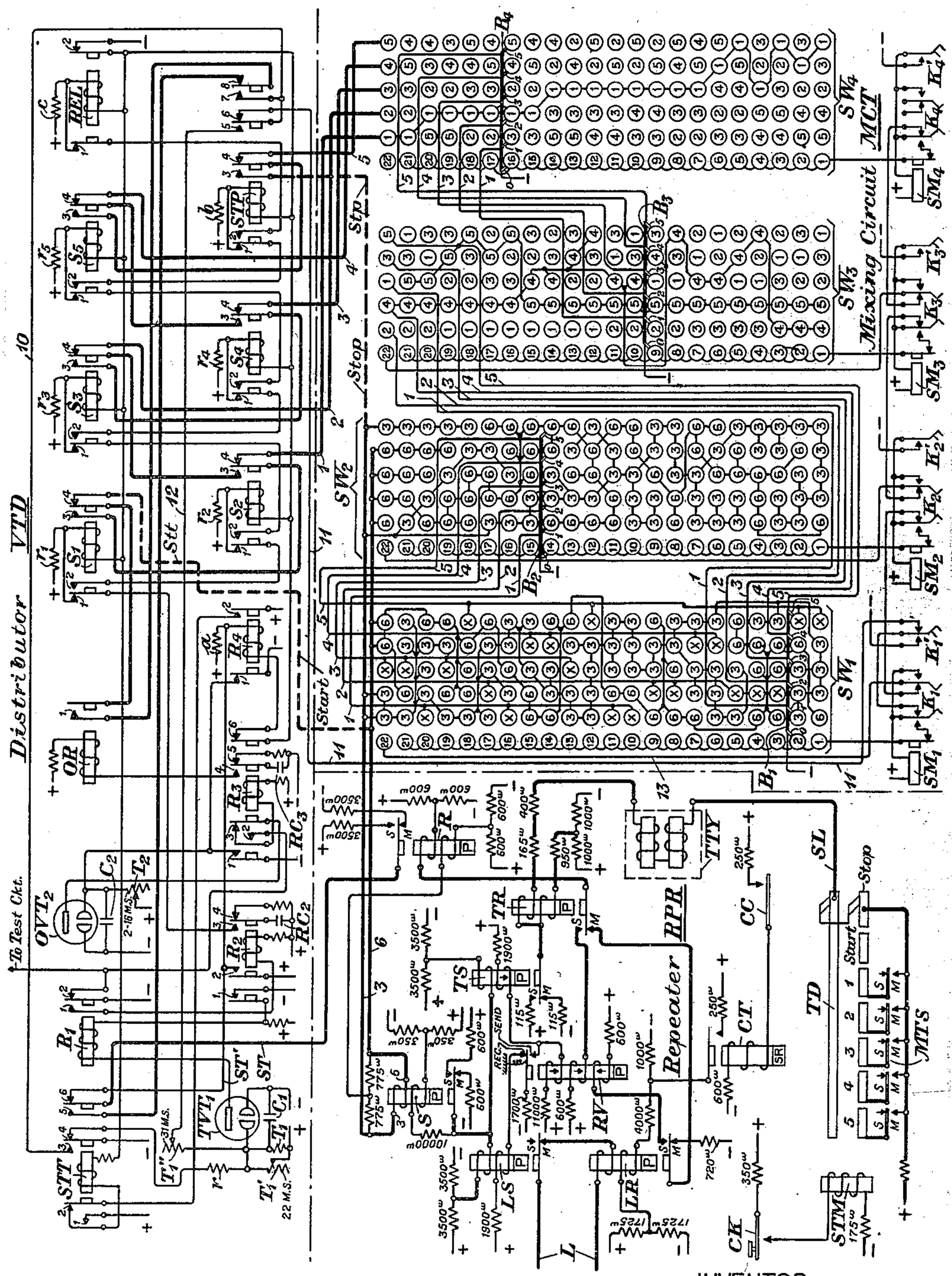
July 9, 1946. C. I. CRONBURG 2,403,888

ENCIPHERING AND DECIPHERING SYSTEM

Filed Feb. 12, 1944



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Patented July 9, 1946 2,403,888

UNITED STATES PATENT OFFICE

2,403,888

ENCIPHERING AND DECIPHERING SYSTEM

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Application February 12, 1944, Serial No. 522,039

14 Claims. (Cl. 178—22)

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This invention relates to teletypewriter communication systems and more particularly to arrangements for enciphering and deciphering messages sent over such systems.

In the art of communication by means of teletypewriters, messages are sent by means of the Baudot code. This code usually comprises five characters determining pulses each of which may be either a marking or a spacing pulse depending upon the character. Where start-stop distributors are used to transmit the pulses to the line or receive them therefrom in successive order, two additional pulses, one for starting and one for stopping the distributor, are usually added to the five pulses of the Baudot code.

Heretofore various methods of attaining secrecy in the transmission of messages by such codes have been proposed. Such methods usually involve some arbitrary variation or change in the five Baudot pulses without affecting the start or stop pulses. These variations usually take the form of changes in the character of the individual pulses. Usually enciphering is accomplished by scrambling the code combinations representing message characters with arbitrary character code combinations punched in a tape in a random manner. To decipher the message at a receiver the enciphered message is scrambled with a similar cipher tape, so that the resultant codes are restored to the form of the original message codes.

Enciphering and deciphering by means of cipher tapes have certain objections due to the impermanent character of the tape, the ease with which it may be prepared by unauthorized persons "breaking" the cipher, etc. There is consequently a need in the art for an enciphering and deciphering arrangement employing durable mechanical elements so designed that any desired cipher code may be set up thereon at will.

To accomplish this result the present invention utilizes mechanical switches, preferably of the step-by-step type. The switches have five banks of code-determining contacts over which wipers may be advanced. By variably wiring corresponding contacts in each of the five banks for each position of the switch a different Baudot code combination may be set up in each switch position so that the cipher code combination will be changed each time the switch is advanced a step. By employing a sufficient number of such switches and suitably varying the wiring of the contact points of the different switches, the five-unit cipher code for any individual character will depend upon the code wiring of a plurality of

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switches, and will vary in accordance with the relative settings of the several switches. This enables a scrambling cipher to be obtained which involves an enormous number of random code combinations to be used before the pattern is repeated.

In accordance with the invention the switches are preferably wired so as to introduce two types of variation into each individual code combination. Certain of the switches may be wired to "scramble" the code combination by superposing an arbitrary cipher code thereon, and others may be wired to produce changes analogous to pulse reversals in the character of some or all of the individual pulses. For example, by the first of these effects the pulses of a character, instead of being transmitted normally may be transmitted in the form of a code combination for an entirely different character. By the second effect, if the five pulses are in the form mark-space-space-mark-space, for example, their character may be changed to space-mark-space-space-mark, this result being attained by inverting the first, second, fourth and fifth pulses.

Another feature of the invention resides in the use of a vacuum tube distributor instead of the usual mechanical distributor. In the mechanical type of distributor a brush rotates over successive ring segments corresponding to the start pulse, five character determining pulses and the stop pulse. In accordance with the present invention a corresponding function is obtained by a combination of vacuum tubes and associated circuits. The vacuum tubes used in the improved distributor may be of any known type, but preferably gas tubes of the so-called "trigger" type are employed. These tubes, in association with certain timing circuits involving condensers and resistances, and certain counting relays, function to distribute a series of pulses to a plurality of successive circuits.

