

June 4, 1946.

E. O. GAMMELL

2,401,475

TELETYPEWRITER SECRECY SYSTEM

Filed May 10, 1943

2 Sheets-Sheet 1

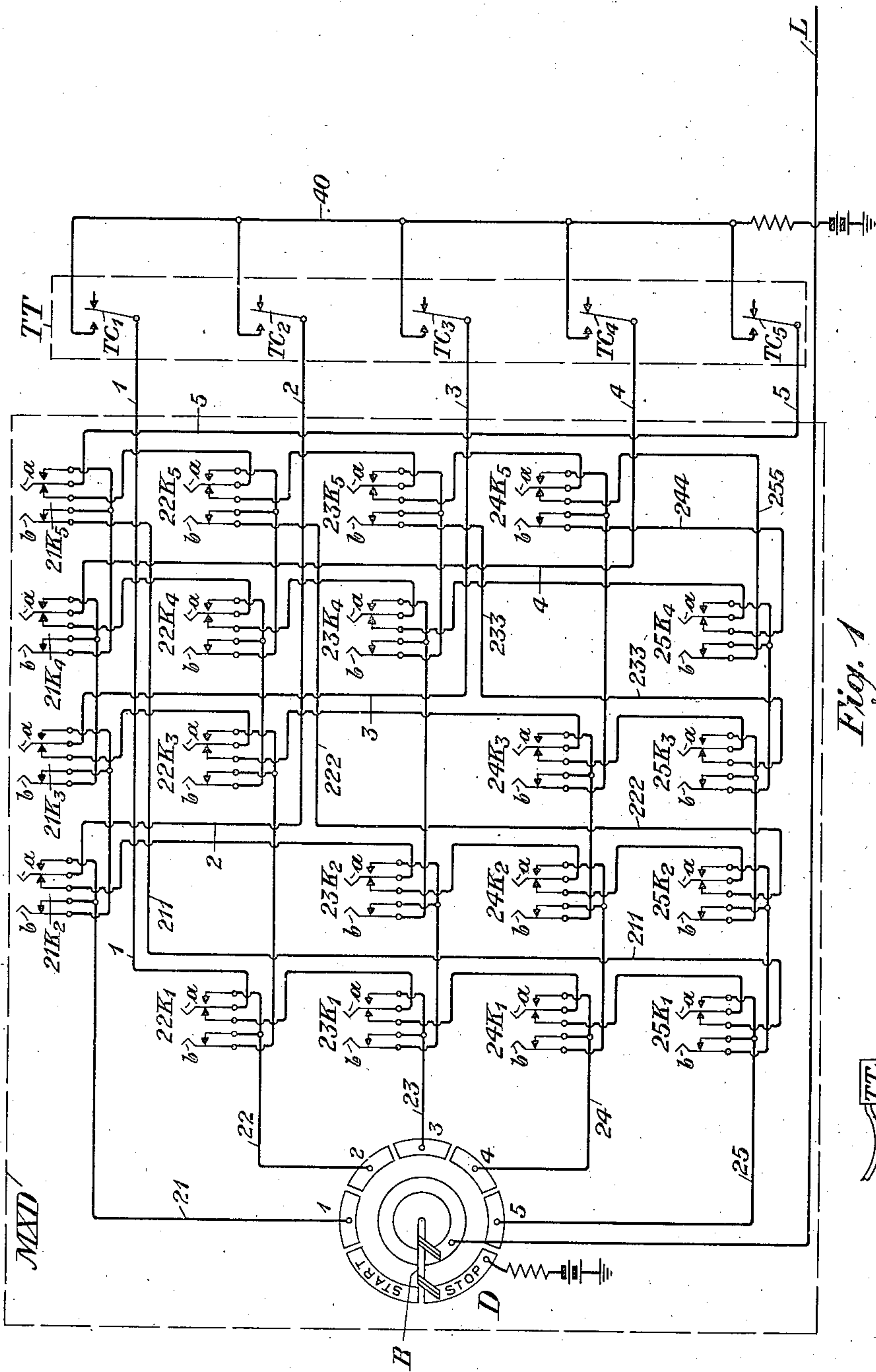


Fig. 1

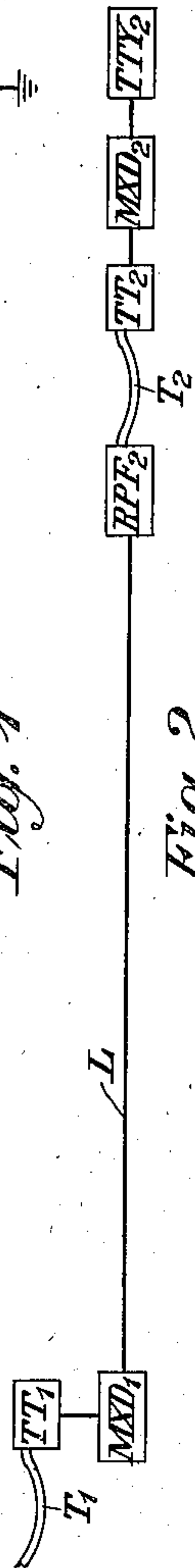


Fig. 2

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2 Sheets-Sheet 2

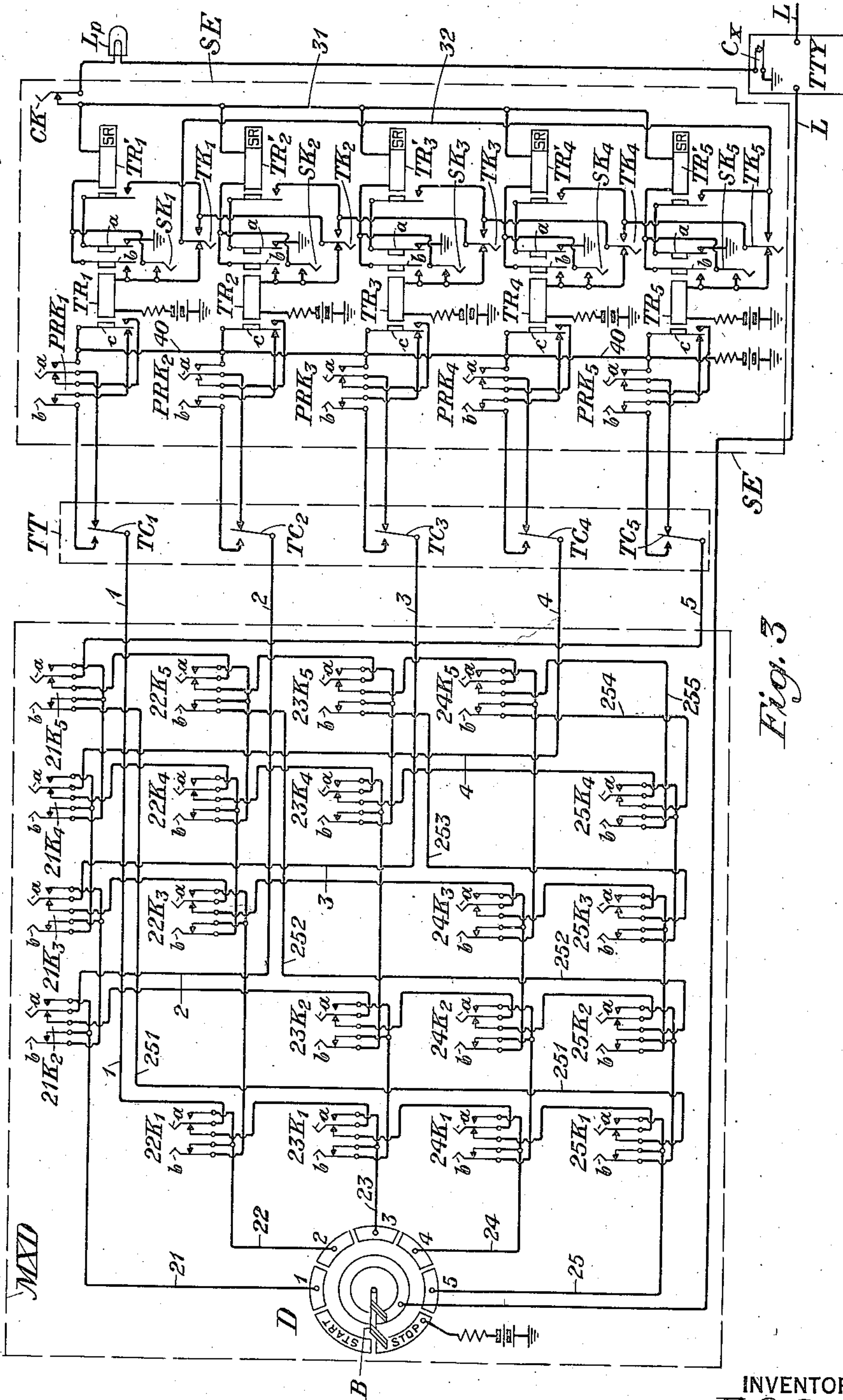


Fig. 3

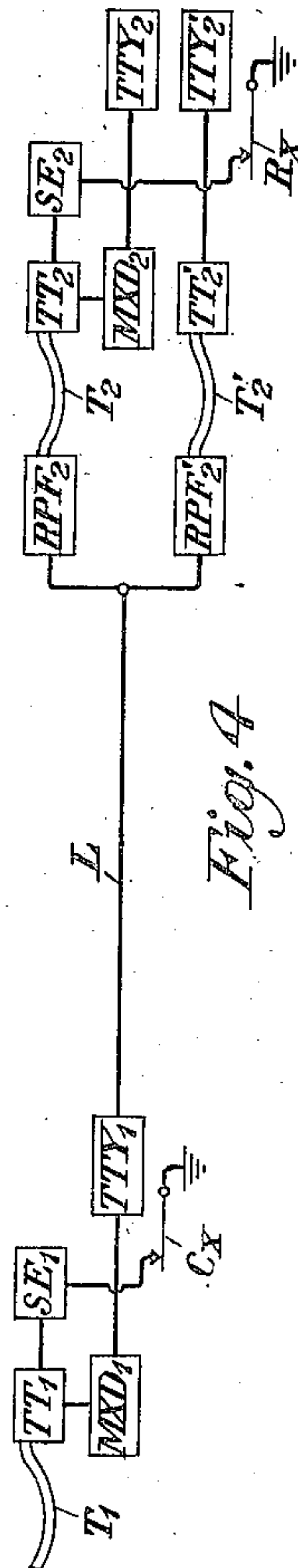


Fig. 4

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2,401,475

TELETYPEWRITER SECRECY SYSTEM

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Application May 10, 1943, Serial No. 486,286

8 Claims. (Cl. 178—22)

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This invention relates to secrecy systems. More particularly it relates to telegraph and teletypewriter systems which are arranged for the secret transmission of signals.

It has heretofore been the practice in teletypewriter systems, for example, to obtain some degree of secrecy by specially arranging the sending contacts and the receiving code bars of the teletypewriter machines. In such prior secrecy systems each teletypewriter signal or character—which usually includes five marking or spacing pulses in the ordinary Baudot code system—undergoes a change in one of its five pulses. For example, the second pulse may be reversed at the transmitter from marking to spacing or vice versa. This type of system is so arranged that a corresponding reversal in the changed pulse is caused to take place at the corresponding code bars in the receiving machine so as to reproduce the original signal or character.

