Nov. 18, 1924. 1,516,180

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SECRET SIGNALING SYSTEM EMPLOYING APPARATUS FOR AUTOMATICALLY ENCIPHERING AND DECIPHERING MESSAGES

Filed June 5, 1922 2 Sheets-Sheet 1

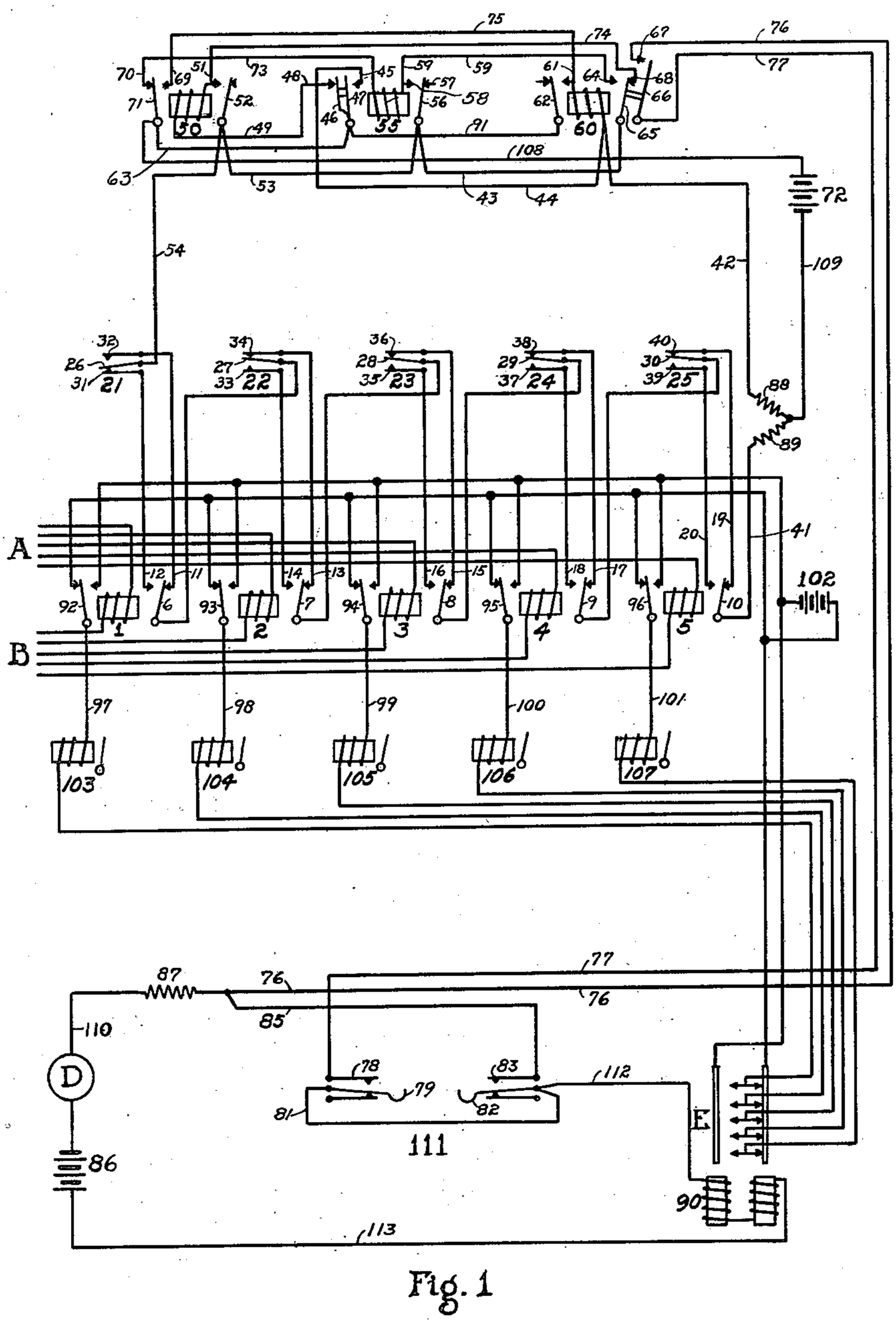

Fig. 1

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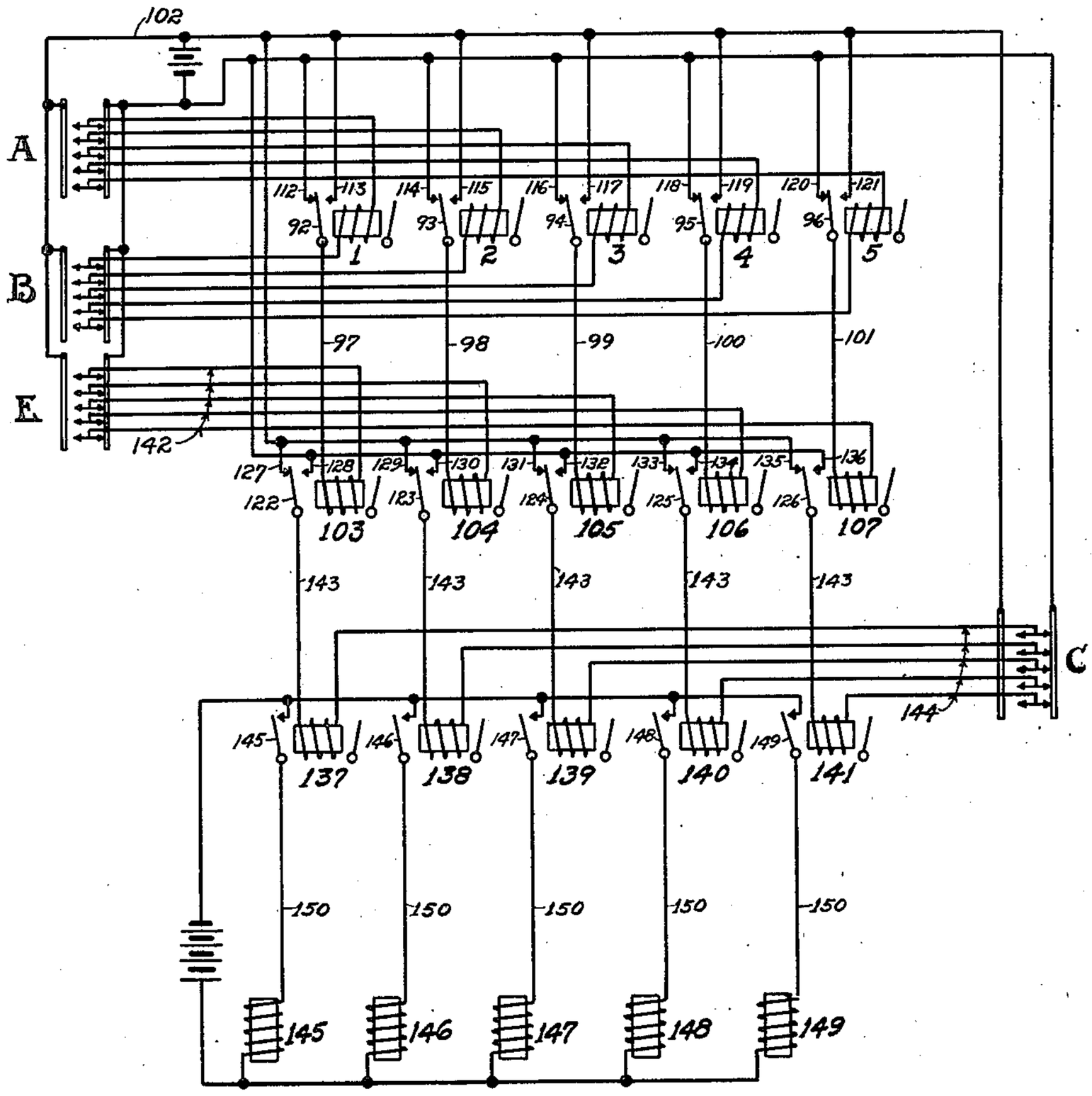

Fig. 2

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UNITED STATES PATENT OFFICE.