While separate tubes may be used for each pulse transmitted, so that the number of tubes will be identical with, or a multiple of, the number of pulses, it is preferred to utilize the same tube for timing all of the pulses. This is possible because in practice all of the pulses except the stop pulse are of the same length. The tube with its timing circuit is used to successively operate counting relays for the start pulse and five character-determining pulses. For the longer stop pulse the constants of the timing circuit associated with the tube are changed to produce a longer pulse interval.

The distributor ordinarily used with encipher-

ing arrangements is of the receiving type. In this type of distributor the pulses are regenerated by transmitting a renewed pulse during a limited part of the pulse interval and preferably near the middle thereof. Therefore, the invention contemplates a second tube associated with a timing circuit for determining the period of duration of the renewed pulse, and for adjusting or "orienting" such period with respect to the total interval assigned to the pulse. This tube, like the tube which times the pulse intervals, repeats its operating cycle for each pulse transmitted.

While as herein illustrated the improved vacuum tube distributor is used only in connection with the enciphering circuit, it will be understood that it may be used in connection with any piece of apparatus and in any type of circuit requiring a distributor.

The invention will now be more fully understood from the following description, when read in connection with the drawing, the single figure of which illustrates a preferred circuit arrangement embodying the invention.

General Description of Apparatus

The circuit arrangement and apparatus of the invention include three main pieces of equipment: (*a*) a repeater RPR for repeating signals from the line L to a receiving teletypewriter TTY in a loop SL, and for repeating signals from the loop SL to the line; (*b*) a vacuum tube distributor VTD; and (*c*) a mixing circuit MCT for determining the cipher with which the message is to be scrambled. In the diagram the repeater is shown in the lower left-hand portion of the drawing, the vacuum tube distributor in the upper part of the drawing, and the mixing circuit in the lower right-hand portion of the drawing.

(*a*) *The repeater*

The repeater is of the reversible type, this being necessary in order that the mixing circuit, which is a one-way circuit, may be pointed in the correct direction depending upon whether signals are being received from the line L by the teletypewriter TTY in the loop SL, or transmitted from the transmitter MTS in the loop to the line. The essential elements of the repeater include four polar relays. (1) a relay LR for receiving signals from the line L, (2) a relay LS for transmitting signals to the line, (3) a relay TR for receiving signals from the transmitter MTS, and (4) a relay TS for sending signals to the teletypewriter TTY.

In order to prevent the relay LS from sending signals to the line L when signals are incoming from the line, and likewise to prevent the relay TS from sending signals to the teletypewriter TTY when the sender MTS is sending out signals, an additional polar relay RV is provided. This relay normally functions to lock up the relay LS so that signals may be received from the line L without interference on the part of the relay LS. When, however, signals are sent out from the transmitter MTS, the first signal shifts the armature of the relay RV to its sending position and locks it in that position so that the relay TS is locked up and the relay LS is unlocked. Relay LS may now repeat signals to the line L and the relay TS is prevented from responding to signals sent out from the loop SL to cause interference in said loop.

The repeater is associated with the enciphering and deciphering arrangements through polar relays S and R. The relay R responds either to

signals repeated from the line L through the relay LR or to signals repeated from the loop SL through the relay TR. Signals from either source are therefore transmitted by the relay R through the distributor shown in the upper portion of the drawing to the mixing circuit shown in the lower right-hand part of the drawing. The relay S, on the other hand, responds to signals which have been passed through the mixing circuit regardless of whether they were originally received from the line L or from the loop SL. In the latter case the signals are repeated by the relay S to the relay LS, to be transmitted to the line L. In the former case they are repeated by the relay S to the relay TS to be transmitted to the loop SL and be recorded on the teletypewriter TTY.

The loop SL, with which the repeater is associated, includes in addition to the teletypewriter TTY for recording either incoming or outgoing signals, a message tape sender or transmitter MTS (or, if preferred, a keyboard transmitter) with which is associated the usual transmitting distributor TD which, in this instance, is of the ordinary transmitting type in which a brush passes over successive segments to successively transmit pulses of a code combination.

(*b*) *Vacuum tube distributor*

The distributor includes essentially a starting relay STT, a timing vacuum tube TVT_1 and associated condenser and resistances for timing its operation, an orienting vacuum tube OVT_2, an orienting relay OR, counting relays S_1 to S_5, inclusive, a stopping relay STP included in the counting relay chain, and a release relay REL. In addition, certain auxiliary relays R_1, R_2, R_3 and R_4 are provided. The function of these relays will appear more fully hereinafter.

The relay R_4, the counting relays S_1 to S_5, inclusive, stopping relay STP, and release relay REL each have their windings connected to positive battery through a suitable resistance such as *a* in the case of relay R_4, r_1 to r_5, inclusive, in the case of relays S_1 to S_5, inclusive, *b* in the case of relay STP, and *c* in the case of relay REL. The current flowing through these resistances is insufficient to operate these relays. However, when the relays are operated by battery connected directly to their windings, the current flowing through their resistances acts as a holding current to maintain them operated and, in effect, lock them up, as will be made clear later.

When a start impulse is relayed from the repeater to the distributor through the relay R of the repeater, the relay R_4 is operated to initiate the action of the distributor. Relay R_4 operates and locks up the starting relay STT and also conditions the orienting vacuum tube OVT_2 for operation. The starting relay when operated remains locked up until the complete cycle of seven impulses has been transmitted. The orienting vacuum tube OVT_2 when conditioned for operation does not immediately trigger off, but its action is delayed for a predetermined time while the condenser C_2 is being charged through the resistance T_2. The latter may be adjusted to cause the tube to discharge or trigger off at any desired interval after the initiation of the start pulse. When said tube operates, relay R_3 responds and causes the orienting relay OR to transmit a brief impulse (about one-fifth as long as the time allotted to the start impulse) to the relay S associated with the repeater.

The operation of the start relay STT condi-

tions the timing vacuum tube TVT_1 for operation to time the impulses. The tube does not operate immediately, however, because the associated condenser C_1 and resistances T_1 and T_1' are of such value that it requires 22 miliseconds to build up a potential on the controlling electrode of the tube which will cause a discharge to take place between its cathode and anode. Upon triggering off, however, it operates the relay R_1, which in turn operates the relay R_2. It also releases relays R_3 and R_4, the former having in the meantime been operated by the vacuum tube OVT_2 as already described. Relay R_2 immediately short-circuits the relay R_1 and the tube TVT_1, the relay R_1 at once releasing relay R_2. The momentary short-circuiting of the tube TVT_1 restores the tube to normal so that it is again conditioned for operation, and repeats its cycle to again trigger off at the end of 22 milliseconds, thus establishing the period for the first character-determining impulse.

The momentary operation of the relay R_2 operated the first counting relay S_1. During the interval required for the second operation of the tube TVT_1, the orienting relay OVT_2 operates as before, so that the orienting relay OR for a brief interval transmits the first character determining impulse relayed by the relay R of the repeater to the mixing circuit.