In my application, Serial No. 479,405, filed March 17, 1943, I have disclosed an arrangement to obtain secrecy by means of pulse reversals, these reversals being produced by a simple circuit translation as distinguished from a mechanical change in the teletypewriter units. Said application also discloses an arrangement to cause the pulse reversals to be transferred from pulse to pulse of the Baudot code in a desired order at successive but unequal intervals. By this method the cipher in accordance with which the code is translated is changed in an arbitrary and irregular manner which renders it more difficult for an unauthorized person to "break" the cipher.

The present invention has for an object to encipher a message by interchanging or transposing the order of the pulses of the code as distinguished from a cipher which involves a mere reversal of one or more of the pulses. For example, instead of sending the pulses in 1—2—3—4—5 order, they may be sent in the order 2—4—5—3—1.

The order in which the pulses of the Baudot code may be transmitted is susceptible of many variations. Consequently by this plan a message may be disguised or concealed by employing a great many ciphers. By changing the order of the pulses from time to time in accordance with a prearranged scheme, or in accordance with instructions transmitted by the sending operator in code to the receiving operator from time to time, a very high degree of secrecy may be obtained. A still higher degree of secrecy may be obtained by not only making changes in the order of the pulses in accordance with the present invention, but in addition introducing pulse reversals by

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means of arrangements such as those disclosed in my application, Serial No. 479,405, already referred to.