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SECRET SIGNALING SYSTEM EMPLOYING APPARATUS FOR AUTOMATICALLY ENCIPHERING AND DECIPHERING MESSAGES.

Application filed June 5, 1922. Serial No. 565,868.

To all whom it may concern:

Be it known that we, WILLIAM F. FRIEDMAN and LOUIS M. EVANS, citizens of the United States, respectively residing at 3220 17th Street NW., Washington, D. C., and 16 Cameron Street, Alexandria, in the county of Alexandria and State of Virginia, have invented certain new and useful Improvements in Secret Signaling Systems Employing Apparatus for Automatically Enciphering and Deciphering Messages, of which the following is a specification.

This invention relates to improvements in secret signaling systems, more particularly to electrical apparatus for the automatic encipherment, and decipherment of messages, and has for its object the provision of apparatus of such arrangement as will insure a higher degree of secrecy and safety than is the case in the heretofore prevalent apparatus. The invention is here illustrated as applied to a well-known form of printing telegraph systems, but is applicable to other signaling systems, as will readily be understood.

As constituted at present, printing telegraph machines adapted for the automatic encipherment and decipherment of messages employ one or more so-called key-tape transmitters, the function of which is to encipher and decipher the messages, and these key-tape transmitters operate continuously or uninterruptedly from the beginning of the encipherment or decipherment to the end of the encipherment or decipherment of the messages, a condition which facilitates solution of the messages by unauthorized persons. Such unauthorized decipherment is very greatly complicated and rendered impossible if an additional key-tape transmitter, the operation of which is absolutely irregular, intermittent, or discontinuous, is inserted in the enciphering and deciphering circuits. The provision of apparatus and circuits to accomplish this purpose forms the basis of our invention.

In order that the invention and its mode of application may be readily understood by persons skilled in the art, we have in the accompanying illustrative drawings, and in the detailed following description based thereon, set forth an embodiment of the same.

In these drawings, Figure 1 is a diagrammatic view of a set of circuits designated hereafter as the "interlocking circuits", the function of which is to control the intermittent operation of an extra key tape transmitter, designated hereafter as the "interruptor key-tape transmitter".

Figure 2 is a diagrammatic view of the circuits controlled by the interruptor key-tape transmitter, whereby the effects of the discontinuous and irregular operation of the interruptor key-tape transmitter are impressed upon the enciphering and deciphering circuits of the normal or continuously operative key-tape transmitters.

In these drawings, only such parts of the apparatus as are necessary to an understanding of our invention are illustrated, all other parts required in the proper operation of the apparatus being well known.

Having more particular reference to the drawings, in connection with which like characters of reference will designate corresponding parts thereof, 1, 2, 3, 4, and 5 are relays, designated hereafter as the "continuously operative key-tape transmitter relays", which are controlled by two key-tape transmitters of well-known form designated hereafter as "transmitters A and B", and which operate in a well-known manner. In the heretofore prevalent apparatus these relays each have but one armature 92 to 96, the function of which is to connect conductors 97 to 101 to the positive or negative pole of battery 102 so that the effects of the joint action of transmitters A and B upon relays 1 to 5 are transferred to a second set of relays to be discussed in detail later. In our modification, relays 1 to 5 have two armatures each, the second set of armatures being designated in Figure 1 as armatures 6 to 10.

When relay 1 is de-energized its armature 6 touches contact 11; when it is energized, its armature 6 touches contact 12. The same applies to relays 2 to 5 with their armatures 7 to 10 and their front and back contacts 13 to 20, respectively. Relays 1 to 5 are affected by the operation of transmitters A and B in a manner which is well-known and unnecessary to be described for a proper understanding of our invention. Suffice it to say that any one of 32 different pairs of

characters on two key tapes simultaneously passing through transmitters A and B produce a similar resultant effect upon relays 1 to 5. For example, the interaction of letters "W" and "X" produces a resultant condition of affairs in relays 1 to 5 which may be designated by the letter "C", but there are 31 other pairs of characters which will produce the same resultant "C" in relays 1 to 5, such as "A" and "F", "B" and "Q", "D" and "U", etc. We are interested only in these resultants.

