting operation, effected by the operation of the key 303, times cycles of the complete distributor, each cycle beginning with the operation of relay 321. In the interval in each such cycle between the third return of the armature of relay 347 to its left-hand contact and the operation of relay 327 both of the conductors 334 and 344 are grounded so that condenser 348 is discharged. With the adjustment of relay 327 being made on a basis of four hundred twenty full cycles of the distributor per minute an interval of one hundred forty-three thousandths second is allotted to each cycle of operation of the distributor. Five of the half cycles of relay 341 are known by previous adjustment to occupy twenty-two thousandths second each for a total of one hundred ten thousandths second. The time interval between the operation of relay 321 and the first movement of the armature of relay 341 to its right-hand contact therefore has a duration of thirty-three thousandths second. Of this interval the time required for the armature of relay 341 to move to its right-hand contact after relay 327 operates is something less than twenty-two thousandths second and the time of operation of relay 327 is something more than eleven thousandths second after the operation of relay 321. Thus the operation of relay 327 does not come exactly in the middle of the interval during which relay 16 responds to the start signal but the operation of relays 338 and 339 does occur in the middle of each interval during which relay 16 is responding to the selecting impulses. The differential is represented by the shortened first half cycle of relay 341. If the timing of relay 302 under the control of condenser 316 and resistor 317 is such that relay 302 should operate to its right-hand contact at the same time that relay 327 operates to its right-hand contact, the start impulse transmitted by relay 17 would be shorter than the selecting impulses by the amount that the first half cycle of relay 341 differs from the other half cycles of that relay. By providing proper values for condenser 316 and resistor 317, the relay 302 may be adjusted to operate slightly in advance of relay 327 so that the start impulse generated by relay 17 will be of the same duration as the selecting impulses.

Although a particular embodiment of the invention has been shown in the drawings and described in the foregoing specification, it will be understood that the invention is not limited to such specific embodiment but is capable of modification and rearrangement without departing from the spirit of the invention and within the scope of the appended claims.

What is claimed is:

1. In a telegraph system, a signal responsive relay, a signal generating relay, a plurality of cipher coding relays for controlling said signal generating relay jointly with said signal responsive relay, selector means individual to and having exclusive control over each of said cipher coding relays for selectively operating said cipher coding relays, and means controlled by certain of said cipher coding relays for actuating said selector means.

2. In a telegraph system, a signal responsive relay, a signal generating relay, a plurality of cipher coding relays arranged in sets individual to each impulse of a telegraph signal for controlling said signal generating relay jointly with said signal responsive relay, selector means individual to and having exclusive control over each of said cipher coding relays for selectively operating said cipher coding relays, and means controlled by certain of said cipher coding relays for actuating said selector means.

3. In a telegraph system, a signal responsive relay, a signal generating relay, a plurality of cipher coding relays arranged in sets individual to each impulse of a telegraph signal for controlling said signal generating relay jointly with said signal responsive relay, switching means individual to each of said cipher coding relays for selectively energizing and releasing said cipher coding relays, and means controlled by certain of said cipher coding relays for actuating said switching means.

4. In a telegraph system, a signal responsive relay, a signal generating relay, a plurality of cipher coding relays arranged in sets individual to each impulse of a telegraph signal for controlling said signal generating relay jointly with said signal responsive relay, switching means individual to said cipher coding relays and arranged in groups for selectively energizing and releasing their associated cipher coding relays, and means controlled by certain of said cipher coding relays for actuating said groups of switching means.

5. In a telegraph system, a signal responsive relay, a signal generating relay, a plurality of cipher coding relays arranged in sets individual to each impulse of a telegraph signal for controlling said signal generating relay jointly with said signal responsive relay, switching means individual to said cipher coding relays and arranged in groups with each switching means in a group associated with a cipher coding relay of a different set for selectively energizing and releasing their associated cipher coding relays, and means controlled by a plurality of said cipher coding relays for actuating each of said groups of switching means.