When the switching equipment for interchanging or transposing the order of the pulses at the sending station is set in a particular manner, the corresponding equipment at the receiver cannot be set to transpose the order of the pulses in the same manner, but must be set to produce an inverse change in the order of the pulses. This will restore the individual impulses of the Baudot code to their original order at the receiver. For example, if the pulses are sent in the order 2—4—5—3—1 at the sending station, the translation of pulses is from 1 to 2, 2 to 4, 3 to 5, 4 to 3 and 5 to 1. At the receiving station the translation must be from 2 to 1, 4 to 2, 5 to 3, 3 to 4 and 1 to 5, in order to restore the original order 1—2—3—4—5.

The invention may now be more fully understood from the following description of the apparatus when read in connection with the accompanying drawings. In the drawings Figure 1 shows the apparatus to be used at a transmitting station for enciphering the message, it being understood that similar apparatus will be used at the receiving station for deciphering purposes. Fig. 2 is a schematic layout of a line circuit having enciphering arrangements of the type shown in Fig. 1 at both the transmitting and receiving stations. Fig. 3 shows a modified arrangement of the apparatus to be used at the transmitting station to introduce pulse reversals as well as to transpose the order of the pulses. Fig. 4 is a schematic layout of a line circuit having enciphering arrangements of the type shown in Fig. 3 at both the transmitting and receiving stations.

Referring to Fig. 1, the circuit at the transmitting station includes a distributor D of the type used in start-stop teletypewriter systems, said distributor having a start segment, five Baudot pulse segments and a stop segment over which a brush B may rotate. When the apparatus is set into operation, the brush B at the sending station may rotate continuously. The brush of the corresponding segment in the receiving printer, however, rotates intermittently, being started by the start impulse sent out by the transmitting distributor, and stopped for a brief interval when the stop impulse is received.

A tape transmitter of the type commonly used in teletypewriter circuits is shown schematically at TT and includes five transmitting contacts, TC₁, TC₂, TC₃, TC₄ and TC₅ by means of which marking or spacing impulses may be applied to

the five code segments of the distributor D in a manner to be described later.

To enable the order of the Baudot code pulses to be transposed or interchanged for cipher purposes, a mixing device MXD is provided, this mixing device being interposed between the tape transmitter T and the distributor D. The mixing device as shown comprises a set of keys so related that the keys are arranged in five horizontal groups, one corresponding to each of the five Baudot segments of the distributor. The keys also fall into five vertical groups, one corresponding to each contact of the tape transmitter TT.

As will be evident from Fig. 1 of the drawings, the contacts of the tape transmitter TT are individually connected to the several conductors 1, 2, 3, 4 and 5. Correspondingly conductors 21, 22, 23, 24 and 25 lead from the segments 1, 2, 3, 4 and 5 of the distributor D. The keys are so arranged that any one of the conductors 1, 2, 3, 4 or 5 may be connected to any one of the conductors 21, 22, 23, 24 or 25.

Normally the conductors 1-5, inclusive, are connected to the conductors 21-25, inclusive, in numerical order. If the conductors were normally disconnected from each other, it would require twenty-five keys arranged in five horizontal and five vertical rows to cross-connect the conductors in all of the possible combinations. Since, however, the conductors are normally connected together as above stated, and each key is arranged to break one of these normal connections, only four keys in each horizontal or vertical row are required, so that a total of twenty keys will make all of the cross-connections possible.

The keys are all designated by the letter K preceded by a number 21, 22, 23, etc., corresponding to the distributor connections 21, 22, 23, etc., with which the several vertical groups of keys are associated. The letter K designating the keys is followed by subscripts such as 1, 2, 3, 4 and 5, corresponding to the conductors 1, 2, 3, 4 and 5 leading to the contacts of the tape transmitter TT. Thus the keys 21K₂, 21K₃, 21K₄ and 21K₅ in the upper horizontal row are all connected in the conductor 21 and serve individually to disconnect said conductor from conductor 1 leading to the contact TC₁ of the tape transmitter and connect it to one of the other conductors 2, 3, 4 or 5 leading to other contacts of the tape transmitter. Similarly all of the keys having the subscript 1 are connected in a vertical row to the conductor 1; those having the subscript 2 are all connected in a vertical row to the conductor 2, etc.

It will also be noted that the last key of each horizontal row is connected to the lower key of one of the vertical rows. For example, the last key 21K₅ of the first horizontal row is connected by conductor 211 to the lower key 25K₁ of the first vertical row. In this vertical row all of the keys have the subscript 1. Likewise the last key 22K₅ of the second vertical row is connected by means of the conductor 222 to the lower key 25K₂ of the second vertical row in which the keys all have the subscript 2. So also key 23K₅ is connected by conductor 233 to key 25K₃, and conductor 244 connects keys 24K₅ and 25K₄.

By means of these connections a circuit may be normally traced from the first segment of the distributor D, over conductor 21, over the normal b contacts of the keys 21K₂ to 21K₅, inclusive, in the first horizontal row, thence over conductor 211, over the normal a contacts of the

vertical row of keys 25K₁ to 22K₁, inclusive, and thence over conductor 1 to the contact TC₁ of the tape transmitter TT. Similarly segment 2 of the distributor is normally connected over the normal b contacts of the keys 22K₁ to 22K₅, inclusive, in the second horizontal row, thence over conductor 222, over normal contacts a of the keys 25K₂ to 21K₂ in the second vertical row, and thence over conductor 2 to contact TC₂ of the tape transmitter. Likewise normal connections may be traced from the third, fourth and fifth segments of the distributor D to the contacts TC₃, TC₄ and TC₅ of the tape transmitter TT. For example, the latter connection extends over conductor 25, thence over the normal b contacts of the keys 25K₁ to 25K₄, inclusive, in the fifth horizontal row, thence over the conductor 255 and over the normal a contacts of the vertical rows of keys 24K₅ to 21K₅, inclusive, in the last vertical row, and thence over conductor 5 to contact TC₅ of the tape transmitter.

With the circuits in the condition above described, the impulses set up by the contacts TC₁-TC₅, inclusive, of the tape transmitter TT will be transmitted in the order of their subscripts from the segments 1, 2, 3, 4 and 5 of the distributor D to the line L. If the contact TC₁ is in its normal or spacing condition, an open circuit impulse will be transmitted. If, however, contact is shifted to the left, which is its marking condition, battery will be transmitted over conductor 40 and over segment 1 of the distributor to the line L as the first impulse of the Baudot code. The second impulse will be either an open circuit impulse or a marking impulse from the contact TC₂, depending whether the contact is in its normal position or has been moved to the left. The characters represented by the Baudot code combinations will, therefore, be transmitted in their normal code arrangements in non-ciphered form.