The circuit arrangement of the distributor is such that the tubes TVT_1 and OVT_2 continue to repeat their cycles during successive 22-millisecond intervals, and successive counting relays such as S_2, S_3, S_4 and S_5 are operated and transmit successive character-determining impulses to the mixing circuit, as will be described more fully later. After the last character-determining impulse has been transmitted, the next relay in the chain, which is the stop relay STP, is actuated. This changes the timing of the tube TVT_1 so that it now requires 31 milliseconds, the normal length of a stop pulse, before it triggers off.

During the stop impulse, the orienting relay OR is operated just as in the case of the other impulses but, due to the fact all of the chain relays have been operated, the momentary start impulse controlled by the orienting relay OR is transmitted directly to the relay S of the repeater and not through the mixing circuit. At the end of the 31-millisecond interval the release relay REL is momentarily operated and releases all of the relays of the distributor so that the distributing apparatus is ready to execute a new code cycle in response to the next start impulse.

The character-determining impulses are not transmitted directly to the relay S of the repeater but first pass through the mixing circuit to be enciphered, and are then transmitted from the mixing circuit to the relay S as will be described. The full sequence of seven impulses is relayed by the relay S through the repeater to the line L or to the loop SL, depending upon whether they originated in the loop or in said line.

(c) *Mixing circuit*

The mixing circuit as illustrated includes four 22-point step-by-step switches SW_1, SW_2, SW_3, and SW_4. Each of these switches has six contacts in each of the 22 rows comprising a bank. Five contacts in each row are used for introducing a cipher into the five character-determining impulses of the codes. The sixth contact in each of the 22 rows of the bank is used to control the stepping of the switches, as will be described in more detail later.

The stepping magnets such as SM_1, SM_2, etc. of the switches are so wired that the switch SW_1 will be advanced one step each time a full set of seven code pulses is transmitted, thereby changing the enciphering code as will be described later. When the first switch SW_1 has thus been advanced to its twenty-second point, the circuit is automatically closed to advance the second switch SW_2 one step. After this switch has been advanced 22 steps (the switch SW_1 having in the meantime rotated through its complete cycle 22 times), the switch SW_2 automatically completes a circuit to advance the switch SW_3 one step. Switch SW_3 after being advanced 22 steps, in turn advances switch SW_4 one step. In this manner a large number of different ciphering combinations may be produced for scrambling successive message code combinations (or for unscrambling received enciphered code combinations) as will be more fully described later.

The switches SW_3 and SW_4 are so arranged as to superpose a cipher in the form of a code representing some arbitrary order on the five message character-determining impulses. The five message character-determining impulses are transmitted through the distributor to the five vertical rows of contacts of the switch SW_4 located at the right of the vertical row of contacts numbered **1** to **22**, inclusive, which latter are used in connection with the stepping operations of the switches. The five character pulse contacts in each row of the switch are wired so that in different positions of the brush B_4 the pulses are changed in order. For example, it will be seen that the top row of contacts of the switch SW_4 are arranged in normal order **1—2—3—4—5**. The contacts of the twenty-first row are numbered in the order **1—2—3—5—4**, and the twentieth row of contacts in the order **5—1—2—3—4**. Each of these represents a different arbitrary ciphering character. Because of the complication of the wiring involved, only the wiring for contact numbered **1** is shown. It may be treated from the first contact in the twenty-second row through various contacts numbered **1** in the other rows, ending with the extreme right-hand contact of the lower row, where the order of numbering of the contacts is **5—4—2—3—1**.

The five pulse transmitting wipers of the brush B_4 are connected, respectively, to corresponding wipers of the brush B_3 of the switch SW_3. This switch is also wired to change the order of numbering of the contacts in each successive row although, of course, the changes are different than they are in the case of the switch SW_4. To avoid complication, only the wiring for two contacts in each row is shown. For example, in the twenty-second row the wiring for the fourth contact starts at the second pulse-determining contact from the left in that row, and may be traced through successive contacts numbered **4** down to the left-hand pulse-determining contact of the first row. Similarly, the wiring for contact numbered **5** starts with the fifth extreme right-hand contact of the twenty-second row and may be traced through successive contacts down to the second pulse-determining contact from the left in the first row.

The wiring in the switches SW_4 and SW_3 is such that the arrangement of contacts is different for each setting of each of the switches, and as the wiring for each pulse passes serially through

contacts of both switches, the setting determined by a particular row of the switch SW_4 may be changed with respect to at least some of the pulses by the row of contacts upon which the switch SW_3 is set. Consequently, in effect two successive shifts in relation occur independently, thus multiplying the possible number of combinations. Obviously a larger number of possible combinations may be obtained by interpolating additional switches similar to SW_3 and SW_4 between said switches.

Switches SW_1 and SW_2 while similar in structure to switches SW_3 and SW_4 are wired to obtain a different result. The function of these two switches is to determine whether the pulses transmitted by the five wires leading from the switch SW_3 will be applied to the No. 3 terminal or the No. 6 terminal of the polar relay S in the repeater. In these switches the numbers applied to the five code-determining contacts in each row indicate whether the connection is to be completed to the one terminal or the other of the relay S.

In the case of switch SW_1, if a particular wiper of the brush rests on a terminal numbered 3 or 6, the connection is completed directly from the corresponding wire of the switch SW_3 to the conductor 3 or 6 as the case may be, leading to the relay S. In the case of contacts marked X, however, of which there is at least one in each row in the switch SW_1, the connection is extended from the switch SW_1 over one of the conductors marked 1, 2, 3, 4 and 5, leading from switch SW_1 to corresponding wipers of the brush B_2 of switch SW_2. In this case the pulse passing over the contact marked X will arrive at one of the terminals of the relay S over a path determined by the setting of the brush B_2.

For example, if as shown in the drawing, the fifth wiper of the brush B_1, is resting on the X contact of the second row of switch SW_1, it will be seen that this contact and other similarly marked contacts in the same vertical row are all connected over wire No. 5 leading from switch SW_1 to the fifth wiper of brush B_2 of switch SW_2. Since in the setting there shown this fifth wiper rests on a segment numbered 6, which is connected to conductor 6 leading to the relay S, the circuit will be completed to terminal numbered 6 of said relay.

In effect the switches SW_1 and SW_2 serve to introduce a different kind of translation or cipher into the code combination. The effect of these switches is to reverse or not reverse any given pulse of the five character-determining pulses, depending upon the setting of the two switches. Another way of looking at it is that the switches SW_1 and SW_2 have the effect of introducing changes in the polarity of certain of the pulses, in addition to the ciphering effect introduced through the agency of the switches SW_3 and SW_4.

In considering these switches it should be noted that the five pulses transmitted successively through the distributor enter the upper row of the switch SW_4 first. They are then passed by the brush B_4 of said switch to the brush B_3 of the switch SW_3 and out over the conductors 1, 2, 3, 4 and 5 leading from said switch to the brush B_1 of the switch SW_1. From this point the pulses are transmitted either directly through contacts of the switch SW_1 to the conductors 3 or 6 leading to the relay S; or, where X contacts are involved, they are led to one or the other of the wipers numbered 1 to 5, inclusive, of the brush B_2, and thence over corresponding contacts to one or the other of the conductors 3 or 6 leading to the relay S.

