

Sept. 24, 1946.

F. F. SHIPLEY

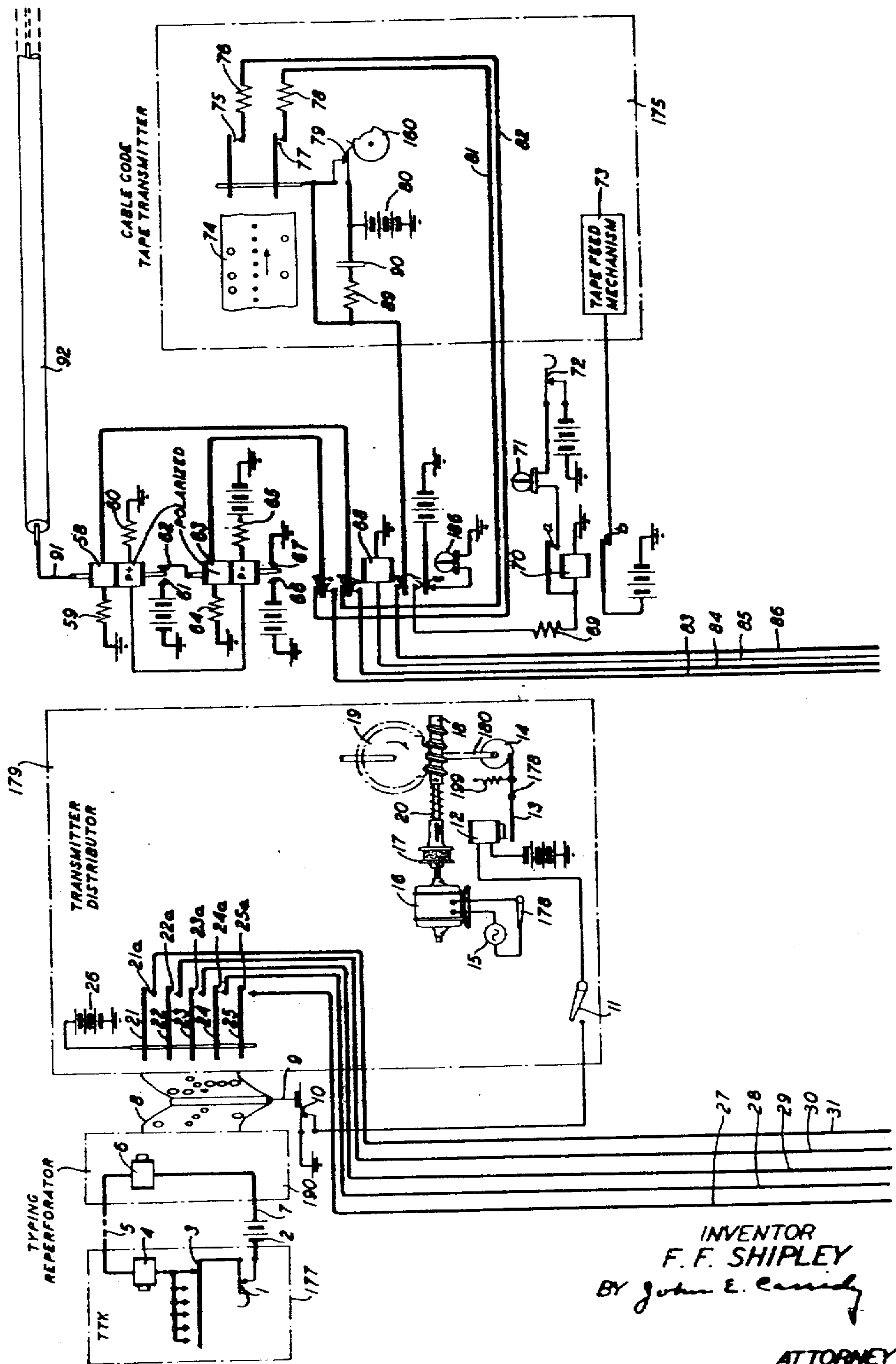
2,408,100

TELEGRAPH PERMUTATION CODE SIGNAL TRANSLATOR

Filed April 28, 1944

5 Sheets-Sheet 1

FIG. 1.



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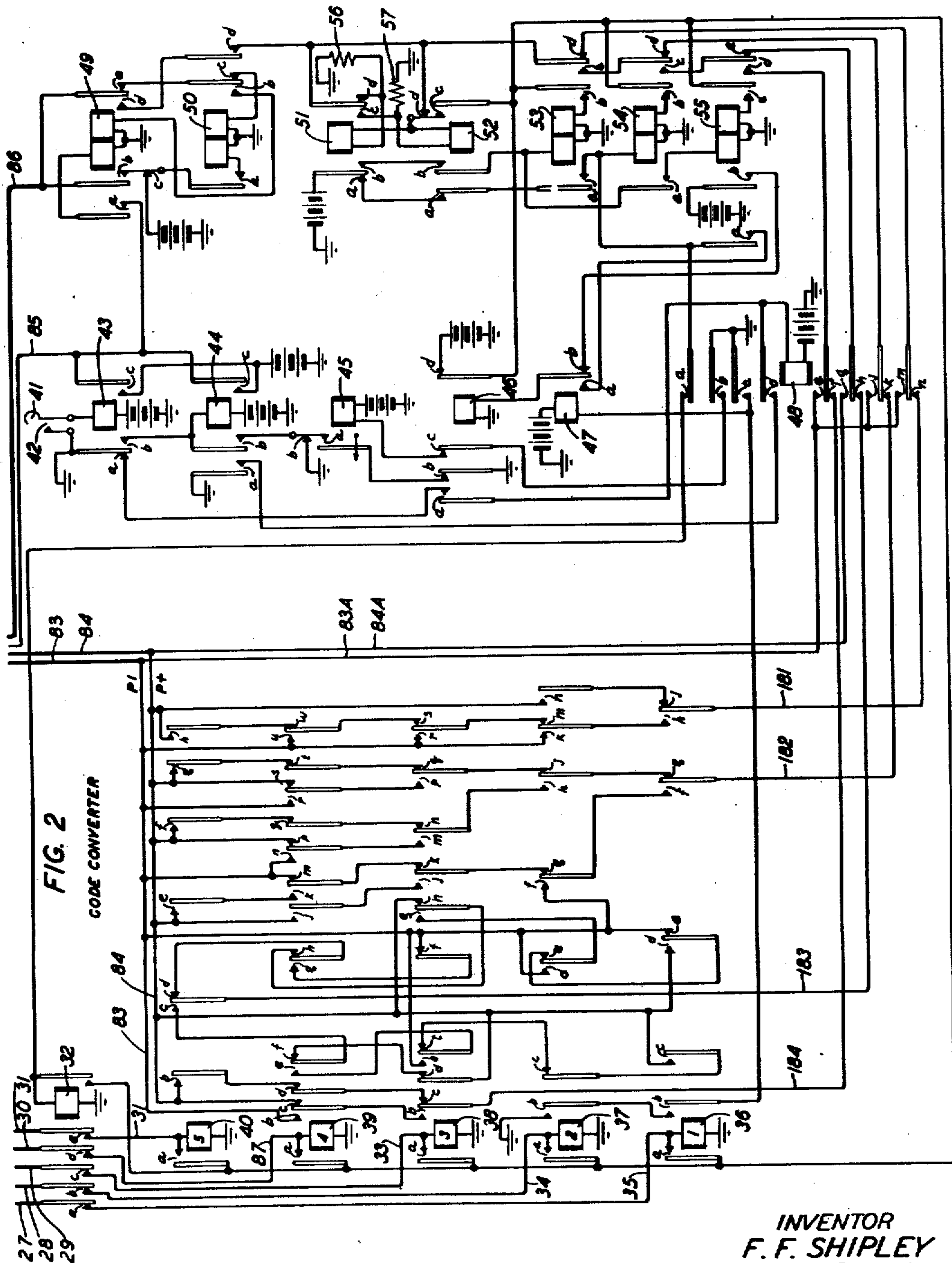
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2,408,100