Suppose now it is desired to transpose the code combinations from their unenciphered form in which they are transmitted in the order 1-2-3-4-5 to some enciphered order. For example, let us assume that it is desired to interchange the order of the pulses to 2-4-5-3-1. The first horizontal row of keys determines which of the contacts of the tape transmitter TT is connected to the first segment of the distributor. Similarly the second horizontal row of keys determines which contact of the tape transmitter is connected to the second segment of the distributor, etc. To transmit the pulses in the order 2-4-5-3-1, the key having the subscript 2 in the first horizontal row, that is key 21K₂, will be thrown. Similarly key 22K₄ in the second row, key 23K₅ in the third row, key 24K₃ in the fourth row and key 25K₁ in the fifth row will be thrown.

With this arrangement of keys segment 1 of the distributor will be connected over conductor 21, make contact a of key 21K₂ and over conductor 2 to the contact TC₂ of the tape transmitter. Therefore, the first pulse transmitted will be that from the contact TC₂. Similarly segment 2 of the distributor is connected over conductor 22, over the normal b contacts of keys 22K₁ and 22K₃, over the make a contact of key 22K₄, over normal a contact of key 21K₄ and over conductor 4 to the contact TC₄ of the tape transmitter, so that the second pulse transmitted will be the fourth pulse set up on the tape transmitter.

Segment 3 of the distributor is connected over the normal b contacts of keys 23K₁, 23K₂ and

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23K₄, over make contact *a* of key 23K₅, over the normal *a* contacts of keys 22K₅ and 21K₅, and thence over conductor 5 to the contact TC₅ of the tape transmitter. Segment 4 of the distributor is connected over conductor 24, normal *b* contacts of keys 24K₁ and 24K₂, make a contact of key 24K₃, over normal *a* contacts of keys 22K₃ and 21K₃, and thence over conductor 3 to contact TC₃ of the tape transmitter. Finally segment 5 of the distributor is connected over conductor 25, make a contact of key 25K₁, over the normal *a* contacts of 24K₁, 23K₁ and 22K₁, and thence over conductor 1 to the contact TC₁ of the tape transmitter. Thus it will be seen that the pulses set up on the tape transmitter will be transmitted from the tape contacts in the following order: TC₂, TC₄, TC₅, TC₃ and TC₁.

The manner in which the transposed or interchanged pulses of the Baudot code are transmitted to a receiving station over the line L and how they are utilized at the receiving station to decipher the message is as follows: In Fig. 2 the message is applied by means of a tape T to the transmitter TT₁ which corresponds to the transmitter T of Fig. 1. The pulses are then interchanged in order by means of the mixing apparatus MXD₁ which corresponds to the apparatus MXD of Fig. 1. The interchanged pulses are then transmitted over the line L and applied to a reperforator PRF₂ which perforates a tape T₂ in which the code combinations will appear in their transposed form.

The code combinations thus appearing in enciphered form upon the tape T₂ are applied to the tape transmitter TT₂ which is similar to the transmitter TT of Fig. 1. The impulses set up on the transmitter are then applied to the mixing or interchanging apparatus MXD₂, which is similar to that of Fig. 1. It operates, as will be explained presently, to restore the order of the impulses of each code combination to its normal form, so that when applied to a teletypewriter such as that shown symbolically at TTY₂, the original message will be printed upon the teletypewriter.

The setting of the mixing apparatus MXD₂ at the receiving station will not be identical with that at the transmitting station, but will be in inverse relation thereto. It will be remembered that at the transmitting station, in order to transmit the pulses 1—2—3—4—5 in the order 2—4—5—3—1, the keys 21K₂, 22K₄, 23K₅, 24K₃ and 25K₁ were operated in the first, second, third, fourth and fifth rows of keys, respectively. In order to restore the pulses to their normal 1—2—3—4—5 order, it is necessary at the receiving station to throw the key 21K₅ in the first horizontal row, the key 22K₁ in the second horizontal row, the key 23K₄ in the third horizontal row, the key 24K₂ in the fourth horizontal row and the key 25K₃ in the fifth horizontal row. This is because the first pulse of the code is set up on contact TC₅ at the receiver, the second pulse on TC₁, the third pulse on TC₄, the fourth pulse on TC₂ and the fifth pulse on TC₃.

It will be seen by tracing the circuits that this setting of the keys will restore the impulses of each Baudot code to their normal order. Bearing in mind that the first impulse of the message character to be transmitted was transmitted as the fifth impulse it will be set up on the contact corresponding to TC₅ on the tape transmitter TT₂ at the receiving station. Therefore, when the brush of the distributor corresponding to D of the mixing apparatus MXD₂ at the receiving

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station passes over its first segment, a circuit may be traced from the contact TC₅ of the tape transmitter, over the conductor 5, over make contact *a* of key 21K₅, and thence over normal *a* contacts of keys 21K₄, 21K₃ and 21K₂ to conductor 21, from which point the circuit passes through the distributor and over a conductor corresponding to the line L of Fig. 1 to the teletypewriter TTY₂. Therefore an impulse corresponding to the original first pulse of the unenciphered Baudot code is transmitted to the teletypewriter.

In a similar manner, bearing in mind that the original second impulse of the unenciphered Baudot code was transmitted as the first pulse, and now appears on the contact TC₁ of the tape transmitter TT₂ at the receiver. The passing of the brush of the distributor over the second segment establishes the following circuit; from the second segment of the distributor, over conductor 22, over the make contact *a* of key 22K₁, and over conductor 1 to the contact TC₁ of the tape transmitter TT₂. The impulse which was originally the second impulse of the unenciphered code is, therefore, transmitted over the second segment of the distributor to the teletypewriter TTY₂. Similarly by tracing the circuits from the other third, fourth and fifth segments of the distributor, it will be seen that all of the pulses in their enciphered form are retransposed to their original positions so that the character originally set up at the transmitting station will be received upon the receiving teletypewriter TTY₂.

Fig. 3 shows how a transposing arrangement such as that illustrated in Fig. 1 may be combined with a pulse-reversing arrangement such as shown in my application, Serial No. 479,405, filed March 17, 1943. The mixing apparatus shown on the left in Fig. 3 and designated MXD is identical with the apparatus bearing the same designation in Fig. 1. Likewise the tape transmitter TT in Fig. 3 is identical with that shown in Fig. 1. However, the connections for applying marking or spacing potentials to the contacts of the tape transmitter TT are arranged in Fig. 3 to pass through a switching apparatus designated SE which will be described in more detail later. The switching apparatus SE is controlled, as will appear hereinafter, by a local teletypewriter TTY connected in the line L.