Description of Operation

(d) *Operation of the repeater when sending from the loop SL to the line L—start impulse*

Let us assume that a message in non-ciphered form is punched in the tape and the tape is fed into the message tape sender MTS. When the operator desires to send this message the key CK is closed to energize the start magnet STM of the rotating distributor TD. This distributor when released rotates continuously at a constant speed and as its wipers pass from the stop segment to the start segment a start impulse (which is a spacing or open circuit impulse) is sent into the loop SL. As the wipers pass successively over the segments marked 1, 2, 3, 4 and 5, the five character-determining pulses are transmitted to the loop. These pulses may be open or closed circuit pulses, depending upon whether the armatures of the transmitter rest upon marking or spacing contacts.

If it rests upon a marking contact a circuit is completed from positive battery, through the distributor and loop SL, thence through the teletypewriter TTY, through the upper winding of the relay TR, over the marking contact of the relay TS to negative battery. Current flows through the lower winding of the relay TR in such direction as to bias the armature of the said relay towards its spacing contact. The current flowing over the path just traced through the upper winding, however, is sufficient to move the armature of the relay TR to its marking contact notwithstanding the biasing effect of the lower winding. If, however, any particular pulse entering the loop from the sender MTS is an open circuit pulse, as will be the case when the corresponding contact of the sender is on its spacing contact, no current will flow through the upper winding of the relay TR. Consequently the current through the biasing winding will shift the armature to its spacing contact. The armature of the relay TR, therefore, follows the marking and spacing character of the pulses transmitted into the loop SL.

As the brush of the distributor TD leaves the last segment and passes over its stop segment, a closed circuit impulse is transmitted to the loop SL. This energizes the upper winding of the relay TR in the repeater and causes the armature of said relay to move to its marking contact. The code combination thus transmitted to the loop is recorded in non-ciphered form on the teletypewriter TTY. It is changed into enciphered form, however, after it leaves the loop and before being sent to the line L. In the meantime the brush continues through its succeeding cycle to transmit the pulses of the next code combination.

Returning to the first code combination transmitted, it will be recalled that the first pulse was a spacing or no-current pulse which caused the relay TR to move its armature from marking to spacing. This completes a circuit from positive battery, through the middle winding of the polar relay RV, over the spacing contact of the relay TR, and through the upper winding of the relay R to negative battery. The current flowing through the middle winding of the relay RV shifts the armature of the relay from its upper or receiving contact to its lower or sending contact.

The armature is locked in this position by a circuit completed from negative battery, through the 1700-ohm resistance, over the sending contact of relay RV, through the upper winding of said relay, to positive battery through the 11,000-ohm resistance. The current through this circuit is small, but sufficient to hold the armature of relay RV upon its lower contact. The relay RV thus remains locked up until a stronger pulse of opposite polarity from the line L operates through the lower winding of said relay to shift its armature to its reeciving contact. Relay RV when thus locked up completes a circuit through the lower winding of the relay TS. The circuit throgh this winding holds the armature of relay TS upon its marking contact regardless of whether marking or spacing pulses flow through its upper winding TS.

Returning now to the circuit traced through the middle winding of the relay RV and the upper winding of the relay R, it will be noted that the current flow is in such a direction through the upper winding of relay R as to shift its armature to its spacing contact. A circuit is thus completed from positive battery through the 3500-ohm resistance, over the spacing contact of the relay R, and over a circuit including conductor ST, as will be described later, to initiate the operation of the distributor. At a suitable point during the 22-milliseconds time allowed for the start impulse of the distributor, the distributor in turn sends a spacing impulse over a circuit that will be described later, to the conductor **3** leading to the No. 3 terminal of the relay S, the circuit continuing through the upper winding of said relay over its No. 6 terminal, through a 775-ohm resistance, and thence through the lower winding of the relay R to negative battery. The current flow over this circuit is in such a direction as to aid in holding the armature of the relay R upon its spacing contact.

The current flow through the upper winding of the relay S is in such a direction as to shift its armature from its marking to its spacing contact, thus completing a circuit from positive battery, through a 600-ohm resistance, over the spacing contact and armature of relay S, through a 10,000-ohm winding and through the lower winding of relay S to negative battery. This current is in such a direction as to hold the armature of relay S on its spacing contact, but is not of sufficient strength to prevent the armature from being shifted to its marking contact in response to a marking current through the upper winding of said relay S.

The operation of the relay S to its spacing contact also connects positive battery over the spacing contact and armature of relay S, and thence in parallel through the upper windings of relays LS and TS to negative battery. The relay TS is not affected by the current flowing through its upper winding, however, as its armature is locked to its marking contact by the current flowing over the sending contact of relay RV and through the lower winding of relay TS. In the case of the relay LS, however, its lower winding is open-circuited and its armature responds to the current flowing through its upper winding, thus shifting to its spacing contact. This opens the line L and sends a start impulse to said line.

In the operations above described the relay LS has opened the line L to send a spacing impulse and, as will be described later, it responds to marking and spacing signals to send character-determining impulses, and finally, the stop impulse. In this connection it should be noted that the receiving relay LR is used for transmitting signals from the line L to the loop SL. Since this relay is in the line L it will follow the operations of the relay LS if left free. This cannot be permitted because its reaction in the line L would break up the outgoing signals.

A contact CC is therefore provided in connection with the sender which, when closed, will operate the relay CT. This contact is arranged to close just before the start signal is transmitted by the sender and to open after the fifth character-determining impulse is transmitted. The relay CT is thus operated each time the contact closes, and applies positive battery through a 250-ohm resistance to a point between the biasing winding of the relay LR and the 1,000-ohm resistance in circuit therewith. The bias effect produced by the biasing winding is normally in the spacing direction. When positive battery is applied as above described, the current in the biasing winding reverses and holds the relay LR on its marking contact. The relay LR is thus unaffected by the signals sent to the line by the relay LS.

One other point needs to be considered. The start impulse and the various character-determining impulses leaving the sender are delayed in passing through the mixing circuit by approximately one-half a pulse length. Therefore it is necessary to hold the relay CT operated approximately one-half pulse length after the last character-determining impulse has been sent to the mixing circuit. This is accomplished by making the relay CT slow to release.

(e) Operation of the repeater when sending to the line L—character determining pulses and stop impulse

We have now seen how the repeater operates to transmit a start impulse from the loop to the line L. Following this impulse the sender MTS sends five character-determining pulses which may be either marking or spacing, depending upon the character to be transmitted. Let us assume the first of the five character-determining impulses is a marking pulse. Positive battery will be connected over the first segment of the distributor TD into the loop SL and will flow through the upper winding of the relay TR and over the marking contact of the relay TS to negative battery. The current flowing through the upper winding of relay TR will be sufficient to overcome the biasing action of the lower winding and will shift the armature of the relay TR back to its marking contact.