TELEGRAPH PERMUTATION CODE SIGNAL TRANSLATOR

Filed April 28, 1944

5 Sheets-Sheet 2



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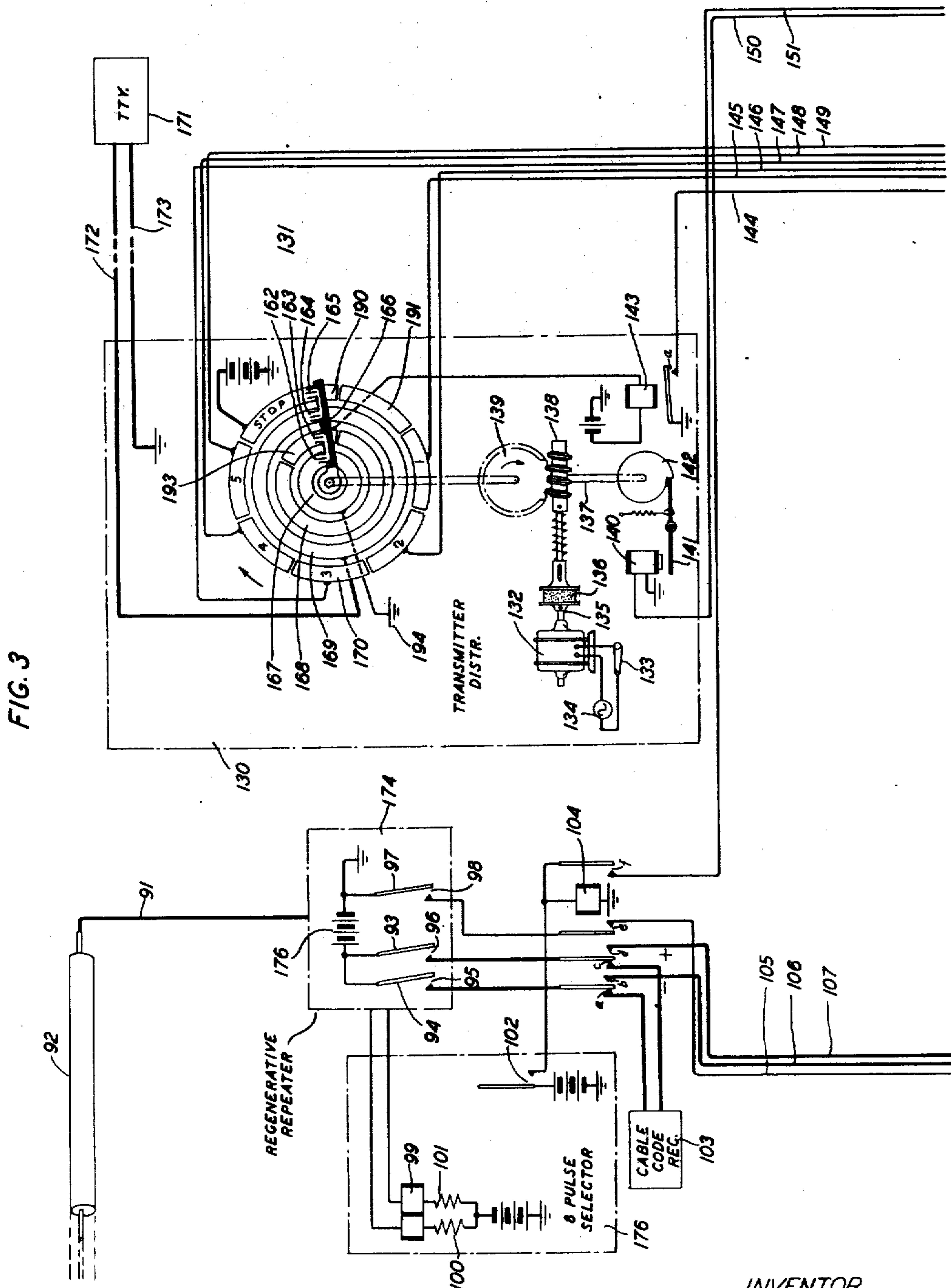
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TELEGRAPH PERMUTATION CODE SIGNAL TRANSLATOR