Now the set of armatures 92 to 96 of relays 1 to 5, merely constitute a system of keys or switches for transmitting positive or negative impulses to relays 103 to 107 and we shall discuss their action subsequently. We are now interested in the other set of armatures 6 to 10 of relays 1 to 5. These armatures constitute a system of circuits whereby a positive impulse may be permitted to pass at certain times, from the positive pole of battery 72 through all the armatures 6 to 10, through switches 21 to 25, arriving ultimately at conductor 54, from which point the positive impulse will be traced subsequently.

Switches 21 to 25 may be set according to any one of 120 different permutations. Suppose they have been set as shown in Figure 1, with blade 26 of switch 21 touching contact 31. Let us suppose, further, that during a certain interval of time, as a result of the passing of a certain pair of characters through transmitters A and B, yielding a certain resultant, which we will designate by the symbol "X", relays 2, 3, 4, 5, remain unenergized, only relay 1 being energized. Armatures 7 to 10 remain in their normal or unattracted positions, but armature 6 is against contact 12. A positive impulse starts from battery 72 through conductor 109 and resistance 89, conductor 41, armature 10, contacts 19 and 40, blade 30, armature 9, contacts 17 and 38, blade 29, armature 8, contacts 15 and 36, blade 28, armature 7, contacts 13 and 34, blade 27, to armature 6. Relay 1 being energized, armature 6 is against contact 12, and the positive impulse continues its way through armature 6, contacts 12 and 31, blade 26 to conductor 54. It is obvious, now, that if relay 1 had not been energized the positive impulse would have stopped at contact 32, which has been opened by switch 21. On the other hand, if any one of the relays 2, 3, 4, or 5 had been energized at the particular time interval under discussion, the positive impulse would never have reached armature 6. The particular permutation set up in the switches 21 to 25 and the particular resultant affecting armatures 6 to 10, therefore, jointly determine whether or not a positive impulse will arrive at conductor 54 from battery 72.

Let us continue now with the positive impulse in conductor 54. It reaches armature 52 of relay 50, finds the path open because this relay is unenergized and therefore continues along conductor 53, to armature 56 of relay 55, there also finds the path open, and hence continues along conductor 43. front armature 65 of relay 60, which is unenergized. Armature 65 is therefore against contact 68, and the impulse continues along conductor 74, winding of relay 50, conductor 49, rear contact 48 and armature 47 of relay 55, conductors 63 and 108 to the negative pole of battery 72. A circuit is therefore completed through the winding of relay 50 and it is energized.

When relay 50 is energized, armature 71 is attracted, coming up against contact 69. A current starts flowing from positive pole of battery 72, through conductor 109, resistance 88, conductor 42, winding of relay 60, conductor 75, contact 69, armature 71 of relay 50, conductor 108 to negative pole of battery 72. Relay 60 is therefore energized. Unless provided against, the instant relay 60 would be energized and its armature 65 drawn away from contact 68, the circuit of winding of relay 50 would be immediately broken and the armature 71 of relay 50 would immediately be released, this in turn breaking the circuit for operating relay 60, which in turn would cause its armature 65 to fall back upon contact 68, and re-establish the circuit for energizing relay 50. Thus these two relays would set up a "chattering" unless relay 50 is momentarily locked in its energized condition, so as to hold it locked throughout the time that relays 1 to 5 are set up according to a given combination as determined by transmitters A and B. Therefore, in order to prevent such chattering, relay 50 is provided with another armature, 52, which, when relay 50 is first energized, makes contact directly from conductor 54 to the winding of relay 50 through contact 51 instead of through armature 65 and contact 68 of relay 60. As long as relays 1 to 5 remain in the same condition they are in at the time the positive impulse first passes through their armatures and switches 21 to 25, relay 50 will remain locked in its energized condition, but the moment a new and a different combination sets itself up in relays 1 to 5, the locking circuit for relay 50 is broken, since the latter circuit is a part of the variable circuit in which armatures 6 to 10 of relays 1 to 5 and switches 21 to 25 constitute the make or break keys.