6. In a telegraph system, a signal responsive relay, a signal generating relay, a plurality of cipher coding relays for controlling said signal generating relay jointly with said signal responsive means, switching means comprising a plurality of contacts and a contactor individual to each of said cipher coding relays each cipher coding relay having its energizing winding connected to a different combination of contacts of its switching means, and means for selectively advancing the contactors of said switching means to cause said cipher coding relays to be selectively energized and released.

7. In a telegraph system, a signal responsive relay, a signal generating relay, a plurality of cipher coding relays for controlling said signal generating relay jointly with said signal responsive relay, switching means comprising a plurality of contacts and a contactor individual to each of said cipher coding relays, means for connecting the energizing winding of each cipher coding relay to less than all of the contacts of its switching means in combination different from the connections of each other cipher coding relay, and means for selectively advancing the contactors of said switching means to cause said cipher coding relays to be selectively energized and released.

8. In a telegraph system, a signal responsive relay, a signal generating relay, a plurality of cipher coding relays for controlling said signal generating relay jointly with said signal responsive relay, switching means comprising a plurality of contacts and a contactor individual to each of said cipher coding relays, means for connecting the energizing winding of each cipher coding relay to less than all of the contacts of its switching means in variable combinations, and means for selectively advancing the contactors of said switching means to cause said cipher coding relays to be selectively energized and released.

9. In a telegraph system, a signal responsive relay, a signal generating relay, a plurality of cipher coding relays for controlling said signal generating relay jointly with said signal responsive relay, switching means comprising a plurality of contacts and a contactor individual to each of said cipher coding relays, a multiple contact jack individual to each cipher coding relay and switching means, said jack having one contact connected to the energizing winding of its cipher coding relay and its other contacts connected to the contacts of its associated switching means, a plurality of multiple pin plugs usable in any of said jacks, said plugs having various combinations of less than all of its pins connected to the pin which cooperates with the cipher coding re-

lay contacts of said jacks, and means for selectively advancing the contactors of said switching means to cause said cipher coding relays to be selectively energized and released through said jacks and plugs.

10. In a telegraph system, a signal responsive relay, a signal generating relay, a plurality of cipher coding relays for controlling said signal generating relay jointly with said signal responsive relay, switching means comprising a plurality of contacts and a contactor individual to each of said cipher coding relays, a multiple contact jack individual to each cipher coding relay and switching means, said jack having one contact connected to the energizing winding of its cipher coding relay and its other contacts connected to the contacts of its associated switching means in random order different for each jack, a plurality of multiple pin plugs usable in any of said jacks, said plugs having various combinations of less than all of its pins connected to the pin which cooperates with the cipher coding relay contacts of said jacks, and means for selectively advancing the contactors of said switching means to cause said cipher coding relays to be selectively energized and released through said jacks and plugs.

11. In a telegraph system, a signal responsive relay, a signal generating relay, a plurality of cipher coding relays for controlling said signal generating relay jointly with said signal responsive relay, switching means individual to said cipher coding relays and arranged in groups for selectively energizing and releasing their associated cipher coding relays, means controlled by certain of said cipher coding relays for selectively actuating said groups of switching means, and means for automatically transposing the operative connections between said certain cipher coding relays and said actuating means.

12. In a telegraph system, a signal responsive relay, a signal generating relay, a plurality of cipher coding relays for controlling said signal generating relay jointly with said signal responsive relay, switching means individual to said cipher coding relays and arranged in groups for selectively energizing and releasing their associated cipher coding relays, means controlled by certain of said cipher coding relays for selectively actuating said groups of switching means, and means operable once for each signal code combination impressed upon said signal responsive relay for transposing the operative connections between said certain cipher coding relays and said actuating means.

13. In a telegraph system, a signal responsive relay, a signal generating relay, a plurality of cipher coding relays for controlling said signal generating relay jointly with said signal responsive relay, switching means individual to said cipher coding relays and arranged in groups for selectively energizing and releasing their associated cipher coding relays, means controlled by certain of said cipher coding relays for selectively actuating said groups of switching means, and means operable in response to a predetermined impulse of unciphered code signal combinations for transposing the operative connections between said certain cipher coding relays and said actuating means.