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5 Sheets-Sheet 3



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TELEGRAPH PERMUTATION CODE SIGNAL TRANSLATOR

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5 Sheets-Sheet 4

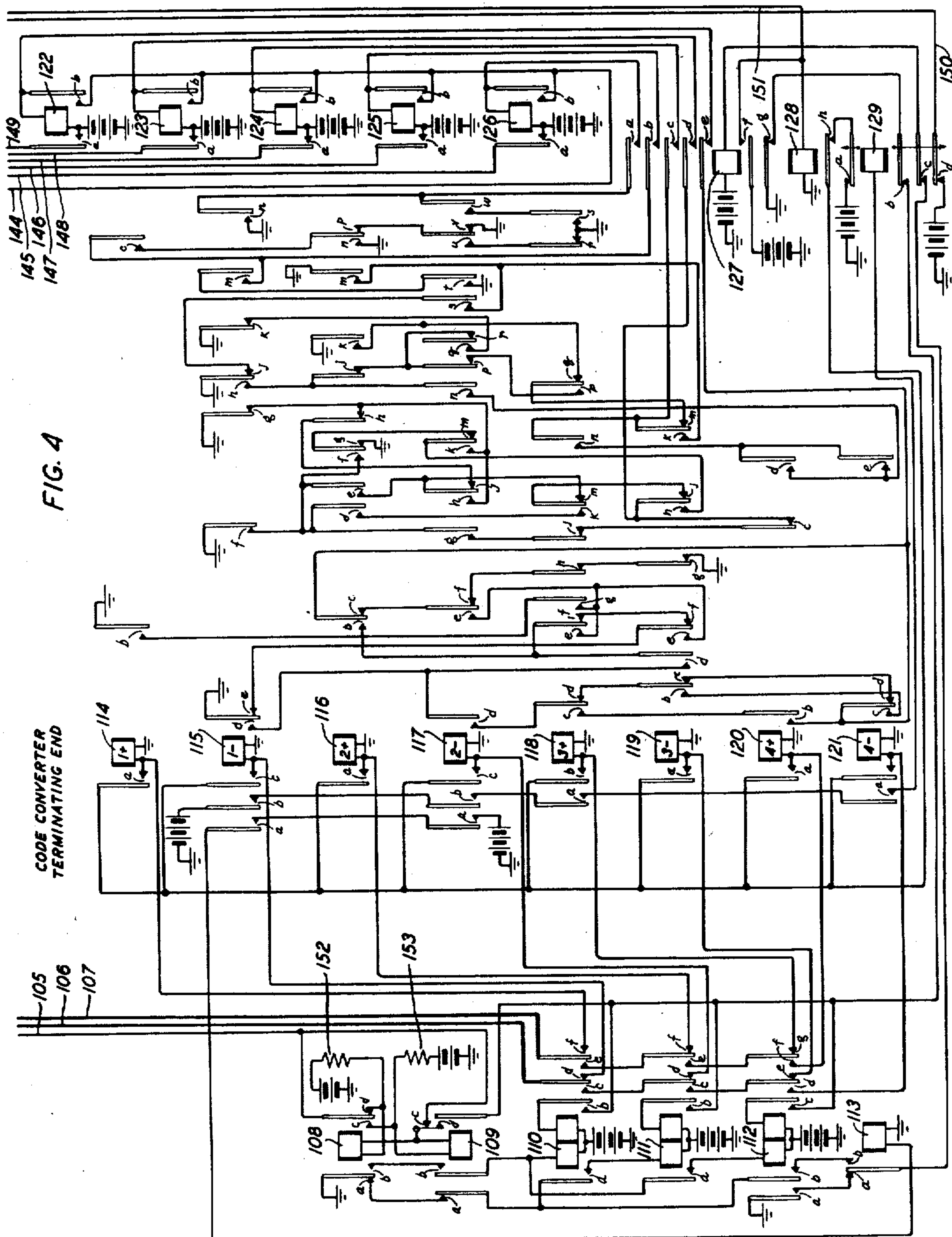


FIG. 4

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TELEGRAPH PERMUTATION CODE SIGNAL TRANSLATOR

Filed April 28, 1944

5 Sheets-Sheet 5

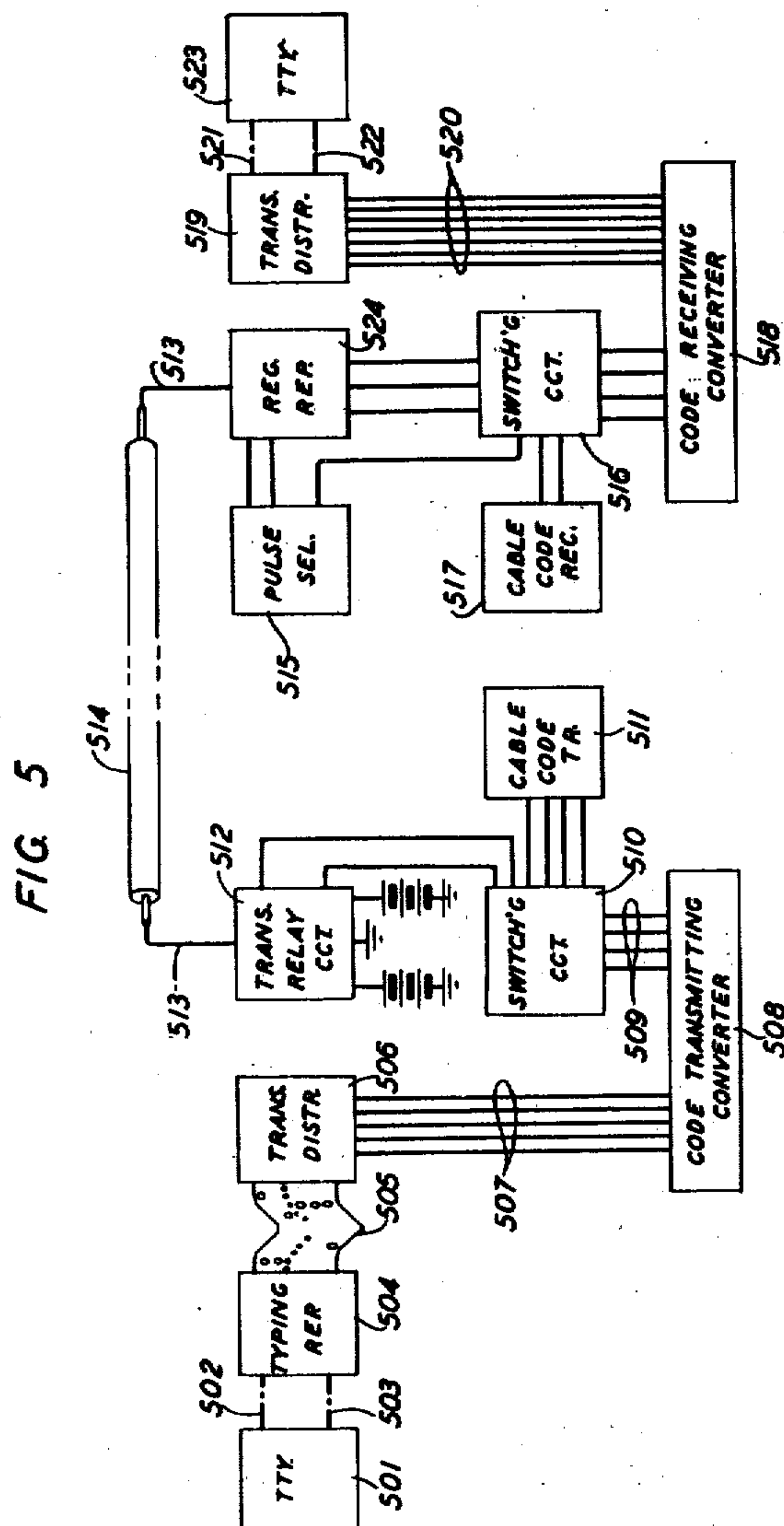


FIG 6

SYMBOL	TAPE PIN RELAYS FIG. 2	CABLE PULSES
a	1 2	--+0
b	1 4 5	-++
c	2 3 4	+0-
d	1 4	-0-
e	1	0-+
f	1 3 4	-+0
g	2 4 5	+00
h	3 5	0+0
i	2 3	++-
j	1 2 4	---0
k	1 2 3 4	--0-
l	2 5	+++
m	3 4 5	0--
n	3 4	0-0
o	4 5	000
p	2 3 5	+0+
q	1 2 3 5	-0+
r	2 4	+0-
s	1 3	-0+
t	5	0++
u	1 2 3	---+
v	2 3 4 5	+--
w	1 2 5	--++
x	1 3 4 5	-+-
y	1 3 5	-00
z	1 5	+--+
-		00+
SPACE	3	0+-
CARRIAGE RETURN	4	00-
LINE FEED	2	+0+
FIGURES	1 2 4 5	---00
LETTERS	1 2 3 4 5	-----
STOP	NOTHING	--+-
START	2 LETTERS (1 2 3 4 5) (2 3 4 5)	NOTHING

601
602
603

FIG. 8

FIG 7

PULSE CONTROL & TRANSFER RELAYS
0 = RELEASED **✓ = OPERATED**

	(1)	(2)	(3)	(4)
PULSE				
RELAY 52	0	✓	0	0
RELAY 51	0	0	✓	0

↑ ↑ ↑
53 54 55
PULSE TRANSFER RELAYS
OPERATE

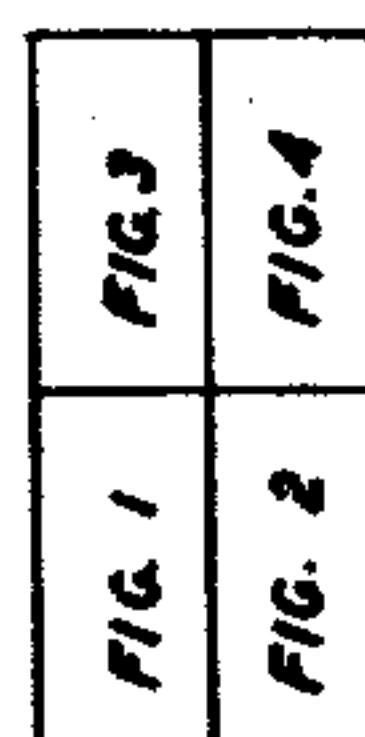


FIG. 8

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2,408,100

TELEGRAPH PERMUTATION CODE SIGNAL
TRANSLATOR

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Application April 28, 1944, Serial No. 533,106

8 Claims. (Cl. 178—3)

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This application relates to the translation of permutation code telegraph signals in accordance with one code into permutation code telegraph signals in accordance with a second and different code.

More specifically this application relates to the translation of five-element two-condition permutation code telegraph signals into three-condition signals some of which have four elements and others of which have three elements.

A system has heretofore been proposed in which five-element two-condition permutation code telegraph signals are all translated into four-element three-condition permutation code signals. The system herein represents an improvement over said proposed system in that it effects a saving in the time required for transmission due to the fact that the transmission of the three-element signals requires less time than the transmission of four-element signals.

As is well known in the art due to the electrical characteristics of certain transmission channels, particularly long submarine cables, it is not possible to transmit over them at a high rate of speed. As a result of this a system of transmission is employed wherein each signal element which is transmitted over the cable may be of any one of three conditions, namely, positive battery, negative battery or ground. With such an arrangement it is possible to define a character with fewer signal elements than in a system wherein each signal element may be of one of two conditions only.

In the arrangement herein a system employing a long telegraph channel arranged for the slower three-condition signaling is used as a link to interconnect two stations arranged for the faster two-condition signaling. More specifically, a transmitting station arranged for the slower three-condition signaling is interconnected through a long submarine cable to a receiving station arranged to receive the slower signals. The circuits are arranged in such manner that when five-element two-condition start-stop permutation code signals are to be transmitted over the cable, the cable is automatically seized at the transmitting end. The five-element two-condition signals are passed through a signal code translator which translates them into three-condition signals suitable for transmission over the cable. Two characteristic signal combinations are first transmitted over the cable. In response to this the receiving end of the cable is switched from its regular receiver and connected instead to a retranslating mechanism. In the retrans-

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lating mechanism the three-condition signal elements are retranslated into the original five-element two-condition signal elements, then the translated signals are impressed on a five-element two-condition receiving system. When the transmission of the translated two-condition signal elements over the cable is terminated a characteristic stop signal combination is transmitted over the cable. In response to this the receiving end of the cable is automatically reconnected to its three-condition cable code receiver.