The effect of energizing relay 50 is, as stated above, to close the circuit for energizing relay 60. Armature 62 is attracted, comes against contact 61, and establishes a circuit from positive pole of battery 72, conductor 109, resistance 88, conductor 42, winding of relay 60, contact 61, armature 62,

conductors 91, 63, 108 to negative pole or battery, thus locking relay 60 in its energized condition. This locked condition will maintain itself indefinitely, until a condition of affairs to be described presently occurs, because the positive pole of battery 72 is now directly connected to one terminal of relay 60, instead of having to pass through the variable circuit in which armatures 6 to 10 and switches 21 to 25 are the keys.

When relay 60 is energized and locked, armature 66 is brought against contact 67 and held there. Contact 67 and armature 66 constitute a make and break key in the circuit which operates magnet 90, which is the magnet that advances or steps the tape forward in the interruptor key-tape transmitter designated hereafter, also as "transmitter E." The circuit for operating magnet 90 is as follows: a positive impulse from battery 86 comes through the distributor D, of well-known form, which passes these positive impulses at regular intervals along the conductor 110, through resistance 87, conductor 76, contact 67 only when relay 60 is energized, thence through armature 66, conductor 77, contact 78, blade 79 of switch 111, (if the switch is swung to the right or "interrupted" position) conductors 81 and 112, winding of magnet 90, conductor 113 to negative pole of battery 86. The operation of magnet 90 is thus dependent upon the closing of contacts at 67 and 78, and so long as contact at 67 is maintained by armature 66, magnet 90 will be operated once for each impulse passed by the distributor D.

There is, however, another circuit for operating magnet 90, as follows: If the arm of switch 111 is swung to the left, or to the "continuous" position, a current will flow from positive pole of battery 86, through distributor D, conductor 110, resistance 87, conductor 85, contact 83, blade 82 of switch 111, conductor 112, winding of magnet 90, conductor 113 to negative pole of battery. Magnet 90 will therefore operate continuously so long as impulses are being passed by the distributor, and independently of the condition of relay 60. If the arm of switch 111 is in the middle or neutral position, of course, no impulses will reach magnet 90. We are interested mainly in the interrupted action of magnet 90, for it is the one which adds to the secrecy and safety of the cipher messages, as will be shown hereafter. The arm of switch 111 is therefore in the "interrupted" position, i. e., blade 79 is against contact 78, and the operation of magnet 90 is dependent upon the maintenance of contact at 67 by armature 66, of relay 60. Let us see how long this condition will continue.

Switches 21 to 25 have not been changed in their positions in any manner. All sorts of resultants have presented themselves at armatures 6 to 10 of relays 1 to 5 during the operation of magnet 90 after relay 60 had been energized and locked. Suppose that every one of the said resultants had been different from the first one, namely, the one in which relay 1 was the only one energized, so that only armature 6 was attracted so as to touch contact 12. None of these other resultants would permit an impulse to pass from conductor 41 to conductor 54 for the path would be broken at one or more points by armatures 6 to 10 or at switches 21 to 25. But suppose now the original resultant "X" again sets itself up. An impulse will then find a complete path from conductor 41 through the various armatures 6 to 10, switches 21 to 25 to conductor 54 in the manner already described in detail. The positive impulse then travels along to armature 52 of relay 50, which has long before been de-energized so that armature 52 is no longer against contact 51. The positive impulse therefore continues along conductor 53 to armature 56 of relay 55, which has not as yet been operated so that armature 56 is still in its unattracted position against contact 57. The positive impulse therefore continues along conductor 43 to armature 65 of relay 60, which is still locked. Armature 65 is against contact 64 and the positive impulse continues along conductor 59, winding of relay 55, conductor 73, contact 70, armature 71 of relay 50, conductor 108 to negative pole of battery 72. Relay 55 is therefore energized, attracting armature 47 and bringing the latter against contact 45. There is however another circuit which also controls relay 55 for when relay 55 is energized, an armature 56 is brought against contact 59, thus completing a second circuit for self-locking relay 55 as follows: from positive pole of battery 72, conductor 109, resistance 89, the various armatures 10 to 6, (which are again set up according to the code requirements for the letter X) switches 25 to 21, conductors 54, 53, armature 56, contact 58, winding of relay 55, conductors 73, 70, armature 71 conductor 108, to negative pole of battery 72. Relay 55 will continue to remain self-locked, however, only so long as the electrical path through armatures 6 to 10 remains unchanged, which is the duration of the setting up of the particular combination of positions of armatures 6 to 10, corresponding to the letter "X". As soon as a different combination sets itself up at those armatures, the secondary path is broken, and relay 55 is deenergized. When relay 55 is energized, a circuit is therefore completed from positive pole of battery 72 through conductor 109, resistance 88, conductors 42, 44, contact 45, armature 47 of relay 55, conductors 63, 108 to negative pole of battery. The effect of this is