14. In a telegraph system, a signal responsive relay, a signal generating relay, a plurality of cipher coding relays for controlling said signal generating relay jointly with said signal responsive relay, switching means individual to said cipher coding relays and arranged in groups for selectively energizing and releasing their associated cipher coding relays, means controlled by certain of said cipher coding relays for selectively actuating said groups of switching means, and means operable in response to unciphered code signal combinations having a predetermined impulse thereof conforming to a particular impulse characteristic for transposing the operative connections between said certain cipher coding relays and said actuating means.

15. In a telegraph system, a signal responsive relay, a signal generating relay, a plurality of cipher coding relays for controlling said signal generating relay jointly with said signal responsive relay, switching means individual to said cipher coding relays and arranged in groups for selectively energizing and releasing their associated cipher coding relays, means controlled by certain of said cipher coding relays for selectively actuating said groups of switching means, means for transposing the operative connections between said certain cipher coding relays and said actuating means, means selectively controlled by certain others of said cipher coding relays for preparing said transposing means to be operated, and means operable in response to unciphered code signal combinations having a predetermined impulse thereof conforming to a particular impulse characteristic for operating said prepared actuating means.

16. In a telegraph system, a signal responsive relay, a signal generating relay, a plurality of cipher coding relays for controlling said signal generating relay jointly with said signal responsive relay, switching means individual to said cipher coding relays and arranged in groups for selectively energizing and releasing their associated cipher coding relays, means controlled by certain of said cipher coding relays for selectively actuating said groups of switching means, means for transposing the operative connections between said certain cipher coding relays and said actuating means, means selectively controlled by certain others of said cipher coding relays for preparing said transposing means to be operated, means operable in response to unciphered code signal combinations having a predetermined impulse thereof conforming to a particular impulse characteristic for operating said prepared actuating means, and means operable once for each signal code combination impressed upon said signal responsive relay for further transposing the operative connections between the first-mentioned certain of said cipher coding relays and said actuating means.

17. In a telegraph system, a signal responsive relay having an armature operable between marking and spacing contacts of opposite polarity, a signal generating relay having a polar operating winding energizable from either of said contacts over either of two paths connected to opposite terminals of said winding, a plurality of switching instrumentalities for selecting either of said paths, means for actuating said switching instrumentalities, means for operating said switching instrumentality actuating means, means for transposing the operating connections between said operating means and said switching instrumentality actuating means, and means responsive to the polarity received by said armature from one of said contacts for operating said transposing means.

18. In a telegraph system, a signal responsive relay having an armature operable between

marking and spacing contacts of opposite polarity, a signal generating relay having a polar operating winding energizable from either of said contacts over either of two paths connected to opposite terminals of said winding, a plurality of switching instrumentalities for selecting either of said paths, means for actuating said switching instrumentalities, means for operating said switching instrumentality actuating means, means for transposing the operating connections between said operating means and said switching instrumentality actuating means, and means responsive jointly to the polarity received by said armature and to the path selected by said switching instrumentalities for operating said transposing means.

19. In a telegraph system, means for generating telegraph signals to be transmitted to a distant point, a signal responsive relay responsive alternatively to signals generated by said generating means or to signals received from a distant point, said relay having an armature operable between marking and spacing contacts of opposite polarity, a signal generating relay having a polar operating winding energizable from either of said contacts over either of two paths connected to opposite terminals of said winding, a pluraltiy of switching instrumentalities for selecting either of said paths, means for actuating said switching instrumentalities, means for operating said switching instrumentality actuating means, means for transposing the operating connections between said operating means and said switching instrumentality actuating means, means controllable alternatively according to the polariy received by said armature from one of said contacts or according to the path selected by said switching instrumentalities and the polarity received by said armature from said contacts for operating said transposing means, and means controlled by said telegraph signal generating means for selecting the alternative operating conditions of the operating means for said transposing means.