The invention is illustrated in its present embodiment on the accompanying drawings which disclose a system for attaining the maximum speed of transmission over a long cable employing the well-known cable code, wherein five-element two-condition start-stop permutation code telegraph signals are translated into three-condition cable code signals. In the present embodiment twenty-four of the thirty-two five-element two-condition signals are translated into three-element three-condition signals and the remaining eight five-element two-condition signals are translated into eight four-element three-condition signals. The invention may be understood from the following description when read with reference to the associated drawings in which:

Fig. 1 shows the transmitting end of the five-element two-condition start-stop permutation code telegraph signal transmitting system and the transmitting end of the three-condition cable code system;

Fig. 2 is the transmitting signal code translator;

Fig. 3 shows the cable code receiver and the five-element two-condition start-stop receiving mechanism;

Fig. 4 shows the receiving code translator;

Fig. 5 shows an introductory diagram for explaining the relationship of the major apparatus units of the system;

Fig. 6 is a cable code diagram used in explaining the code translations;

Fig. 7 is a diagram used in explaining the operation of the code translating pulse control relays; and

Fig. 8 is a diagram showing the manner in which Figs. 1, 2, 3 and 4 should be arranged physically each in relation to the other to form an operative system.

Refer now to Fig. 5. In Fig. 5 as mentioned above, the major apparatus units employed in Figs. 1 to 4 are shown in their relationship to each other. This will be explained as an intro-

duction to a more detailed description to follow. The teletypewriter transmitting station 501 which generates five-element two-condition start-stop teletypewriter code combinations is interconnected by means of two conductors 502 and 503 to a typing reperforator 504. The teletypewriter signal combinations transmitted from teletypewriter transmitting station 501 are received by the typing reperforator 504 and punched in a tape 505. The punched tape 505 is passed through a transmitting distributor. The transmitting distributor impresses five-element two-conditions signals through the five conductors 507 and the code converter 508 which converts the five-element two-condition signals into three-condition signals some of which are three-element and others of which are four-element. From the code converter 508, the translated signals are impressed through the four conductors 509 on the relay switching circuit 510. Cable code transmitter 511 is normally connected through switching circuit 510 to the cable transmitter relay circuit 512. When signals are transmitted from the teletypewriter's station 501, however, the system is arranged so that the cable code transmitter 511 is disconnected by the switching circuit 510 and the teletypewriter signals are impressed through the cable transmitter relay circuit 512 on the cable conductor 513 which is enclosed in cable 514. The cable extends to the distant receiving station where the cable conductor 513 is connected to a regenerative repeater 524 which is ordinarily connected through switching circuit 516 to the cable code receiver 517. Whenever the cable transmitter 512 is seized by the operation of the teletypewriter transmitting station 501, two characteristic signaling combinations are first transmitted over cable conductor 513. In response to this, switching circuit 516 is controlled through pulse selector 515 so as to disconnect cable code receiver 517 from regenerative repeater 524 and the regenerative repeater 524 is connected through the switching circuit 516 to the code receiving converter 518. In the code receiving converter the three and four-element three-condition signals are reconverted into five-element two-condition signals and impressed through conductors 520 and transmitting distributor 519. The transmitting distributor 519 impresses the signals on conductors 521 and 522 which extend to a distant teletypewriter receiving station 523.

Refer now to Fig. 6. Column 601 in Fig. 6 shows 26 letter and 6 functional symbols making a total of 32 used in five-element two-condition teletypewriter code transmission. It shows also a Stop designation and a Start designation. The 32 five-element code combinations have marking elements in the signal element positions shown in column 602 and spacing elements in the other of the five positions of each combination. The marking elements operate correspondingly numbered relays in the code converter per Fig. 2. Column 603 shows the three and four-element three-condition code combinations into which the corresponding five-element two-condition combinations are translated. Reference to columns 601 and 603 indicates that 24 of the 32 five-element letter and functional combinations shown in column 601 are translated into three-element cable code pulses and 8 of the 32 are translated into four-element cable code pulses. In column 603, — represents a negative pulse, + represents a positive pulse and 0 represents a ground pulse as the signal element transmitted over the cable

in the signal element position indicated. The foregoing will become more apparent below.

Reference to the bottom line of Fig. 6 shows the word "Start" in column 601 and the bottom line in column 602 is designated "2 letters." This indicates that two five-element teletypewriter code combinations corresponding to the functional code combination for printing letters, namely, + + + + + and + + + + + are translated into two four-element combinations, namely, — — — — and — — — —, and are transmitted over the cable when the system is to be arranged for the transmission of translated teletypewriter code combinations. These combinations are employed in switching the receiving end of the cable mechanism only and are not impressed on the receiving translator. The second last line in Fig. 6 indicates that a distinctive combination, namely, — — + — is transmitted over the cable as a stop signal when the transmission of translated teletypewriter code signals over the cable is completed. In response to this particular combination the regenerative repeater 514 is disconnected from the code receiving converter 518 and connected to the cable code receiver 517. There is no combination corresponding to this Stop combination shown in column 602. The reason for this is that the Stop combination is generated originally in the code converter in response to the operation of a switch when teletypewriter transmission is ended and there is no corresponding five-element code combination required for the performance of this function.

Detailed operation of circuit

The circuit per Figs. 1, 2, 3 and 4 is shown in the normal idle condition. When in this condition the armatures of relays 58 and 63 are actuated to engage their respective right-hand contacts under the influence of current flowing in a circuit which extends from battery through resistance 65, bottom winding of relays 63 and 58 and resistance 60 to ground. The circuit through the top windings of each of relays 58 and 63 is open. Relay 68 is released as key 41, Fig. 2, is not operated and contacts 43c and 44c are both open. Relay 104 in Fig. 3 is released and the receiving regenerative repeater 174 is connected through contacts 104a and 104c to the cable code receiver 103. The cable code transmitter 175 is well known in the art and will not therefore be described in detail herein. Regenerative repeater 174, selector 176 and the cable code receiver 103 are also well known in the art and will not therefore be described herein.

Relay 70, Fig. 1, is in the released condition and when in this condition establishes a circuit from battery through contact 70b through the tape feed mechanism 73 of the cable code transmitter to ground energizing the tape feed mechanism which is also well known in the art. Tape 74 is perforated in accordance with the continental cable code. The tape 74 is drawn into position so that the code combination appearing in tape 74 is presented to the tape sensing mechanism. If the upper longitudinal section is perforated in a particular transverse position, contact 75 will be closed. Cam 160 is rotated by a mechanism not shown. Cam 160 is arranged so that its associated contact 79 is closed during three-quarters of a revolution of the cam and contact 79 is open during one-quarter of a revolution. When contact 79 is closed, a circuit may be traced from battery 80 through contact 79 and, if contact 75 is closed,

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through contact 75, resistance 76, conductor 82, contact 68a, top winding of relay 63 and resistance 64 to ground actuating the armature of relay 63 to the left closing contact 66. The tape 74 is so perforated that contacts 75 and 77 are never closed simultaneously. The armature of relay 58 will be in engagement with its contact 62. A circuit may therefore be traced from negative battery through contact 66, contact 62 and cable conductor 91 which extends through the submarine cable to the distant regenerative repeater 174. In response to this signal the armature 94 will be actuated to close its contact 85 in a well-known manner. A circuit may then be traced from positive battery 176 through 94, contact 95 and contact 104a to the cable code receiver 103. Attention is called to the fact that, since contact 79 is open during a quarter of each revolution of cam 160, the armature of relays 58 and 63 will be under the influences of their biasing windings at such times. Contacts 62 and 67 will therefore be closed and ground will be connected to cable conductor 91 so as to discharge the cable. This is known in the art as curbing. Attention is also called to the fact that, in addition to ground for curbing, ground is also connected to cable 91 for one of the three signaling conditions when contacts 67 and 62 are closed.

The regenerative repeater 174 is under control of a tuning fork, not shown. The tuning fork is tuned to the speed of the sending distributor and reproduces the pulse for each revolution. This mechanism is well known in the cable telegraph art.