The switching apparatus SE includes five pairs of transfer relays such as TR₁—TR₁', TR₂—TR₂', etc., one pair corresponding to each pulse of the Baudot code. Associated with each pair of transfer relays is a starting key. The key associated with the pair of relays TR₁—TR₁' is shown at SK₁, and similarly the starting keys for the other pairs of transfer relays are shown at SK₂, SK₃, SK₄ and SK₅, respectively.

By operating any particularly starting key as, for example, the starting key SK₂, the corresponding pair of transfer relays TR₂ and TR₂' is operated and locked up to reverse the corresponding pulse of the Baudot code, which in this case is the second pulse. These relays will remain locked up until, as will be described later, the Baudot code combination for "figures" shift is sent to the line L from the distributor D followed by the code combination of some predetermined letter such, for example, as the letter S or the letter H. When this condition occurs, the teletypewriter mechanism TTY will, immediately after the S combination has been transmitted, momentarily open the contact C_x to unlock the previously operated pair of transfer relays. The release of these relays causes the next pair of

transfer relays to be operated in turn. In the case assumed the next pair of transfer relays will be the relays TR₃ and TR₃' which, when energized and locked up, will cause the third impulse of each Baudot code to be reversed until such time as another "figures-S" combination occurs, whereupon the control is transferred to the fourth pair of transfer relays to reverse the fourth impulse of the code, etc.

When the fifth pair of transfer relays TR₅—TR₅' is operated in turn to reverse the fifth impulse, the ensuing "figures-S" combination will release the fifth pair of transfer relays and transfer the control to the first pair of transfer relays TR₁—TR₁'. Thereafter the control is successively passed through the various pairs of transfer relays again. The shifting of control from one pair of transfer relays to another occurs at irregular intervals determined by the fortuitous occurrence in the enciphered message of the "figures-S" combination. As an unauthorized person tapping the line cannot know in advance when such a combination will occur, he would have no way of knowing that the cipher had been changed. This, of course, tends to render it much more difficult to "break" the cipher.

Associated with each pair of transfer relays is a transfer key such as the key TK₁ associated with the first pair, the transfer key TK₂ associated with the second pair, etc. By operating any one or more of these transfer keys the corresponding pair or pairs of transfer relays will be effectively eliminated from the chain. Under these conditions the succession of controls will pass only through the pairs of transfer relays whose transfer keys are not actuated.

It is also possible to reverse more than one impulse of the Baudot code at a time. For example, if instead of starting the enciphering process by operating the key SK₂, the starting keys SK₁ and SK₃ are simultaneously operated, the pairs of transfer relays TR₁—TR₁' and TR₃—TR₃' will be simultaneously energized and locked up to reverse the first and third impulses. As soon as a "figures-S" combination occurs, however, these two pairs of transfer relays will be released and the second and fourth pairs of transfer relays will be actuated, these in turn being followed by the third and fifth pairs. After these are released by the ensuing "figures-S" combination the control will be transferred to the fourth and first pairs, the control later passing to the fifth and second pairs, etc.

Instead of using the transfer relays to reverse impulses, this effect may be accomplished by actuating any one or more of the lock-in pulse-reversal keys PRK₁—PRK₅, inclusive, as will be described later. When the pulse reversal keys are used to reverse impulses, and it is desired to shift the reversal to other impulses, the transmitting operator must notify the receiving operator in code what keys are to be used to effect the shift. Before the lock-in pulse-reversal keys are used, any transfer relays which may have been previously operated and locked up are restored to normal by operating a clear-out key CK.

The details of the circuit arrangement of Fig. 3 will be clear from the following description of its operation. Let us assume first that none of the keys of the apparatus MXD is operated, and that no one of the five sets of transfer relays of the switching apparatus SE is operated. Also assume that none of the pulse-reversal lock-in keys PRK₁—PRK₅ of the switching apparatus SE is operated. It will be evident that under these

conditions the message will be transmitted in normal code combinations without being enciphered by any pulse reversals or by any transposition of pulses.

For example, as the brush arm B of the distributor D in Fig. 3 passes over its No. 1 segment, the conductor 21 will be connected through keys of the mixing apparatus MXD to the conductor 1, as described in connection with Fig. 1. Therefore, the line L will be connected over the inner ring of the distributor and over said conductors 21 and 1 to the tape contact TC₁. If the first pulse is a spacing pulse, the tape contact TC₁ will be in its right-hand position and the circuit will be continued over said contact and over the normal contact of spring a of key PRK to the front contact of armature c or relay TR₁. As the relay TR₁ is not energized, the front contact of said armature c is open, and consequently an open circuit pulse is transmitted to the line. If, however, the first pulse of the code combination is a marking pulse, the tape contact TC₁ will be in its left-hand position and the circuit will be extended over the normal contact of spring b of key PRK₁, over the back contact of armature c of relay TR₁ and thence over conductor 40 to battery. Under these conditions a marking impulse is transmitted to the line L. The first pulse is consequently not reversed.

Similarly, as the brush passes over the second segment of the distributor, if neither the transfer relay TR₂ nor the key PRK₂ is actuated, an open circuit will be transmitted to the line when the tape contact TC₂ is in its right-hand or spacing position, whereas if it is in its left-hand or marking position, battery will be connected to the line. Hence the second impulse will not be reversed. Likewise, under the conditions assumed, the remaining pulses are also set normally and in regular order.

If it is desired to encipher the message by pulse reversals, the operator may cause the first pulse to be reversed by operating the start key SK₁, thus energizing transfer relays TR₁ and TR₁' in series over a circuit from battery through the winding of relay TR₁, over the contact of key SK₁, through the winding of relay TR₁', over the normally closed contact of clear-out key CK, through the lamp L_p and over the contact C_x of the teletypewriter TTY to ground. When thus actuated, relays TR₁ and TR₁' are locked up in series over the front contact of the armature b of relay TR₁, said locking circuit extending over the circuit above traced to ground at the contact C_x of the teletypewriter TTY.