Current will now flow from negative battery, through a 720-ohm resistance, over the marking contact of the relay LR, over the marking contact of relay TR, through the upper winding of the relay R to positive battery. The current flowing through the upper winding of the relay R will overcome the effect of the current in the lower or holding winding of said relay, and will shift its armature to its marking contact. Negative battery is now connected through a 3,500-ohm resistance and over the marking contact of relay R to the conductor ST. From conductor ST the circuit continues through the vacuum tube distributor VTD and the mixing circuit MCT by a path which will be described later in connection with the operation of these pieces of apparatus. Thence it continues over either conductor **3** or conductor **6** leading from the mixing circuit to one of the terminals of the upper wind-

ing of the relay S, through said operating winding, and thence through the 775-ohm resistance and the lower winding of the relay R to positive battery.

The current through the circuit above described is initiated by the action of the relay R as a marking current. Due, however, to the arrangements of mixing circuit MCT, as appears more fully later, the current may flow through the operating winding of the relay S in either of two directions, to produce either a marking or spacing action of the relay S, depending upon the setting of the switches of the mixing circuit. However, it should be noted that regardless of the direction of current flow through the operating winding of the relay S the connection of the lower or holding winding of the relay R is to either positive or negative battery through 600-ohm resistances. Therefore, when the current applied to one end of the circuit is marking so that negative battery is applied to that end of the circuit, the current flow through the holding winding of the relay R will be to positive battery. Therefore, it will be in such a direction as to tend to hold the armature of the relay R upon its marking contact. This will be true regardless of whether the armature of relay S is actuated to a marking or a spacing contact.

Similarly, if the first pulse had been a spacing pulse, the armature of the relay R would have completed a circuit from positive battery, over the spacing contact of the relay R, and thence over the circuit through the distributor VTD and the mixing circuit MCT through the operating winding of the relay S, and thence through the lower winding of the relay R to negative battery. Again the operation of the relay S will depend upon the setting of the switches and the character of the received pulse. But regardless of the setting of the switches, the current flow through the holding winding of the relay R would be in a direction to hold the armature of the relay R upon its spacing contact. As a result of this action the armature of the relay R is held upon the contact to which it has been moved, even though the current through its operating winding has ceased. There it remains until such time as the current through the operating winding is in the opposite direction, so that it overcomes the effect of the lower holding winding and shifts the armature.

Returning now to the relay S. This relay moves its armature to its marking or spacing contact depending upon the setting of the switches in the mixing circuit MCT and the character of the pulse received, and thereby connects negative or positive battery over its armature to the upper windings of relays LS and TS. The relay TS does not respond to this action because, as already described, its armature is locked against its marking contact by the action of the relay RV. This relay, it will be recalled, remains locked up so long as signals are sent from the local loop SL to the line L, and is only unlocked when signaling in the reverse direction commences, as will be described later. The relay LS, however, responds to the action of the armature of relay S to send into the line L a marking or spacing pulse, depending upon the setting of the mixing circuit MCT. The relay CT, of course, operates as already described to lock up the relay LR to prevent it from responding to pulses sent into the line L.

In a similar manner the other four character-determining pulses are sent from the distributor TD to the loop SL and operate the relay TR and the relay R, as already described, to send pulses of marking or spacing current to the conductor ST. Thence they pass through the distributor VTD and the mixing circuit MCT, through the upper winding of the relay S, and through the holding winding of the relay R to battery. The relay S therefore sends to the line L marking or spacing impulses, depending upon the received impulses and the setting of the mixing circuit MCT.

Finally, the stop pulse is sent from the distributor TD over the stop segment of said distributor to the loop SL. This is a closed circuit pulse and operates through the relays TR and R to cause the armature of the latter relay to rest upon its marking contact and connect negative battery to the conductor ST. As will be described later in connection with the vacuum tube distributor VTD, this circuit will continue through the distributor to the conductor *stp*, and thence through the upper winding of the relay S and the lower or holding winding of the relay R to positive battery. Thus the complete code combination of seven pulses is sent to the line L.

In the meantime after the fifth character-determining pulse is sent by the distributor TD, the contact CC opens and after a short delay the relay CT releases, thereby unlocking the lower winding of the relay LR in the line circuit until the code combination for a new character is sent. During the brief period that the holding winding of the relay LR is thus unlocked, it is possible for an operator at a distant station to send a break signal which will release the relay LR, and in a well-known manner obtain control of the circuit for transmission from the line L to the loop SL.

(f) Operation of the repeater when sending from the line L to the loop SL—start pulse

In transmitting signals in the reverse direction, that is, from the line L to the loop SL, the operation is somewhat similar to that above set forth. However, the apparatus involved in the vacuum tube distributor VTD and that involved in the mixing circuit MCT are in effect reversed. Hence the signals from the line L now pass through the distributor and mixing circuit to the loop SL, instead of signals from the loop SL passing through the distributor and mixing circuit to the line L as previously described.

The operation of the distributor under these conditions is as follows:

When the transmitter MTS is stopped by opening the key CK so that it comes to rest, the line relay LR is unaffected by the contact CC and is therefore free to follow the incoming line signals. The distributor TD, of course, comes to rest on its stop contact and in this position the contact CC is opened and remains open. Therefore, relay CC releases its contact and unlocks the relay LR by reducing the current flow through its lower winding, so that a mere biasing effect is produced which can be overcome by current pulses from the line through the upper or operating winding of relay LR.

The function of the mixing circuit in this instance is to unscramble the scrambled impulses that come in from the line L after having been scrambled at a distant station. The cipher code combinations which are set up in the mixing circuit MCT for scrambling are the same as those used at the sending station, and when combined with the effect of the scrambled pulses incoming

from the line, will cause the printer TTY to record the message in its normal or non-ciphered form.

The first impulse received from the line L will, of course, be a start pulse, i. e., an open circuit pulse. The normal current flowing through the upper winding of the relay LR will therefore cease, and the lower or biasing winding shifts the winding of said relay to its spacing contact. This completes a circuit from positive battery through a 600-ohm resistance, through the lower winding of the relay RV, over the spacing contact of the relay LR, over the marking contact of relay TR, through the upper or operating winding of relay R, and through another 600-ohm resistance to negative battery.

At the time the circuit above traced is completed, no current is flowing through the middle winding of the relay RV, and the upper winding is locked up through the 11,000-ohm resistance. This is sufficient to hold the armature of the relay RV on its lower or sending contact as long as there is no greater pull exerted in the opposite direction by one of the other windings. When signals were being sent from the loop SL to the line L as previously described, no current passed through the middle winding of the relay RV during the transmission of marking pulses, and during spacing impulses it was in such direction as to assist the upper winding of relay RV to hold its armature upon its lower contact.

However, under the condition of reception from the line L we now have, no current whatever flows through the middle winding of relay RV. Therefore, when current flows through the lower winding over the circuit above traced, the pull exerted by the lower winding is opposite in direction to that exerted by the upper winding, and is sufficiently greater so that it overcomes the holding effect of said upper winding. The result is that the armature of relay RV is now shifted to its upper or sending contact in response to the first spacing signal received.

During reception from the line L, only spacing impulses through the lower winding will operate upon the relay RV and no current will flow in the upper and middle windings. Therefore, the spacing pulses in the lower winding hold said armature in its upper position so long as signals are being received from the line L. In the marking condition the light biasing spring holds the armature of relay RV on its receiving contact. Therefore relay RV locks up the relay LS through its lower winding, thus preventing said relay from responding to signals from the relay S, but the lower winding of the relay TS receives no current. Therefore relay TS is able to follow the signals received by the relay S and transmit them into the loop SL.