When the lower longitudinal section of tape 74 is perforated in a particular transverse position, contact 77 will be closed. When contact 79 is closed, a circuit may be traced from positive battery 80 through contact 79, contact 77, resistance 78, conductor 81, contact 68c, top winding of relay 58 and resistance 59 to ground actuating the armature of relay 58 to the left to close contact 64. Under these circumstances, positive battery is impressed through contact 61 on regenerative repeater 174 actuating the armature 93 to the left to close contact 96. A circuit may then be traced from positive battery through the armature 93, contact 96 and contact 104c to cable code receiver 103. If tape 74 is not perforated in either one of its two positions contacts 75 and 77 will both be open. The armatures of relays 58 and 63 will be under the influences of their biasing windings and their armatures will be in the positions shown in Fig. 1. Under this condition, a circuit may be traced from ground through contact 67 and contact 62 to conductor 91. In response to this, the armature of regenerative repeater 174 will be maintained in the position to which it was last actuated and the third of the three possible signaling conditions for an element will be impressed on the cable code receiver 103 in a well-known manner.

It will now be assumed that the operator at the teletypewriter station 177 wishes to transmit. Switch 178 will be closed to energize motor 16. Switch 11 will be closed to energize the transmitter distributor. The keys of teletypewriter keyboard transmitter 3 will be operated. In response to the open and closed signaling conditions for the signal elements of the five-element two-condition permutation code the receiving magnet 6 of the typing teletypewriter will be successively energized and deenergized over a circuit which may be traced from the left-hand

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terminal of battery 2 through the contact of break key 1 transmitting contacts 3, winding of the teletypewriting magnet 4, conductor 5, winding of typing reperforator magnet 6 and conductor 7 to the right-hand terminal of battery 2. It is pointed out that the teletypewriter station 177 may be interconnected to the typing reperforator 199 through long channels extending through a number of telegraph repeater and switching points.

When sufficient tape has been perforated, tape lever 9 will be lowered closing tape control contact 10. A circuit may then be traced from ground through contact 10, switch 11 and the winding of magnet 12 to battery. The transmitter cam stop lever 13 will be actuated in a clockwise direction about its fixed pin 178 against the influence of spring 199. The right-hand end of lever 13 is disengaged from a shoulder on the periphery of cam 14. Motor 16 drives shaft 20 through clutch 17. Shaft 20 is coupled to shaft 180 through worm 18 and worm gear 19. When cam 14 is released shaft 180 rotates drawing the tape 8 through transmitter distributor pins 21 to 25 in a well-known manner. The operation of the transmitter distributor 179 described in detail in Patent 2,055,567 to E. F. Watson, September 29, 1936, the pertinent portions of which are hereby made part of this description. Successive transverse sections of tape 8 will be perforated with successive combinations of the five-element two-condition code typed by the teletypewriter 177. There are five sensing pins 21 to 25 in the transmitting distributor 179. Where an element in tape 8 is perforated the corresponding contact 21a to 25a will be closed and where an element is not perforated the corresponding contact will be open. If a contact such as 21a is closed, a circuit may be traced from battery 26 through contact 21a, conductor 31, contact 32e and the winding of relay 40 to ground operating relay 40. There is a corresponding circuit for each of the other contacts 22a to 25a which extends through conductors 27 to 30, contacts 32a to 32d, conductors 35, 34, 33 and 87 and the windings of relays 36 to 39, respectively to ground. A particular code combination perforated in tape 8 is presented to the sensing pins 21 to 25 of the transmitting distributor 179 simultaneously. The circuits through the windings of relays 36 to 40 are established simultaneously and relays 36 to 40 will be set in unison at a particular instant for each combination. Relays 36 to 40 will be operated or unoperated depending upon whether its corresponding element in the five-element permutation code is a marking or a spacing element and upon whether it is represented by a perforated or an unperforated elemental area in a transverse section of tape 8. Each of relays 36 to 40 controls a plurality of contacts. The contacts of relays 36 to 40 will be set in conformity with the code. Relays 36 to 40 are also designated 1 to 5 to facilitate reference to table 602 in Fig. 6.

To anticipate the description of the detailed operation of the circuit, it is pointed out that it is possible to establish a path from battery 80 through any one of four branches through the bank of pulse control relays shown in the right-hand portion of Fig. 2 and through some particular one of conductors 181 to 184 which extends through the contacts of relays 36 to 40 shown in the left-hand portion of Fig. 2 and terminates either in conductor 83 or 84 which controls the operation of relays 58 and 63. The pulse control

relays shown at the right of Fig. 2 are arranged so that they first direct the battery pulse originating in battery 80 for the first revolution of a three or four revolution cycle of cam 160 to conductor 181. Depending upon the settings of the contacts of relays 36 to 40, conductor 181 will be connected to either conductor 83 or to conductor 84 to control the proper relay of relays 58 and 63 so as to send either a positive or negative pulse through the submarine cable to the distant station. To obtain the third condition that is the ground signaling condition, when required, the path extending from conductor 181 through the contacts of relays 36 to 40 will be open at some one of the switching points in the chain. When the circuit is open, relays 58 and 63 will be under control of their biasing circuits and ground will be transmitted for the particular signal element. The pulse control relays shown in the right-hand portion of Fig. 2 will switch the path extending from battery 80 through the contacts of the pulse control relays to conductor 182 for the second signal element of the code to be transmitted over the cable. The second element will be positive battery, negative battery or ground, depending upon whether or not a closed path is provided from conductor 182 to conductor 83 or 84 or if the path from 182 to both conductors 83 and 84 is open. For the third revolution of cam 160 the pulse control relays at the right of Fig. 2 will connect battery 80 to conductor 183. The circuit is arranged so that if the particular five-element two-condition combination has been translated into a three-element cable code combination the pulse control relays at the right of Fig. 2 will not progress after three elements have been transmitted but will restore the circuit so that the cycle may be repeated from the starting point. That is to say, after three pulses have been transmitted, battery 80, on the following revolution of cam 160, will be connected through the pulse control relays to conductor 181 to transmit the first element of the succeeding three or four-element code combination. However, if the five-element two-condition teletypewriter combination has been translated into a four-element cable code signal combination, this will be automatically recognized by a chain circuit through particular relays of the relay group 36 to 40 which are operated only when a five-element signal is to be translated into a four-element signal. The chain circuit will control the pulse control circuit so that, instead of restoring the pulse control circuit to normal at the end of transmission of the third signal element, the pulse control circuit will progress so that battery 80 is connected through the pulse control circuit to conductor 184, which controls relays 58 and 63 in the same manner as does each of conductors 181 to 183. In this case the fourth signal element is transmitted before the pulse control circuit restores the mechanism to the condition for the start of a new cycle of operations. This will now be described in more detail.

Preliminary to the operation of teletypewriter 177, locking key 41, Fig. 2, will be operated, closing contact 42 and operating relay 43 over an obvious circuit. The operation of relay 43 establishes a circuit from battery through the winding of relay 44 and contact 43b to ground, operating relay 44. A circuit may then be traced from battery through contact 44c and conductor 85 which extends through the winding of relay 68 to ground operating relay 68. The operation of re-

lay 68 disconnects the cable code transmitter 175 from the cable transmitting relays 58 and 63 by opening contacts 68a and 68c. When relay 44 operates, it locks over a circuit from battery through the winding of relay 44, contact 44b and contact 45b to ground. The reason for this will become apparent below.

While relay 68 is in the released condition a circuit may be traced from battery through contact 68g and the filament of lamp 186 to ground. Lamp 186 is lighted at such time to indicate that relays 58 and 63 are under control of the cable code tape transmitter 175. The closing of contact 68f establishes a circuit from battery through contact 68f, resistance 69 and the winding of relay 70 to ground operating relay 70. The closing of contact 70a when key 72 is closed establishes a circuit from battery through the contact of key 72, filament of lamp 71, contact 70a and the winding of relay 70 to ground, locking relay 70 and lighting lamp 71. The lighting of lamp 71 indicates that the cable transmitting relays 58 and 63 are under control of the teletypewriter through the code converter mechanism. The operation of relay 70 by opening contact 70b deenergizes the tape feed mechanism 73 of the cable code tape transmitter 175. This stops the feeding of tape 74 through the cable code transmitter. Conductors 83, 84 and 86 are extended through contacts 68b, 68d and 68e, respectively. The closing of contacts 68b and 68d connects the output leads 83 and 84 of the code converter per Fig. 2 through the top windings of relays 63 and 58, respectively. The closing of contact 68e connects the motor lead or, as it is otherwise known, the battery feed lead, which extends from battery 80 through contacts 79, when closed, contacts 68e and through conductor 86 to the pulse control relays at the right of Fig. 2.