Under these conditions, if the tape contact TC₁ is in its right-hand position, as would be the case when the first pulse of the enciphered Baudot code is a spacing pulse, the circuit from the first segment of the distributor (if the apparatus MXD is not set to transpose pulses) will be extended over the right-hand contact of tape contact TC₁, over the normal contact of spring a of key PRK₁, over the front contact of armature c of relay TR₁ (which is now pulled up), and thence over conductor 40 to battery. Thus a marking impulse will be transmitted to the line instead of a spacing impulse. If, however, the tape contact TC₁ is in its left-hand or marking position, the circuit from the first segment of the distributor will be extended over said contact and over the normal make contact of spring b of key PRK₁ to the back contact of armature c of relay TR₁. As this relay is pulled up, the circuit is open at this point and a spacing pulse

instead of a marking pulse is sent to the line L. If no other pairs of transfer relays are operated, the other four pulses of each Baudot code are sent out unreversed.

Of course, if keys of the mixing apparatus MXD are operated to transpose the pulses, the connections above described for the first pulse may be switched to some other segment of the distributor D instead of the first segment. For example, if pulses are transposed from the order 1—2—3—4—5 to the order 2—4—5—3—1, as previously described, the switch 25K₁ in the fifth horizontal row of mixing apparatus MXD will be actuated. Consequently the conductor 1 will be connected through the switch 25K₁ and over the conductor 25 to the fifth segment of the distributor D. Therefore, the reversed first pulse set up on the tape transmitter TT by the action of the transfer relays TR₁ and TR₁' will not be the first pulse transmitted by the distributor, but will be the last one. Indeed, under the conditions above described, the first pulse transmitted by the distributor D will be the pulse set up on the contact TC₂ of the tape transmitter TT. This pulse will not be reversed unless the second set of transfer relays is actuated, or the lock-in pulse-reversal key PRK₅ is thrown.

From the foregoing it will be seen that when both the mixing apparatus MXD and the switching equipment SE are used simultaneously, the apparatus MXD transposes the order of the pulses, and in addition at least one of the transposed pulses is reversed, either by the setting of one of the pulse-reversal keys of the PRK series, or by the operation of a pair of transfer relays such as TR₁ and TR₁'. Consequently the character transmitted from the distributor D to the line L will not be the character punched on the tape which operates the tape transmitter TT, but will be some other character, depending upon the order in which the pulses are transmitted by the apparatus MXD, and upon which of the transposed pulses is at any particular time reversed.

Assuming that, as above described, the transfer relays TR₁ and TR₁' were actuated and the keys of the apparatus MXD set to transpose the order of the pulses as described in connection with Fig. 1, successions of code combinations enciphered in accordance with the setting of the switching equipment SE and the apparatus MXD will continue to be transmitted to the line L until the setting is changed. When in the course of the message, the combination "figures-S" is transmitted to the line, the contact C_x will be momentarily opened by the teletypewriter TTY, as described in connection with Fig. 1. This combination is not necessarily the signal combination set up on the transmitter TT, but is usually some other combination of successive characters, translated by the setting of the switching equipment SE and the mixing apparatus MXD into the code combinations for "figures-S."

Upon the momentary opening of the switch C_x in response to this combination, the relays TR₁ and TR₁' will be released and the next pair of relays TR₂ and TR₂' will be operated and locked up, thus in turn reversing the second impulse of each code combination set up on the tape transmitter TT. The circuit for operating the relay TR₂ passes over the back contact of armature *a* of relay TR₁, over the front contact of slow-release relay TR₁', over the normal contact of transfer key TK₂, and through the winding of relay TR₂ to battery. Relay TR₂, at the front contact of its armature *b*, completes a locking cir-

cuit through its own winding and through the winding of the relay TR₂', and thence over the contact of clear-out key CK to ground over the contact C_x.

The impulse set up on the contact TC₂ of the tape transmitter TT is now reversed, but under the conditions above assumed, this impulse will not be transmitted as the second impulse but as the first impulse, due to the actuation of the key 21K₂ which connects the first segment of the distributor D to the contact TC₂ in a manner already described in connection with the similar equipment of Fig. 1. Similarly, as successive pairs of transfer relays are energized and locked up when preceding transfer relays are released, other pulses will be reversed.

For example, when the second pair of transfer relays is released in response to a "figures-S" combination, the third pair will be energized to reverse the impulses set up on contact TC₃, and when the third pair is released by another "figures-S" combination, the fourth pair will be energized to reverse the pulses set up on the contact TC₄. Likewise when the pair of relays TR₄ and TR₄' is released, the fifth pair of relays is actuated to reverse the pulse set up on contact TC₅.

When the fifth pair of transfer relays (TR₅ and TR₅') is released by the momentary opening of the contact C_x in response to a "figures-S" combination, the release of the relay TR₅ closes a circuit from ground over the back contact of armature *a* of the relay TR₅, over the front contact of slow-release relay TR₅', over the conductor 32, over the normal contact of transfer key TK₁, and through the winding of relay TR₁ to battery. Relay TR₁ is thus energized and locks up in series with relay TR₁' to again reverse the first impulse of the Baudot code. This condition continues until the next "figures-S" signal is received, when the control is shifted to the next pair of transfer relays and the cycle is repeated.

As described in my copending application, Serial No. 479,405, filed March 17, 1943, any desired pair of transfer relays may be eliminated from the chain by operating the corresponding transfer key. For example, if it is desired to eliminate the transfer relays TR₂ and TR₂' from the chain, the transfer key TK₂ is operated to its right-hand position. Consequently, when the relay TR₁ is released in response to a "figures-S" combination, a circuit is completed over the back contact of armature *a* of relay TR₁, front contact of slow-releasing relay TR₁', over the right-hand contact of key TK₂, over the left-hand contact of key TK₃, through the winding of relay TR₃ to battery. Relays TR₃ and TR₃' are energized and locked up, and relays TR₂ and TR₂' are omitted from the chain, so that the second pulse will not be reversed. In a similar manner, any other pair of transfer relays may be eliminated from the chain, and if desired, more than one pair may be eliminated simultaneously by operating the proper transfer keys.

The switching equipment SE may be used to reverse more than one pulse in each code combination. For example, if the start keys SK₂ and SK₄ are operated simultaneously, relays TR₂ and TR₂' will be energized and locked up over obvious circuits, and at the same time relays TR₄ and TR₄' will be energized and locked up. This will result in reversing the second and fourth pulses of the Baudot code. If the pulses are also transposed by the mixing apparatus MXD as above described so that the order of the pulses is changed from 1—2—3—4—5 to the order 2—4—

5—3—1, the first segment of the distributor will be connected to conductor 2, and consequently the first pulse transmitted to the line L will be reversed, although this pulse corresponds to the reversed second pulse of the original Baudot combination. Likewise the second segment of the distributor will be connected to conductor 4 in a manner previously described, and, therefore, the second pulse transmitted to the line L will be reversed, although this pulse actually corresponds to the reversed fourth pulse of the Baudot code. The third, fourth and fifth pulses transmitted to the line will correspond respectively to the fifth, third and first pulses of the Baudot code, as already described, but these pulses will not be reversed.