The start signal current flowing through the upper winding of the relay S causes its armature to be shifted to its spacing contact, thereby connecting positive current to the operating windings of relays TS and LS. Relay LS is disabled, but relay TS follows the signal and shifts its armature to its spacing contact, thus connecting positive battery to the junction point of the upper and lower windings of the relay TR. From this point a biasing current passes through the lower winding of said relay, through the 950-ohm resistance, and a 1,000-ohm resistance to negative battery. No current flows through the upper winding of said relay TR because positive battery is connected to the loop SL over the stop segment of the distributor TD. Hence the connection of

positive battery over the armature of relay TS merely opposes the potential applied to the other end of the loop and no current flows.

It will be noted that the current flowing through the lower winding of the relay TR is in such a direction as to hold the armature of said relay on its marking contact. Therefore the relay TR does not respond to a spacing impulse transmitted by the relay TS. As will be shown later, said relay TR does not respond to a marking signal transmitted by the relay S, because the windings of the relay TR are balanced and oppose each other. Consequently, during the condition of transmission from the line L to the loop SL, the relay TR is not actuated. The start signal produces a no-current condition in the loop SL as already described. This condition is equivalent to a start pulse in the subscriber's loop, and the receiver TTY starts its cycle to receive the character-determining pulses which follow.

(g) Operation of the repeater when sending from line L to loop SL—character - determining pulses and stop impulses

The first character-determining pulse now comes in over the line L. Let us assume this is a marking pulse so that current flows through the upper or operating winding of the relay LR. This current is sufficient to overcome the effect of the holding current in the lower winding so that the armature of the relay LR is now shifted to its marking contact. This completes a circuit from negative battery over said contact, over the marking contact of the relay TR, and through the upper or operating winding of relay R to positive battery. Relay R shifts its armature to its marking contact and connects negative battery over said contact to the conductor ST. The circuit from this conductor extends through the vacuum tube distributor VTD in a manner to be later described, and thence over certain contacts and wiper brushes of the mixing circuit MCT (depending upon its setting), thence over conductor **3** or **6** as the case may be to the upper winding of relay S, through a 775-ohm resistance, and through the lower winding of the relay R to positive battery.

The current through the lower winding of relay R is in such direction as to tend to hold the armature of said relay upon the contact which established the circuit. In this case it tends to hold the armature upon the marking contact. The current through the operating winding of the relay S, however, without changing the direction of current through the lower winding of the relay LR, may be in either of two directions, depending upon the setting of the mixing circuit. Therefore it operates the armature of said relay S to either its marking or spacing contact depending upon the direction of current flow.

In any event, due to the fact that the switches of the mixing circuit MCT are set in the same way as the corresponding switches in the mixing circuit at the distant sending station, the mixing circuit will determine that the direction of the current flow through the upper windings of the relay LS will be in such direction as to restore the pulse received to non-ciphered condition. Thus if the original pulse, before scrambling, was a marking pulse, the current flowing through the upper windings of the relay S will be in such direction as to shift its armature to marking position. This causes the relay TS to operate to marking position and connect battery to the midpoint of the windings of the relay TR.

From the midpoint of the windings of relay TR the circuit extends through the lower winding through a 950-ohm resistance, and through a 1,000-ohm resistance to positive battery. Similarly the current through the upper winding extends through the 165-ohm and 400-ohm resistances, through the winding of the magnet of receiving teletypewriter TTY, and finally over the distributor brush and stop segment of distributor TD to positive battery. The current through the two windings of the relay TR produces equal and opposite effects so that the armature of said relay is not shifted. Current, however, flows through the subscriber's loop SL through the upper winding of the relay TR as just described, thereby causing the receiving teletypewriter TTY to receive the first character-determining impulse as a marking signal.

In a similar manner the succeeding four character-determining impulses received from the line L are transmitted through the repeater, through the vacuum tube distributor VTD and mixing circuit MCT, as later described. These pulses operate the relay S to marking or spacing as the case may be, thereby producing a corresponding marking or spacing signal in the loop SL. As these pulses have been restored to their original non-ciphered form, the teletypewriter TTY prints the character originally originated at the sending station. A receiving station not equipped with the deciphering mixing circuit will, however, print some other character than that originally initiated, because the pulses will be received in scrambled form.

Following the last character-determining impulse the stop pulse is sent. This is a closed circuit or marking pulse and operates the relay LR to in turn cause the relay R to shift its armature to marking position. Negative battery is thus connected over the armature of the relay R to the conductor ST and through the distributor, in a manner to be described later, to the stop conductor *stp*. This conductor is connected to the conductor **3** leading to the terminal **3** of the upper winding of the relay S, and thence through said winding over a circuit previously traced to positive battery. Relay S, therefore, actuates its armature to its marking contact, in turn causing relay TS to send a marking signal into the loop SL, thus producing a stop signal for the receiving teletypewriter TTY.

(h) Operation of vacuum tube distributor VTD—start pulse

When a code combination is transmitted either from the loop SL to the line L or vice versa, the relay R of the repeater responds as previously described to send, first, a start impulse which is a spacing signal. Consequently, a circuit is completed from positive battery, over the space contact of the relay R, over conductor ST, over contact **6** of the start relay STT of the distributor, and thence over conductor ST', through the winding of relay R_4, over contact **6** of relay R_3, and over contact **2** of release relay REL to negative battery.

The current normally flowing through the winding of the relay R_4 through the resistance *a* is insufficient to operate said relay. When, however, current flows through the winding of said relay over the circuit just traced, the total current flowing through the winding of the relay R_4 is increased sufficiently to cause said relay to pull up its armature. When the relay R_4 pulls up its

armature it will remain actuated by the current flowing through the resistance *a* even after the operating circuit above traced is opened at contact **6** of relay STT as will be described later. It will remain so operated until the relay R_3 later opens its contact **6** and thus open-circuits the relay R_4, as will presently appear.

Relay R_4 completes a circuit from positive battery, over its contact **2**, over the contact **2** of start relay STT, through the winding of said relay, and thence over contact **2** of release relay REL to battery. Relay STT is at once energized and locked up over its contact **1**, so that it remains actuated during the complete cycle of the distributor, which involves all seven pulses of a code combination. It is not released until at the end of the cycle the release relay REL opens its circuit, as will be described later.

Normally, negative battery is connected over contact **1** of relay R_4 to the starter anode of the orienting vacuum tube OVT_2, thus short-circuiting the condenser C_2. The relay R_4 upon being energized, however, opens this short-circuit at its contact **1**, so that the condenser C_2 is no longer short-circuited. Therefore, potential begins to build up from positive battery through the resistance T_2 to charge condenser C_2 high enough to ionize the path through the tube. This causes current to flow from negative battery to the main anode and through the tube OVT_2 to the plate of said tube, thence over contact **3** of relay R_3 and through the winding of said relay to positive battery.