It is necessary to insure that the first pulse which is transmitted through the cable after the transfer from the cable code tape transmitter to the code converter is not mutilated. This is performed by relays 49 and 50. After the operation of relay 68 if contact 79 is closed, or as soon thereafter as contact 79 is closed, a circuit is established from battery 80 through contact 79, contact 68e, conductor 86, contact 49e, contact 50c and the right-hand winding of relay 50 operating relay 50. Relay 50 first locks over a circuit from battery through contact 49c, contact 50a and its left-hand winding to ground. The operation of relay 50 by closing contact 50b extends conductor 86 through contact 50b and the right-hand winding of relay 49 to ground operating relay 49. When relay 49 operates, the original locking path for relay 50 is opened at contact 59c, but conductor 86 is extended through contact 49b, contact 50a and the left-hand winding of relay 50 maintaining relay 50 locked for an interval. When cam 160 has rotated into its curbing position contact 79 is opened and relay 50 will release. Relay 49 locks as soon as it is operated over a circuit which may be traced from ground through the left-hand winding of relay 49 and contact 49a to parallel branches. One branch extends through contact 43c to battery and the other branch extends through contact 44c to battery.

When the curbing portion of the cam revolution is reached, conductor 86 is extended through contacts 49d and 50d to contacts of counting relays 51 and 52 and in parallel through contact 53d and contact 48a to conductor 181. The operation of the counting relays will be described hereinafter.

It has been explained above that the first two combinations punched in tape 8 are two combinations corresponding to the teletypewriter letters function. This combination is the combination which is ordinarily used to control the receiving teletypewriting so that after it has been typing figures it types letters. In this case, however, this combination is to be used to switch the distant receiving end of the mechanism connected to the cable so that the cable is connected to the receiving code converter. The two letters combinations are not transmitted into the receiving code retranslator in Fig. 4.

As indicated in columns 601 and 603, in response to each of the two five-element code combinations for letters which consist of five marking signal elements relays 36 to 40 also designated 1 to 5 will all be operated. When all the relays are operated, a circuit may be traced from conductor 181 through contact 36h and contact 37k to conductor 83 from which point the circuit extends through contact 68b, top winding of relay 63 and resistance 64 to ground operating the armature of relay 63 to close contact 66. A negative pulse will be transmitted over the cable and impressed through regenerative repeater 174 on the eight-pulse selector 176. This is the first of the four negative pulses into which each of the five-element combinations for letters is translated. In order to operate the eight-pulse selector 176, it is necessary to transmit eight negative pulses in succession over the cable. This will be effected by the translation of two five-element letter combinations into two four-element code combinations each one of which latter elements is negative. As explained above, after the first pulse is transmitted through conductor 181 the second, third and fourth pulses will be transmitted through conductors 182, 183 and 184, respectively. Then the cycle will be repeated in response to the appearance of the second letters code combination in tape 8. The pulse control relays at the right-hand side of Fig. 2, as mentioned above, will effect the transfer of motor conductor 86 to each one of conductors 182, 183 and 184 in turn and then will repeat the cycle under control of cam 160. How this is effected will now be explained in detail.

When battery 80 is again connected to conductor 86, in addition to operating relay 63 to send a negative pulse over the cable, relay 52 will be operated and locked to battery under control of relay 46. The operating circuit for relay 52 extends from conductor 86 through contact 49d, contact 50d, contact 52d, winding of relay 52 and resistance 51 to ground. The locking path extends from battery through contact 46d, contact 52e, winding of relay 52 and resistance 51 to ground. The operation of relay 52 supplies battery over a circuit through contact 46d and contact 52c to the right-hand terminal of the winding of relay 51, but the winding of relay 51 is shunted by battery supplied over conductor 86 through contact 51d which connects to the left-hand terminal of the winding of relay 51, from which point the circuit extends through resistance 56 to ground, so that relay 51 does not operate at this time. Relay 51 cannot operate as long as contact 79 remains closed. When 79 opens, the shunt circuit is no longer effective and relay 51 operates. When relays 51 and 52 are both operated a circuit may be traced from battery through contact 51b, contact 52b and the left-hand winding of relay 53 to ground, operating relay 53. When relay 53 operates, it

locks over a path from battery and through contact 46d, contact 53b and the right-hand winding of relay 53 to ground. The operation of relay 53 also connects motor lead 86 through contact 53c, contact 54d and contact 48k to conductor 182. Since relays 36 to 40 are all operated, a circuit may be traced from conductor 182 through contact 36f and contact 37f to conductor 83. When contact 79 again closes, the armature relay 63 will again be actuated to close contact 66 and a negative pulse will be transmitted over the cable as the second of the four-element code pulses. When contact 79 closes relay 52 is released since the path through the winding of relay 52 is shunted by battery through contact 51c and resistance 57 to ground. When relay 52 releases relay 51 will lose its holding path since contact 52c through which battery was supplied for the holding of relay 51 is opened. However, relay 51 will not release as it will be held operated from battery supplied over conductor 86 through contact 52d. Relay 51 will be maintained operated by battery 80 through contact 79 until contact 79 opens, when relay 51 will release. When both relays 51 and 52 release, a circuit may be traced from battery through contact 51a, contact 52a, contact 53a and the left-hand winding of relay 54 operating relay 54. The operation of relay 54 transfers motor lead 86 to conductor 183. The circuit may be traced through contact 49d, contact 50d, contact 53c, contact 54c, contact 55e and contact 48h to conductor 183. With relays 36 to 40 operated, a circuit may be traced through contact 40c, contact 39e and contact 38e to conductor 83. When battery 80 is again connected through conductor 86 to conductor 83, the third negative pulse will be transmitted over the cable. Relays 51 and 52 will again operate as described above. A circuit may then be traced from battery through contact 51b, contact 52b, contact 54a and the left-hand winding of relay 55 to ground operating relay 55. When relay 55 operates it locks over a circuit from ground through the right-hand winding of relay 55, contact 55c and contact 46d to battery. The operation of relay 55 connects motor conductor 86 to conductor 184. The circuit may be traced through contact 49d, contact 50d, contact 53c, contact 54c, contact 55d and contact 48f to conductor 184. With relays 36 to 40 all operated, the circuit extends from conductor 184 through contact 38b and contact 39b to conductor 83. When contact 79 again closes, a negative pulse will be transmitted over the cable as the fourth pulse of the four-element code. Relays 51 and 52 operate and release as previously described.

Relays 36 to 40, as mentioned above, are numbered also 1 to 5, respectively. This indicates that relays 1 to 5 are under control of signal elements 1 to 5, respectively, of the five-element code. Attention is called to columns 602 and 603 of Fig. 6. Reference to these columns indicates that whenever a five-element signal is translated into a four-element signal, relays 1 and 2 are always among the relays which are operated. Further, when a five-element signal is translated into a three-element signal, relays 1 and 2 are never operated simultaneously. For the letters combination relays 1, 2, 3, 4 and 5 are all operated. Since relays 1 and 2 are operated, a circuit may be traced from ground through contact 37b, contact 36b, and the winding of relay 47 to battery, operating relay 47. Therefore at the end of the fourth pulse a path is established

which may be traced from battery through contact 51a, contact 52a, contact 53a, contact 55a, contact 47a and the winding of relay 46 to ground, operating relay 46. This in turn opens the locking path for relays 53, 54, 55 and 46, releasing these relays preparatory to sending the succeeding character.

Returning to the interval during which the first character combination was sent, when relays 36 to 40 were operated they locked to the back contact of relay 46. After the first pulse had been sent out and relays 51 and 52 released they furnished a path which may be traced from battery through contact 51a, contact 52a, contact 53a, contact 48a and the winding of relay 32, operating relay 32. This opened the operating paths of relays 36 to 40. The tape in the transmitting distributor was then advanced to the position of the succeeding combination by means of a mechanism attached to shaft 180. When relay 32 operated it too locked to the battery supplied through contact 46d. The operation of relay 46 at the end of the fourth pulse therefore released relays 36 to 40 and 32.

The cycle just described will be repeated to send out the second code combination for letters to control the switching of the receiving end of the cable. Thereafter, the code converter mechanism will be controlled in a generally similar manner to translate as many combinations as appear in the tape. Relays 36 to 40 will be operated in accordance with the table indicated in column 602 to establish the proper paths in response to the combinations for the thirty-two letters and teletypewriter receiver adjusting functions indicated in column 601. The proper combinations of positive or negative battery or ground will be established by relays 58 and 63 under control of the closed paths or open paths established through the contacts of relays 36 to 40 for the various combinations.