to short-circuit relay 60 which has remained locked, as described above, for the major portion of the current will choose the shorter path indicated directly above while only a small portion of the current will choose the longer path which includes the positive pole of battery 72, conductor 109, resistance 88, conductor 42, winding of relay 60, contact 61, armature 62, conductors 91, 63, 108 to negative pole of battery 72. When relay 60 is de-energized the primary circuit for energizing relay 55 is at once broken at contact 64, but as stated before relay 55 remains locked because its armature 56 is still making contact at 58, and this condition continues only during the period that resultant "X" is set up at armatures 6 to 10 in relays 1 to 5. Upon the passing of this resultant and the setting up of a different one, relay 55 is immediately de-energized.

When relay 60 is de-energized, armature 66 returns to its unattracted position, breaking contact at 67, and thus breaking the circuit for magnet 90. The entire circuit has been thus restored to normal and the cycle of operations can begin again. The interlocking circuit therefore goes through the following cycle;

(1) A predetermined permutation of setting of switches 21 to 25 permits a positive potential to flow from positive pole of battery 72 through the armatures 6 to 10 of relays 1 to 5, when a certain resultant of a pair of characters passing through transmitters A and B sets itself up in relays 1 to 5; this positive potential continues through relay 50 to negative pole of battery 72, thus energizing relay 50.

(2) Relay 50 closes the circuit for energizing relay 60, which locks itself. Contact is established at 67, and the circuit for energizing magnet 90 is completed.

(3) Upon the second occurrence of a similar resultant in relays 1 to 5, a circuit is closed which energizes relay 55 and this results in short-circuiting and unlocking relay 60, breaking the circuit for energizing relay 55 and magnet 90, and restoring the interlocking circuit to normal and preparing it for a second cycle of operations.

The same results can be obtained by relay 55 opening the circuit of the winding of relay 60, instead of short-circuiting relay 60, but this requires a good adjustment of contacts.

Let us now consider the purpose of actuating magnet 90. Referring now to Figure 2, in the heretofore prevalent apparatus, armatures 92 to 96 are connected to conductors 97 to 101, which lead directly to the windings of relays 137 to 141, designated as the "resultant relays." The other terminals of these resultant relays are connected to conductors leading to a transmitter C, designated as the "message transmitter." The effects of the action of relays 1 to 5 are therefore impressed directly upon the resultant relays 137 to 141 in conjunction with the message transmitter C. In our modification, however, we have inserted an additional transmitter E, identical in construction with transmitters A and B, which are of well-known form, and the action of which needs no detailed explanation, other than to say that they are agencies which translate combinations of perforations in paper tapes into electrical impulses according to a well-known system of code signals and these electrical impulses affect relays. As shown in Figure 2, armatures 92 to 96 of relays 1 to 5 are connected to conductors 97 to 101 which form one set of terminals of the windings of the extra relays 103 to 107. The other set of terminals to the windings of relays 103 to 107, viz, conductors 142, lead to a set of five tape-controlled make and break contacts in transmitter E. Relays 103 to 107 are therefore controlled jointly by the armatures 92 to 96 of relays 1 to 5 and the five make and break contacts of transmitter E. It is this transmitter E which functions irregularly and intermittently whenever its magnet 90 is actuated.

Armatures 122 to 126 of relays 103 to 107 are connected to the set of conductors 143, which form one set of terminals of the windings of relays 137 to 141. The other set of terminals of these relays, conductors 144, lead to the five make and break contacts in message transmitter C.