The time required for the potential to build up upon the condenser C_2 will be from 2 to 16 milliseconds, depending upon the adjustment of the resistance T_2. Therefore, when this period has elapsed the relay R_3 will be energized as above described. At its contact **1** relay R_3 will again connect negative potential to the start anode of the tube OVT_2. This causes current flow through the tube to cease and disestablishes the original energizing circuit of relay R_3. Relay R_3, however, upon energizing, opens its initial circuit at contact **3**, and at contact **2** completes a locking circuit over back contact **2** of relay R_1 to negative battery. Relay R_3 will therefore remain locked up until relay R_1 is operated, as will be later described.

At its contact **6** relay R_3 opens the energizing circuit of relay R_4, which at once releases. Finally, at its contact **4**, relay R_3 completes a circuit from negative battery, through condenser RC_3 (which has been previously discharged over the contact **5** of relay R_3), through the winding of the orienting relay OR, to positive battery. The condenser RC_3 now gradually charges up, and during the time that it is being charged (an interval of approximately 4.4 milliseconds), the relay OR receives current and is operated.

Returning now to the start relay STT which was operated and locked up when the start impulse was initially received, said relay by opening its contact **4** and closing its contact **3**, removes the negative potential which is normally applied through the resistance *r* to the start electrode of the timing vacuum tube TVT_1. At its contact **3** relay STT closes a circuit from negative battery, over said contact **3**, over conductor **10**, contact **6** of stop relay STP, over conductor **11**, over the normal contact key K_1', over the back left-hand contact of key K_1, and thence to positive battery through the winding of the stepping magnet SM_1 of the switch SW_1 in the mixing circuit MCT. This prepares the switch

SW_1 to be advanced one step at the end of the operation of the distributor, as will be later described.

The removal of the negative battery from the start anode of the tube TVT_1 permits a potential to be gradually built up on the condenser C_1 from positive battery through the resistances T_1 and T_1', which are adjusted so that this potential will reach a value to cause ionization of the tube TVT_1 after a period of 22 milliseconds, this period corresponding to the time allowed for the start impulse. While this tube is thus being gradually built up to "trigger off," a start impulse will be relayed through the distributor over contact 5 of the start relay STT when the orienting relay OR operates as previously described. This occurs from 2 to 16 milliseconds after the above 22-millisecond start interval commences, depending upon the adjustment of the resistance T_2 in the circuit of the orienting vacuum tube OVT_2 as previously pointed out.

Let us assume that this adjustment is such that said tube operates the orienting relay OR 8 milliseconds after the start pulse is initially received from the relay R of the repeater. After this period has elapsed the start impulse is relayed through the distributor from positive battery, over the spacing contact of the relay R of the repeater, start conductor ST, over contact 5 of start relay STT, over contact 8 of the stop relay STP, over closed contact 1 of the orienting relay OR (which, as already stated, remains closed for about 4.4 milliseconds), over back contact 4 of relay S_1, over the heavy dotted line *stt* to conductor 6, thence through the upper winding of relay S from terminal 6 to terminal 3, and thence through a 775-ohm resistance to negative battery through the lower winding of relay R.

This pulse lasts for 4.4 milliseconds while the condenser RC_3 is charging up, and maintains the relay OR operated for this period of time. As soon as the condenser is fully charged, however, current ceases to flow, and contact 1 of relay OR is opened so that the start pulse ends. The start pulse, however, is transmitted to relay LS or TS, as the case may be, to the line L or the loop SL, depending upon whether the signal was originated in the loop SL or came in from the line L.

Returning now to the vacuum tube TVT_1, after 22 milliseconds have elapsed the condenser C_1 has been charged up so that an arc is established for the control electrode (the electrode at the left) to the cathode (the lower right-hand electrode). The gas in the tube is now ionized and the resistance of the tube is broken down. This discharges the condenser C_1 to put the tube TVT_1 in condition to start its tuning cycle anew. At the same time a circuit is thus completed from negative battery to the cathode of the tube TVT_1, through said tube to the plate thereof, and through the winding of relay R_1 to positive battery. Relay R_1 upon being energized opens at its contact 2 the locking circuit previously traced for the relay R_3, which is released. Relay R_3 at its contact 4 opens the circuit of the relay OR (which is already released owing to the condenser RC_3 being fully charged) and at contact 5 relay R_3 completes the discharge circuit for the condenser RC_3.

(i) Operation of vacuum tube distributor VTD—character determining pulses

Returning now to relay R_1, said relay by closing its contact 1 initiates a new cycle of operations relating to the transmission of the first of the five character-determining pulses. Over its contact 1 relay R_1 completes a circuit from negative battery, through the winding of the relay R_2 to positive battery. Relay R_2 upon being energized causes current to momentarily flow from positive battery through the condenser RC_2 (during the brief interval required for said condenser to be fully charged), over contact 1 of relay S_1, through the winding of said relay, and over the contact 2 of release relay REL_2 to negative battery. The momentary impulse thus flowing through the winding of the relay S_1 increases the current through said winding sufficiently to cause said relay to attract its armature. Said armatures will be held up by said relay after the momentary operating pulse ceases, due to the holding current through the resistance r_1. Thus relay S_1 will be in effect locked up until the release relay REL operates at the end of the cycle of the distributor, as will be described later. The relay S_1 changes the pulse distributing connections of the distributor as will presently appear.

Returning to relay R_2, immediately upon operating said relay, at its contact 1 comprises a negative short-circuit for the winding of the relay R_1 and the plate circuit of the timing vacuum tube TVT_1, thereby releasing the relay R_1. At its contact 2, relay R_2 completes a circuit from positive battery, through the winding of relay R_4, over back contact 6 of relay R_3, and over contact 2 of release relay REL to negative battery. Relay R_4 (which had previously been released when relay R_3 was actuated) is now again operated over the circuit just described. It will be held operated by the current through the resistance *a* until the relay R_3 is again operated, as will appear presently. At its contact 1 relay R_4 again removes the negative short-circuit from the start electrode of the orienting tube OVT_2 to start the cycle of said tube anew.

In the meantime relay R_2, having at its contact 1 short-circuited the winding of the relay R_1 and the plate circuit of the timing tube TVT_1, is released at contact 1 of relay R_1 as soon as the relay R_1 releases due to this short-circuiting action. Relay R_2 upon being released, at contact 3 opens the operating circuit for relay S_1, and at contact 2 opens the operating circuit for the relay R_4. Relays S_1 and R_4 remain operated, however, due to the holding current through their respective resistances r_1 and *a*. At contact 1, relay R_2 removes the short-circuit from the winding of the relay R_1 and the plate of the vacuum tube TVT_1.

When, as previously described, the condenser C_1 is discharged by the arc between the control electrode and the cathode, the 22-millisecond cycle of the tube TVT_1 starts again as the condenser C_1 begins to charge up through the resistances T_1 and T_1'. The result is that, as before, the resistance of the tube breaks down at the end of another period of 22 milliseconds, and current flows to the plate to again operate the relay R_1 at the end of the 22-millisecond interval corresponding to the first character-determining impulse.

In the meantime, before the vacuum tube TVT_1 thus operates to terminate the 22-millisecond interval, condenser C_2 associated with the orienting tube OVT_2 is building up its charge, so that at the end of its adjusted period (which we have assumed to be 8 milliseconds) the resistance of said tube breaks down, and the operating circuit of the relay R_3 is again completed over the plate

of the orienting tube OVT_2. Relay R_3 again locks up, short-circuits the tube OVT_2 over its contact 1 as before to discharge condenser C_2, releases relay R_4, and at contact 4 of relay R_3 the 4.4-millisecond operating circuit of the relay OR is once more completed.