Attention is called to the fact that for twenty-four of the letter characters and functions indicated in column 601, three-element signals only are transmitted over the cable. How this is performed will now be described.

Since relays 36 and 37 corresponding to signal elements 1 and 2 of the five-element code are never operated simultaneously when a three-element signal is to be transmitted over the cable, some one of contacts 36b and 37b will always be open under such condition. Therefore, relay 47 will never be operated when a three-element signal is to be transmitted. As a result of this at the end of the third pulse when relay 55 is operated, a path will be available immediately for the operation of relay 46. This path may be traced from battery through contact 55b, contact 47b, and the winding of relay 46 to ground. Relay 46 will therefore operate at the end of the third pulse and restore the circuit to its original starting condition immediately.

When it is desired to stop sending, key 41 is restored to its original position. This releases relay 43. Nothing further will happen until the character in process of being sent has been transmitted. If the message has been completed the transmitter will be sending blanks, that is to say, all of the contacts 21 to 25 will be open and all of relays 36 to 40 will be released. In any event, relay 46 will be operated at the end of transmission of the combination in either one of the two manners heretofore described. A circuit may then be traced from battery through the winding of relay 48, contact 46a and contact 43a to ground, oper-

ating stop relay 48. When relay 48 operates it locks over a path from battery through the winding of relay 48, contact 48d and contact 44a to ground. As soon as relay 46 releases relay 45 operates over a circuit which may be traced from battery through the winding of relay 45, contact 46c, and contact 48b to ground. The operation of relay 45 transfers the holding path for relay 44, through contact 45a, contact 46b to ground. The operation of stop relay 48 establishes the proper combination for the stop signal indicated in the second last line from the bottom in column 603 of Fig. 6. This combination is — — + —. Since this is a four-element signal relay 47 is operated through contact 48c to ground. The manner in which the operation of relay 48 sets up the stop combination — — + — will now be described.

For the first pulse battery 80 will be impressed through contact 79, contact 68e, contact 49d, contact 50d, contact 53d, contact 48m, conductor 83a, conductor 83, contact 68b, top winding of relay 63 and resistance 64 to ground. This as has been shown results in the transmission of a negative pulse over the cable as the first element of the Stop signal combination. For the second element relay 53 will be operated as described above and the path from battery 80 will be transferred through contact 53c, contact 54d and contact 48h to conductor 83a which will result in the transmission of the second negative pulse of the combination. For the third pulse of the combination relays 53 and 54 will both be operated. Under this condition the circuit from battery 80 will extend through contact 53c, contact 54c, contact 55e, and contact 48f to conductor 84d which extends through conductor 84, contact 68d, top winding of relay 58 and resistance 59 to ground. This results as has been previously shown in the transmission of a positive pulse as the third element of the four-element Stop signal combination. For the fourth element relays 53, 54 and 55 will all be operated. The circuit will therefore extend through contact 53c, contact 54c, contact 55d, and contact 48e to conductor 83a which will effect the transmission of a negative pulse as the fourth element of the Stop signal combination.

When the four pulses of the Stop signal combination have been transmitted relay 46 will again operate. Since contact 46b is opened relay 44 will release. This in turn releases the stop relay 48, transfer relay 68 and relay 49. Relay 45 is a slow-to-release relay. Its slow release insures the release of relay 44 but with the release of relay 48, relay 45 releases. Relay 46 releases all other operated relays and the circuit is returned to normal.

Refer now to Figs. 3 and 4. The fork-controlled regenerative repeater 174 which is maintained in synchronism with the sending mechanism will send the eight negative pulses into the pulse selector 176 in a well-known manner. In response to eight consecutive negative pulses contact 102 is closed also in a well-known manner. It is not possible for this to happen in response to any sequence of signal combinations other than two letter combinations in succession. The closure of contact 102 operates relay 104 over an obvious circuit. When relay 104 operates it locks over a circuit from battery through contact 129d, contact 104f and the winding of relay 104 to ground.

Whenever a positive pulse is received over the cable the armature 93 will be actuated to close contact 96 and whenever a negative pulse is received the armature 94 will close contact 95.

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When a ground pulse is received, neither contact 95 nor 96 will be closed. Whenever a pulse is received, whatever its nature, whether positive battery, negative battery, or ground, the armature 97 will close contact 98 and connect ground through contact 98 and contact 104e to conductor 105. Contact 99 will open during the curbing interval between each pulse. The operation of the regenerative repeater 114 which performs these functions is well known. When, in response to the pulses, ground is applied to conductor 105, which corresponds to motor conductor 85 in Figs. 1 and 2, relays 108 and 109, the wiring of which is substantially the same as that for relays 51 and 52, in Fig. 2, will be controlled in substantially the same manner as relays 51 and 52. Relays 110, 111 and 112 will be controlled in response to the pulses over conductor 105 in substantially the same manner as relays 53, 54 and 55 in Fig. 2. This combination of relays will function to count the pulses and advance the leads 106 and 107 from one pair of translating relays to the next. The only essential difference in operation is that the locking circuit for relays 108 to 112 extends through contacts 129b and 127g. In the case of the first pulse relay 110 will be in the released condition as was the case for relay 53. If the pulse received over the cable is positive, the circuit will be extended through conductor 107, contact 110f and the winding of relay 114 to ground, operating relay 114. If the pulse is negative, the circuit will be extended through conductor 106, contact 110d and the winding of relay 115 to ground, operating relay 115. If the pulse is a ground pulse, both conductors 106 and 107 will be open and neither relay 114 nor relay 115 will be operated. The eight relays 114 to 121 provide a pair of relays for each of the four pulses. If a particular pulse is positive, a particular one of the two relays corresponding to each pulse will be operated and if it is negative, the other of the pair will be operated. If it is a ground pulse, neither one will be operated. After the first pulse is received, leads 106 and 107 will be extended through contacts 110c and 110e and contacts 111d and 111f to the windings of relays 116 and 117, either one of which or neither of which will be operated, in response to the second pulse, depending upon the nature of the pulse received over the cable. Then conductors 106 and 107 will be extended through contacts 111c and 111e and contacts 112e and 112g to the windings of relays 118 and 119 for the third pulse. Upon the operation of relay 112 the circuit will be extended through contacts 112d and 112f to relays 120 and 121 for the fourth pulse.

Attention is called to the fact that all four-pulse combinations transmitted over the cable and no three-pulse combinations have negative pulses for both of the first two pulses. This may be seen from reference to column 603. Each pair of relays of the relay group 114 to 121 is designated 1+, 1-, 2+, 2-, etc. 1+ indicates that relay 114 is operated when the first element of a combination received over the cable is a plus element. 1- indicates that relay 115 is operated when the first pulse of a combination received over the cable is a negative element, etc. When the first and second elements of a combination are both negative elements, relay 1- and relay 2-, designated 115 and 117, respectively, will both be operated. For this condition a circuit may be traced from battery through contact 117a, contact 115a and the winding of relay 113

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to ground, operating relay 113. Relay 113 acts as a control to distinguish between three-element code combinations and four-element code combinations received over the cable. If relay 113 is not operated only three pulses are counted. Relay 113 controls relay 127. If relay 112 is operated and relay 113 is released a circuit may be traced from ground through contact 112a, contact 113a, contact 129c and the winding of relay 127 to battery, operating relay 127. This condition will obtain for three-element signals. When relay 113 is operated and relay 112 is also operated a circuit may be traced from ground through contact 108a, contact 109a, contact 112b, contact 113b, and the winding of relay 127 to battery, operating relay 127. This condition will obtain for a four-element signal.