When, however, in response to a "figures-S" combination the contact C_x is momentarily opened, the locking circuit for the pair of relays TR_2 and TR_2' and the locking circuit for the pair of relays TR_4 and TR_4' will be opened, causing the release of these two pairs of relays. Relay TR_2 upon releasing causes the relays TR_3 and TR_3' to operate and lock up. At the same time relay TR_4 upon releasing causes the relays TR_5 and TR_5' to operate and lock up. This reverses the third and fifth pulses of the original Baudot code. With the mixing apparatus MXD set, as already described, the third reversed pulse will be transmitted to the line L as the fourth pulse and the fifth reversed pulse of the original Baudot code will be transmitted to the line L as the third pulse.

It will be, of course, evident that when the next "figures-S" combination occurs, the relay TR_3 upon releasing will operate and lock up the fourth pair of transfer relays to reverse the fourth pulse of the Baudot code, while the relay TR_5 upon releasing will operate and lock up relays TR_1 and TR_1' over a circuit previously traced, thereby reversing the first pulse. It will thus be evident that the control is transferred from time to time through the chain of transfer relays two at a time, the next succession being the fifth and second pairs, then the first and third pairs, etc.

The manner in which the apparatus shown in Fig. 3 operates at the transmitting station is indicated symbolically at the left-hand of Fig. 4. Here the switching equipment SE_1 operates on the tape transmitter TT_1 to reverse certain pulses of the tape T_1 fed into the transmitter. The five pulses of each Baudot code with certain pulses thus reversed are in turn fed into the mixing apparatus MXD₁, which transposes the pulses in accordance with the setting of its keys. The code combinations thus enciphered are then transmitted through the teletypewriter TTY_1 to the line L. Whenever a "figures-S" combination is received in the teletypewriter TTY_1 , it operates the contact C_x to shift the control of the transfer relays of the switching equipment SE_1 to reverse different pulses of each Baudot code.

The enciphered codes are transmitted over line L to the receiving station, where they are applied to two renerforators RPF_2 and RPF_2' of known type. These machines perforate two tapes T_2 and T_2' , respectively, in accordance with the enciphered code combinations. The tape T_2' is fed into a tape transmitter TT_2' to operate a teletypewriter TTY_2' in accordance with the enciphered code. Whenever a "figures-S" combination is recorded on the teletypewriter TTY_2' , it momentarily opens the contact R_x to shift the control by means of the switching equipment SE_2 to the next set or sets of transfer relays. It will

be understood, of course, that the operation of the contact C_x at the sending station has at that station caused a similar shift of the transfer relays in the switching equipment SE_1 . Thus when a shift in the pulse to be reversed takes place at the sending station, a similar shift occurs at the receiving station. The result of this is that the pulse reversed at the transmitting station is always rereversed or restored to normal at the receiving station.

It remains to be seen how the pulses transposed by the mixing equipment MXD₁ at the transmitting station are retransposed by the similar equipment MXD₂ at the receiving station. Whenever the operator at the transmitting station sets the keys of the apparatus MXD₁ to transpose the order of the pulses in a particular manner, information is transmitted in code form to the receiving operator so that the receiving operator may set the keys of the apparatus MXD₂ to cause a reversed transposition of the pulses. This reversed transposition will be accomplished in the manner already described in connection with the mixing apparatus MXD₂ in Fig. 2.

It will be seen, therefore, that the tape T_2 , which is perforated in accordance with the enciphered code, will operate the contacts of transmitter TT_2 in accordance with said code. The transfer relays of the switching equipment SE_2 operate to restore to normal any reversed pulses set up on the tape transmitter TT_2 . Also such pulses as are transposed will be retransposed to their original order by the apparatus MXD₂. Consequently the code combinations will be transmitted in unenciphered form to the recording teletypewriter TTY_2 . The teletypewriter TTY_2 , therefore, prints the message as it was originally set up on the tape T_1 .

It will be understood, of course, that if the switching equipment SE_1 at the sending station is set to reverse certain pulses by the operation of pulse-reversal keys such as PRK_1 , etc., the switching equipment SE_2 at the receiving station will have its pulse-reversal keys set accordingly. Information may be transmitted in code from the transmitting operator to the receiving operator as to how the pulse-reversal keys of the switching equipment SE_2 must be set.

It will be obvious that by combining a system of pulse-reversals with a system of pulse transpositions as above described, it will be very difficult for unauthorized persons to decipher the message by tapping the line. It will also be clear that when desired either the pulse-reversing equipment SE or the pulse transposition equipment MXD may be used separately. Thus by using the pulse-reversal equipment SE without setting any of the keys of the transposition equipment MXD, the message will be enciphered by merely reversing certain pulses. On the other hand, by setting certain keys of the transposition equipment MXD without operating any of the transfer relays or pulse-reversal keys of the switching equipment SE , the message may be enciphered by only transposing the order of the pulses.

While this invention has been disclosed in certain specific arrangements which are deemed desirable, it will be obvious that the general principles herein set forth may be embodied in many other organizations widely different from those illustrated without departing from the spirit of the invention as defined in the appended claims.

What is claimed is:

1. In a secrecy system, means to translate mes-

sages into combinations of impulses representing characters or other signals in accordance with the Baudot code, means to encipher said code combinations by transposing the order of the pulses of each Baudot code, means to further encipher said code combinations including devices individual to each of the five pulses comprising the Baudot code and capable when operated of reversing the corresponding pulse of each code combination before it is transmitted, means causing any desired one of said devices to reverse the pulse controlled by it in all of a number of successive code combinations, thereby enciphering a message or part thereof in one form, and means responsive each time certain Baudot code combinations occur to defeat control by a previously operated device and to transfer pulse reversal control to other of said devices in succession to cause another pulse reversal in a different number of successive code combinations.