The resultant relays 137 to 141 actuate armatures 145 to 149, which act as switches in conductors 150 of the circuits controlling the operations of the mechanism directly concerned in printing the letters; or in perforating a tape of code signals representing these letters, or; of the circuits leading to a distributor which passes combinations of impulses to be transmitted along the line to a receiving distributor at a receiving station.

It is seen then that the final or resultant relays 137 to 141 are controlled by four transmitters. Transmitters A, B, and C, when the enciphering or deciphering process is once started, operate continuously from the beginning to the end of the message being enciphered or deciphered. Transmitter, E, however, operates discontinuously, intermittently and irregularly, as controlled by transmitters A and B acting jointly upon relays 1 to 5, through the interlocking circuit and switches 21 to 25. These switches may be set so as to allow the interlocking circuit to be actuated by any one of 32 different resultants passing through relays 1 to 5. A single message may therefore be made to yield 120 different cipher messages by manipulating switches 21 to 25. Fur-

thermore, the action of transmitter E being irregular, and manifesting itself in absolutely no way in the cipher messages, any cyclic phenomena, such as are introduced by the continuous action of key-tape transmitters A and B in the heretofore prevalent apparatus, are entirely eliminated. This, from the point of view of secrecy and safety, constitutes a very great advantage in the system. It is obvious that at the deciphering station a similar arrangement of circuits must be provided as at the enciphering station, the system of cipher operations being such that the decipherment is simply the reverse of the encipherment, using the same key-tapes and permutation of switches.

We claim:—

1. In an electrical enciphering and deciphering system, comprising one or more key-tape transmitters controlling the operation of a plurality of key-tape transmitter relays, an additional key-tape transmitter, the operation of which may be made constant and continuous, or variable and interrupted at the will of the correspondents.

2. In an electrical enciphering and deciphering system, comprising one or more key-tape transmitters controlling the operation of a plurality of key-tape transmitter relays, an additional key-tape transmitter, the operation of which may be made variable and interrupted at the will of the correspondents through the provision of a system of relays constituting an interlocking circuit and a plurality of switches, said switches controlling the operation of the said interlocking circuit by acting conjointly with the armatures of said key-tape transmitter relays.

3. In an electrical enciphering and deciphering system, comprising one or more key-tape transmitters controlling the operation of a plurality of key-tape transmitter relays, said relays being provided with a set of armatures which, together with a set of variable switches, act as variable members in a circuit which controls the operation of a tape-stepping magnet in an additional key-tape transmitter, said magnet causing the key tape to be started and stopped alternately but irregularly by the energizing or non-energizing of said magnet.

4. In an electrical enciphering and deciphering system, comprising one or more key-tape transmitters controlling the operation of a plurality of key-tape transmitter relays, an additional key-tape transmitter together with a second set of key-tape transmitter relays, said second set of relays being controlled jointly by the armatures of the first of said set of key-tape transmitter relays and a set of make and break contacts in the said additional key-tape transmitter, the effects of the operation of the said second set of key-tape transmitter relays being impressed upon a third set of resultant relays which are also affected by the operation of a message transmitter acting conjointly with the armatures of the said second set of key-tape transmitter relays.

5. In an electrical system including an interlocking circuit, a plurality of regularly and irregularly functioning key tape transmitters and relays, means for enciphering and deciphering messages, said means comprising a plurality of switches capable of being set according to varying permutations, and adapted to control said interlocking circuit, said circuit being adapted to control the operation of the tape stepping magnet of said irregularly operated key tape transmitter.

6. In an electrical system including regularly and irregularly functioning key tape transmitters, means for combining the effects of the operation of said transmitters for the purpose of enciphering and deciphering messages.

7. In an electrical system, including a circuit and regularly and irregularly functioning key tape transmitters, said circuit being controlled by the interaction of said regularly functioning key tape transmitters, means for combining the effects of all of said transmitters for the purpose of enciphering and deciphering messages.

In testimony whereof they affix their signatures.

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LOUIS M. EVANS.