Relay 127 will therefore be operated at the end of the reception of a code signal combination whether the combination be a three-element or a four-element character. The operation of the particular relays of the group 114 to 121, sets the contacts of these relays so that when relay 127 is operated the proper circuits will be established to control relays 122 to 126 so as to establish the proper five-element combinations corresponding to the three or four-element combinations on relays 122 to 126. Such of the relays 122 to 126 as are operated, lock, through their 122b to 126b contacts and conductor 144 to ground through contact 143a when contact 143a is closed in a manner to be described. When the brush arm 166 is in the stop position, as shown, a circuit may be traced from battery through the winding of relay 143, segment 193, brushes 163 and 162 and ring 167 to ground 194 maintaining relay 143 operated. The combinations established on relays 122 to 126 will be impressed through the corresponding contacts of the group 122a to 126a and conductors 145 to 149 on segments 1 to 5 of the outer ring of distributor 131. As brush arm 166 is rotated, each one of segments 1 to 5 will be connected in turn through brushes 165 and 164 to solid continuous conducting ring 169. From ring 169 the circuit extends through conductor 152, to the distant teletypewriter receiving station 171, and returns over conductor 173 to ground. When the brush arm is in the stop position the circuit through the teletypewriter receiving mechanism is closed from battery through stop segment 190, brushes 165 and 164 to inner ring 169 from which point the circuit has been traced through the station to ground. When brush arm 166 sweeps over start segment 191 the circuit through the teletypewriter station will be opened. This results in the transmission of the characteristic start signal element of the start-stop signal train. Relay 143 will be released when rotatable arm 166 of distributor 131 moves off its stop segment. Segment 193 of inner ring 168 subtends the same angle as stop segment 190. Brush 163 will sweep off segment 193 when brush 165 sweeps off the stop segment. Relay 143 will be released at this instant and the combination which has been established on relays 122 to 126 will be locked thereon. Control relay 143 is released when brush 163 reengages segment 193.

The distributor 131 is under control of relay 127. When relay 127 is operated a circuit may be traced from battery through contact 127f, conductor 151 and the winding of start magnet 140, energizing magnet 140. When magnet 140 is energized, rotatable arm 160 is rotated clockwise in a well-known manner. When relay 127

is released, magnet 140 is deenergized and the rotation of arm 166 is stopped with the arm in the stop position. The operation of relay 127 also releases the counting relays at the left of Fig. 4 by opening contact 127g. The operation of relay 127 also establishes a circuit from battery through contact 127f and the winding of relay 128 to ground, operating relay 128. Such of the relays 114 to 121 as are operated for a particular combination, lock, through contact 128h and contact 129a to battery. The opening of contact 128h releases such of the relays as have been operated. The release of the translating relays 114 to 121 places the circuit in the condition for the reception of the succeeding character combination. The sequence of operation and release of relays beginning with the operation of relay 127 occurs within the curbing interval which, as explained above, is equal to approximately one-fourth of the time of revolution of the sending cam 160.

When the stop signal combination --+-- is received, it operates stop relay 129. This circuit may be traced from positive battery through contact 115b, contact 117b, contact 118a, contact 121a and the winding of relay 129 to ground. Relays 115, 117, 118 and 121 are operated in response to the stop combination --+--. The operation of stop relay 29 opens the holding circuit for transfer relay 104 which was traced through contact 129d which is now open. This returns the circuit to normal. Relay 127 does not operate in response to this combination so that the combination which is set up on the translating relays is not impressed through the contacts of relay 127 on the distributor 131.

Refer to Fig. 6. The numbers in column 602 indicate marking signal elements in corresponding signal element positions of the five-element signal combinations for the symbol in the corresponding line in column 601. Where a signal element position number does not appear in column 602 it indicates a spacing signal element in the corresponding missing signal element position number in the five-element two-condition code. A marking signal element in a particular signal element position number, as explained above, operates a correspondingly numbered relay of the group at the left of Fig. 2. For a spacing signal element in a particular signal element position no relay in this relay group will be operated.

An examination of the combinations employed for any single character will illustrate the principle of translation. Take the letter f, for example, and refer to the sixth line from the top in columns 601, 602 and 603 in Fig. 6. The five-element two-condition combination for the letter f is translated into a three-element three-condition combination. The tape will be so punched at the sending end that the relays for signal elements 1, 3 and 4, viz, 36, 38 and 39, will be operated. This will result in a closed circuit through conductor 83 for the first pulse, a closed circuit through conductor 84 for the second pulse and both conductors 83 and 84 will be open for the third pulse. This will transmit a negative pulse as the first pulse, a positive pulse on the second pulse, and a ground pulse on the third. At the receiving end, relays for 1- and 2+, viz, 115 and 116, will be operated. This will result in the operation of relays M1, M3 and M4 or relays 126, 124 and 123 to reproduce the original signal. This in turn will produce marking signal elements in signal element positions 1, 3 and 4 and spacing signal elements in signal element

positions 2 and 5 to conform to the original five-element combination.

The translation of all of the other five-element two-condition combinations first into three or four-element three-condition combinations and then into the original combinations may be understood from the foregoing example and the detailed description of the translation of each is not considered necessary to an understanding of the invention.

What is claimed is:

1. In a telegraph system, a source of five-element two-current condition permutation code telegraph signals, a telegraph signal code translator, a telegraph channel, means connected to said source for impressing said signals on said translator, means in said translator for converting certain of said five-element signals into three-element permutation code telegraph signals and others of said five-element signals into four-element permutation code telegraph signals, and means connected to said translator for impressing said three-element signals and said four-element signals on said channel.

2. In a telegraph system, a source of thirty-two five-element two-current condition permutation code telegraph signal combinations connected to a permutation code signal translator, and means in said translator for translating more than half of said five-element combinations into three-element three-current condition telegraph signal combinations and the remainder of said five-element signal combinations into four-element three-current condition telegraph signal combinations.

3. In a telegraph system, a source of permutation code telegraph signal combinations, each of said combinations completely defining a symbol or function, each of said combinations consisting of n signal elements, each of said signal elements being of one of two possible current conditions, said source connected to a permutation code telegraph signal translator, means in said translator for translating certain of said combinations into corresponding combinations each having $(n-1)$ signal elements, and means in said translator for translating the remainder of said combinations into corresponding combinations each having $(n-2)$ signal elements.

4. In a telegraph system, a source of at least thirty-two five-element two-condition permutation code telegraph signal combinations connected to an electromechanical permutation code signal translator, and means in said translator responsive to the reception of particular ones of said signal combinations for translating said received combinations into particular ones of thirty-two three-current condition permutation code signal combinations certain of which are four-element combinations and others of which are three-element combinations.

5. In a telegraph system, a source of four-element and three-element three-condition permutation code telegraph signals connected to a permutation code telegraph signal translator, and means in said translator responsive to the reception of said signals for translating said received signals into five-element two-condition permutation code telegraph signals.

6. In a telegraph system, a source of five-element two-condition permutation code telegraph signal combinations connected to a first electromechanical translating device, means in said device for translating a number of said combinations into a corresponding number of three-ele-

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ment three-condition permutation code telegraph signal combinations, means in said device for translating the remaining number of said five-element combinations into a corresponding number of four-element three-condition permutation code telegraph signal combinations, a second electromechanical translating device, a telegraph channel interconnecting said devices, means for impressing said translated signal combinations on said second translator through said channel, and means in said second translator for retranslating said translated signal combinations into their original form.

7. In a telegraph system, a first telegraph station, a telegraph signal translator, a first telegraph channel connecting said station and said translator, a telegraph signal retranslator, a second telegraph channel connecting said translator and said retranslator, a second telegraph station, a third telegraph channel connecting said retranslator and said second station, means in said first station for impressing a number n , equal to $(b+c)$, of five-element two-condition permutation code telegraph signal combinations through said first channel on said translator, means in said translator responsive to the reception of b of said n signal combinations for translating said b combinations into b three-element three-condition permutation code telegraph signal combinations, means in said translator responsive to

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the reception of c of said n five-element combinations for translating said c combinations into c four-element three-condition permutation code telegraph signal combinations, means in said translator for impressing said four-element or said three-element combinations through said second channel on said retranslator, means in said retranslator responsive to the reception of said four-element or said three-element combinations for retranslating said four-element or said three-element combinations into their original form, and means in said retranslator for impressing said retranslated combinations on said second station through said third channel.

8. In a telegraph signal transmitting and receiving system, the method of transmitting p permutation code telegraph signal combinations, each of said p combinations having n elements, each of said elements being of any one of m conditions, which comprises the translation of q of said p combinations into q combinations each having $(n-a)$ elements, each of which $(n-a)$ elements may be of any one of $(m+b)$ conditions, and the translation of the remaining $(p-q)$ combinations into $(p-q)$ combinations each having $(n-c)$ elements, each of which $(n-c)$ elements may be of any of $(m+b)$ conditions, in order to save transmission channel time.

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