20. A method of ciphering, at the transmitting end, and deciphering at the receiving end, a permutation code message which comprises initiating ciphered transmission and deciphered reception of a message at corresponding starting points in identical ciphering and deciphering sequences and causing identical changes in said sequences at random intervals as a function of the codes transmitted.

21. A method of ciphering, at the transmitting end, and deciphering at the receiving end, a permutation code message which comprises initiating ciphered transmission and deciphered reception of a message at corresponding starting points in identical ciphering and deciphering sequences and causing identical changes in said sequences at random intervals under control of the unciphered codes transmitted and correspondingly under control of the deciphered codes received.

22. The method of ciphering permutation code messages which comprises converting each message code combination to be transmitted into another code combination selected at random and converting each successive message code combination into a code combination determined as a combined function of a ciphering mechanism and the preceding message code.

23. The method of deciphering ciphered permutation code messages which comprises converting each received cipher code combination into a message code combination and determining the nature of each conversion after the first as a function of a deciphering mechanism and the preceding message code combination.

24. In a telegraph system, a signal responsive relay, a signal generating relay, a plurality of cipher coding relays for controlling said signal generating relay jointly with said signal responsive relay, switching means comprising a plurality of contacts and a contactor individual to each of said cipher coding relays, interchangeable means for connecting the energizing winding of the cipher coding relay to less than all of the contacts of its switching means in variable combinations, and means for selectively advancing the contactors of said switching means to cause said cipher coding relays to be selectively energized and released.

25. In a telegraph system, a signal responsive relay, a signal generating relay, a plurality of cipher coding relays for controlling said signal generating relay jointly with said signal responsive relay, switching means comprising a plurality of contacts and a contactor individual to each of said cipher coding relays, means universally interchangeable among said switching means and said cipher coding relays for connecting the energizing winding of each cipher coding relay to less than all of the contacts of its switching means in variable combinations, and means for selectively advancing the contactors of said switching means to cause said cipher coding relays to be selectively energized and released.

26. In a telegraph system, a signal responsive relay, a signal generating relay, a plurality of cipher coding relays for controlling said signal generating relay jointly with said signal responsive relay, switching means individual to said cipher coding relays and arranged in groups for selectively energizing and releasing their associated cipher coding relays, means controlled by certain of said cipher coding relays for selectively actuating said groups of switching means, and means operable in response both to code signal combinations before ciphering and to code signal combinations after deciphering having a predetermined impulse thereof conforming to a particular impulse characteristic for transposing the operative connections between said certain cipher coding relays and said actuating means.

27. In a system for selectively establishing the starting condition of telegraph signal ciphering apparatus, a plurality of stepping switches each including at least one bank of contacts for causing the ciphering of telegraph signals and at least one other bank of contacts and a contactor for each of said banks, a stepping magnet for each switch having an interrupter contact, means for preparing a circuit from any contact of said other bank of each switch over which to energize its stepping magnet through the contactor cooperating with said other bank in shunt relation to its interrupter contact, and means for simultaneously completing the energizing circuits of all of said stepping magnets through their interrupter contacts to initiate advancement of said contacts toward completion of said prepared circuits.

28. In a system for selectively establishing the starting condition of telegraph signal ciphering apparatus, a plurality of stepping switches each including at least one bank of contacts for causing the ciphering of telegraph signals and at least one other bank of contacts and a contactor for each of said banks, a stepping magnet for each switch having an interrupter contact, manually operable means for preparing simultaneously a

circuit from one contact of said other bank of contacts of each of said switches over which to energize the stepping magnets associated with said switches through the contactors associated with the respective other banks in shunt relation to the interrupter contacts of said magnets, and means for simultaneously completing the energizing circuits of said magnets through their interrupter contacts to initiate advancement of said contactors toward completion of said prepared circuits.