2. In a secrecy system, means to translate messages into combinations of impulses representing characters or other signals in accordance with the Baudot code, means to encipher said code combinations by transposing the order of the pulses of each of a succession of such Baudot codes in the same manner, means to further encipher said code combinations including devices individual to each of the five pulses comprising the Baudot code and capable when operated of reversing the corresponding pulse of each code combination before it is transmitted, means causing any desired one of said devices to reverse the pulse controlled by it in all of a number of successive code combinations, thereby enciphering a message or part thereof in one form, and means responsive each time certain Baudot code combinations occur to defeat control by a previously operated device and to transfer pulse reversal control to other of said devices in succession to cause another pulse reversal in a different number of successive code combinations.

3. In a secrecy system, means to translate messages into combinations of impulses representing characters or other signals in accordance with the Baudot code, means to encipher said code combinations by transposing the order of the pulses of each Baudot code, means to further encipher said code combinations including devices individual to each of the five pulses comprising the Baudot code and capable when operated of reversing the corresponding pulse of each code combination before it is transmitted, means causing any desired one of said devices to reverse the pulse controlled by it in all of a number of successive code combinations, thereby enciphering a message or part thereof in one form, means responsive each time certain Baudot code combinations occur to defeat control by a previously operated device and to transfer pulse reversal control to other of said devices in succession to cause another pulse reversal in a different number of successive code combinations, means to transmit the code combinations thus enciphered, means at a receiving station to restore the pulses of each received code combination to its original order, and means at each receiving station to restore the reversed pulses to normal.

4. In a secrecy system, means to translate messages into combinations of impulses representing characters or other signals in accordance with the Baudot code, means to encipher said code combinations by transposing the order of the pulses of each of a succession of such Baudot

codes in the same manner, means to further encipher said code combinations including devices individual to each of the five pulses comprising the Baudot code and capable when operated of reversing the corresponding pulse of each code combination before it is transmitted, means causing any desired one of said devices to reverse the pulse controlled by it in all of a number of successive code combinations, thereby enciphering a message or part thereof in one form, means responsive each time certain Baudot code combinations occur to defeat control by a previously operated device and to transfer pulse reversal control to other of said devices in succession to cause another pulse reversal in a different number of successive code combinations, means to transmit the code combinations thus enciphered, means at a receiving station to restore the pulses of each received code combination to its original order, and means at each receiving station to restore the reversed pulses to normal.

5. In a secrecy system, means to translate messages into combinations of impulses representing characters or other signals in accordance with the Baudot code, said means including a transmitter having contacts individual to each pulse of a Baudot code combination and to which said pulses may be applied, a distributor having segments for each pulse of a code combination to successively transmit said pulses, means adapted to connect the individual segments of said distributor to the individual contacts of said transmitter, means to shift said connections at will to encipher said code combinations by transposing the order in which the pulses are transmitted, means to further encipher said code combinations including devices individual to each of the five pulses comprising the Baudot code and capable when operated of reversing the corresponding pulse of each code combination before it is transmitted, means causing any desired one of said devices to reverse the pulse controlled by it in all of a number of successive code combinations, thereby enciphering a message or part thereof in one form, and means responsive each time certain Baudot code combinations occur to defeat control by a previously operated device and to transfer pulse reversal control to other of said devices in succession to cause another pulse reversal in a different number of successive code combinations.

6. In a secrecy system, means to translate messages into combinations of impulses representing characters or other signals in accordance with the Baudot code, said means including a transmitter having contacts individual to each pulse of a Baudot code combination and to which said pulses may be applied, a distributor having segments for each pulse of a code combination to successively transmit said pulses, means adapted to connect the individual segments of said distributor to the individual contacts of said transmitter, means to shift said connections at will to encipher said code combinations by transposing the order in which the pulses are transmitted, means to further encipher said code combinations including devices individual to each of the five pulses comprising the Baudot code and capable when operated of reversing the corresponding pulse of each code combination before it is transmitted, means causing any desired one of said devices to reverse the pulse controlled by it in all of a number of successive code combinations, thereby enciphering a message or part thereof in one form, means responsive each

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time certain Baudot code combinations occur to defeat control by a previously operated device and to transfer pulse reversal control to other of said devices in succession to cause another pulse reversal in a different number of successive code combinations, and means at a receiving station to restore the pulses of each received code combination to their original order and for restoring the reversed pulses to normal.

7. In a secrecy system, means to translate messages into combinations of impulses representing characters or other signals in accordance with the Baudot code, said means including a transmitter having contacts individual to each pulse of a Baudot code combination and to which said pulses may be applied, conductors leading from each of said contacts, a distributor having segments for each pulse of a code combination to successively transmit said pulses, conductors leading to each of said segments, a set of coordinate switching points arranged in rows extending in two directions, said conductors from the transmitter contacts leading to the switching points in each of the rows extending in one direction, said conductors leading to the segments of said distributor being associated one with each of the rows of switching points extending in the other direction, means at each switching point to connect the conductors leading from the transmitter contacts with the conductors leading to the segments of the distributor in any desired order, means to further encipher said code combinations including devices individual to each of the five pulses comprising the Baudot code and capable when operated of reversing the corresponding pulse of each code combination before it is transmitted, means causing any desired one of said devices to reverse the pulse controlled by it in all of a number of successive code combinations, thereby enciphering a message or part thereof in one form, and means responsive each time certain Baudot code combinations occur to defeat control by a previously operated device and to transfer pulse reversal control to other of said devices in succession to cause another

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pulse reversal in a different number of successive code combinations.

8. In a secrecy system, means to translate messages into combinations of impulses representing characters or other signals in accordance with the Baudot code, said means including a transmitter having contacts individual to each pulse of a Baudot code combination and to which said pulses may be applied, conductors leading from each of said contacts, a distributor having segments for each pulse of a code combination to successively transmit said pulses, conductors leading to each of said segments, a set of coordinate switching points arranged in rows extending in two directions, said conductors from the transmitter contacts leading to the switching points in each of the rows extending in one direction, said conductors leading to the segments of said distributor being associated one with each of the rows of switching points extending in the other direction, means at each switching point to connect the conductors leading from the transmitter contacts with the conductors leading to the segments of the distributor in any desired order, means to further encipher said code combinations including devices individual to each of the five pulses comprising the Baudot code and capable when operated of reversing the corresponding pulse of each code combination before it is transmitted, means causing any desired one of said devices to reverse the pulse controlled by it in all of a number of successive code combinations, thereby enciphering a message or part thereof in one form, means responsive each time certain Baudot code combinations occur to defeat control by a previously operated device and to transfer pulse reversal control to other of said devices in succession to cause another pulse reversal in a different number of successive code combinations, and means at a receiving station to restore the pulses of each received code combination to their original order and for restoring the reversed pulses to normal.

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