29. In a system for selectively establishing the starting condition of telegraph signal ciphering apparatus, a plurality of stepping switches each including at least one bank of contacts for causing the ciphering of telegraph signals and at least one other bank of contacts and a contactor for each of said banks, a stepping magnet for each switch having an interrupter contact, a plurality of manually and individually operable devices for preparing circuits from any one of certain selected contacts of said other bank of each said switches in combinations of one circuit for each such bank over which to energize the stepping magnets associated with said switches through the contactors associated with the respective banks in shunt relation to the interrupter contacts of said magnets, and means for simultaneously completing the energizing circuits of said magnets through their interrupter contacts to initiate advancement of said contactors toward completion of said prepared circuits.

30. In a system for selectively establishing the starting condition of telegraph signal ciphering apparatus, a plurality of stepping switches each including at least one bank of contacts for causing the ciphering of telegraph signals and at least one other bank of contacts and a contactor for each of said banks, a stepping magnet for each switch having an interrupter contact, means for variably and selectively extending conductive paths from more than one contact and less than 20 per cent of the contacts of said other bank of each of said switches, a plurality of manually and individually operable devices for preparing circuits over one of the conductive paths from said other bank of each switch in variable combinations of one circuit from each such bank over which to energize the stepping magnets associated with said switches through the contactors associated with the respective banks in shunt relation to the interrupter contacts of said magnets, and means for simultaneously completing the energizing circuits of said magnets through their interrupter contacts to initiate advancement of said contactors toward completion of said prepared circuits.

31. In a system for selectively establishing the starting condition of telegraph signal ciphering apparatus, a plurality of stepping switches each including at least one bank of contacts for causing the ciphering of telegraph signals and at least one other bank of contacts and a contactor for each of said banks, a stepping magnet for each switch having an interrupter contact, means for preparing a circuit from any contact of said other bank of each switch over which to energize its stepping magnet through the contactor cooperating with said one bank in shunt relation to its interrupter contact, means for simultaneously completing the energizing circuits of said magnets through their interrupter contacts to initiate advancement of said contactors toward completion of said prepared circuits, an indicator device, and means operable over each of said prepared circuits upon completion of said circuit for cooperatively operating said indicator device to indicate completion of all of said circuits.

32. In a system for selectively establishing the starting condition of telegraph signal ciphering apparatus, a plurality of stepping switches each including at least one bank of contacts for causing the ciphering of telegraph signals and at least one other bank of contacts and a contactor for each of said banks, a stepping magnet for each switch having an interrupter contact, means for preparing a circuit from any contact of said other bank of each switch over which to energize the stepping magnet through the contactor cooperating with said bank in shunt relation to its interrupter contact, means for simultaneously completing the energizing circuits of said magnets through their interrupter contacts to initiate advancement of said contactors toward completion of said prepared circuits, a relay associated with each of said prepared circuits and operable upon completion of its circuit, a chain circuit path normally open at an armature and contact of each of said relays, and an indicator device operable over said chain circuit path for indicating completion of all of said prepared circuits.

33. In a system for selectively establishing the starting condition of telegraph signal ciphering apparatus, the combination comprising a plurality of stepping switches each having banks of contacts and a contactor for each bank, a stepping magnet for each switch having an interrupter contact, means for preparing a circuit from any contact of one bank of each switch over which to energize its stepping magnet through the contactor cooperating with said one bank in shunt relation to its interrupter contact, and means for simultaneously completing the energizing circuits of all of said stepping magnets through their interrupter contacts to initiate advancement of said contactors toward completion of said prepared circuits.

34. In a system for selectively establishing the starting condition of telegraph signal ciphering apparatus, a plurality of stepping switches each including at least one bank of contacts for causing the ciphering of telegraph signals and at least one other bank of contacts and a contactor for each of said banks, means associated with each of said switches for causing step-by-step operation thereof, means for selectively preconditioning one contact of said other bank of each of said switches to interrupt said step-by-step operation, and means for initiating simultaneous continuous step-by-step operation of all of said switches toward said preconditioned contacts.

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