During this brief operation of the relay OR the first character-determining impulse is transmitted. This impulse passes over the armature of the relay R, over conductor ST, over contact 5 of start relay STT, over contact 8 of stop relay STP, over contact 1 of relay OR, over contact 3 of now operated relay S_1, over back contact 4 of relay S_2, and thence to the conductor numbered 1 leading to switch SW_4 of the mixing circuit. This circuit will be completed through the mixing circuit in a manner later to be described, and extended either over conductor 3 or conductor 6 associated with the relay S, to operate said relay. Relay S thus repeats the pulse (not enciphered) through the repeater to the line L or the loop SL, as the case may be.

At the end of 22 milliseconds the vacuum tube TVT_1 again operates the relay R_1 to initiate a new cycle of operations of the distributor corresponding to the second character-determining impulse. The relay R_1 upon being operated, at its contact 2 opens the locking circuit for the relay R_3, which is again restored to normal. By closing its contact 1 relay R_1 again operates relay R_2. Relay R_2 at its contact 1 again short-circuits the winding of relay R_1 and the plate circuit of the timing vacuum tube TVT_1.

At its contact 3, relay R_2 connects a momentary circuit from positive battery through the condenser RC_2, over the front contact 2 of relay S_1, over the back contact 1 of relay S_2, through the winding of said relay S_2, and over the back contact 2 of release relay REL to negative battery. Relay S_2 being thus operated, is held operated by the current through the resistance r_2, and prepares a new path through the distributor over its contact 3, as will be described later. At its contact 2, relay R_2 operates the relay R_4, which, at its contact 1, again disconnects negative batterey from the start electrode of tube OVT_2. Said tube now commences its cycle anew to operate the orienting relay OR after 8 milliseconds of the next 22-millisecond interval has elapsed.

Meanwhile the winding of the relay R_1, upon being short-circuited by the action of the relay R_2, releases the relay R_2 immediately after it has been initially operated, and restores it to normal. The condenser C_1 discharges in a manner previously described, so that the tube TVT_1 commences its 22-millisecond cycle for a third time, during which the second character-determining pulse is transmitted.

Thereafter, upon the operation of the orienting relay OR, the pulse circuit through the distributor is established for 4.4 milliseconds from positive or negative battery, as the case may be, over the armature of the relay R of the repeater, over conductor ST, contact 5 of relay STT, contact 8 of relay STP, contact 1 of relay OR, contact 3 of relay S_1, contact 3 of relay S_2, contact 4 of relay S_3 to the conductor numbered 2 leading to switch SW_4 of the mixing circuit. After passing through the mixing circuit in a manner appearing more fully hereafter, this circuit is completed through the upper winding of the relay S to operate it to marking or spacing in accordance with the character of the impulse received from the relay R as modified by the setting of the mixing circuit MCT.

Without going into further detail, the vacuum tubes TVT_1 and OVT_2 go through their cycles and are then restored to normal to start cycles anew, until six 22-millisecond cycles are completed. The sixth cycle corresponds to the fifth character-determining pulse of the received code combination. As these cycles are being executed the counting relays S_3, S_4 and S_5 are in turn operated. Therefore, during the period corresponding to the third character-determining cycle, the pulse from the armature of relay R passes over the circuit previously traced to the closed contact 1 of the orienting relay OR, and thence over contact 3 of relay S_1, contact 3 of relay S_2, front contact 3 of relay S_3, and over the back contact 4 of relay S_4 to conductor numbered 3 leading to the switch SW_4. Likewise during the period corresponding to the fourth character-determining impulse, a similar circuit is completed over contact 1 of the relay OR, contact 3 of relay S_1, contact 3 of relay S_2, contact 3 of relay S_3, contact 3 of relay S_4, contact 4 of relay S_5, and over conductor numbered 4 to the switch SW_4. Finally, during the period corresponding to the fifth pulse, a similar circuit is established over contact 1 of relay OR, and over the No. 3 contacts of relays S_1, S_2, S_3, S_4, and S_5, and thence over the back contact 4 of stop relay STP to conductor numbered 5 leading to the switch SW_4.

(j) Operation of vacuum tube distributor VTD—stop impulse

Six 22-millsecond cycles have now been executed by the distributor apparatus, the time of each of these cycles being determined by the timing vacuum tube TVT_1. The orienting vacuum tube OVT_2 at the proper time during each of these successive intervals distributes the start impulse and the five character-determining impulses, respectively, over various contacts of the stepping relays of the distributor, as above described.

When the last 22-millisecond interval has been completed, the vacuum tube TVT_1 triggers off and operates the relay R_1, which, as before, releases relay R_3 and operates relay R_2. Relay R_2 in turn operates relay R_4 which starts the cycle of the orienting vacuum tube OVT_2. Finally, the relay R_2, at its contact 1, short-circuits the winding of the relay R_1 and the plate circuit of the tube TVT_1, releasing the relay R_1. The relay R_1 restores relay R_2, so that the short-circuit at contact 1 of relay R_2 is removed from said relay R_1 and the vacuum tube TVT_1. The vacuum tube has in the meantime started its cycle for the seventh time. As this cycle corresponds to the stop pulse, it must be made somewhat longer than the six preceding cycles.

This is accomplished in the following manner: While the relay R_2 was energized in the manner just described, and before it was released, it completed a momentary circuit over its contact 3 from positive battery, through the condenser RC_2, over the contact 3 of said relay R_2, over contact 2 of relay S_1, contact 2 of relay S_2, contact 2 of relay S_3, contact 2 of relay S_4, contact 2 of relay S_5, thence over contact 1 of stop relay STP, and through the winding of said relay to negative battery over contact 2 of the release relay REL. The stop relay STP is now operated and holds up through its resistance *b*, but its initial energizing circuit is immediately thereafter reopened at contact 3 of relay R_2 by the release of said relay R_2, as above described.

Relay STP upon being energized, at its contact 6 opens the circuit previously traced for the stepping magnet SM_1 of the switch SW_1. The stepping magnet is now released and upon being released advances the brush B_1 of said switch one step to change the setting of the mixing circuit MCT. At contact 5 of stop relay STP, a circuit is established from negative battery, over contact 3 of start relay STT, over conductor 10, contact 5 of relay STP, over conductor 12 to the adjustable resistance T_1''. Resistance T_1'' is thus connected to negative battery in shunt with the condenser C_1, which is also connected to negative battery. This retards the charging of the condenser C_1 through the resistances T_1 and T_1'. The result is that 31 milliseconds is now required to charge up said condenser to such potential that the tube TVT_1 will trigger off and operate the relay R_1.

In the meantime, by the closing of its contact 7, stop relay STP prepares a circuit which, upon the operation of the orienting relay OR, sends a stop impulse to the relay S of the repeater as follows: From negative battery, over contact 3 of relay STT, over conductor 10, over contact 7 of relay STP, over contact 1 of orienting relay OR, over contacts numbered 3 of relays S_1, S_2, S_3, S_4, S_5 and STP, thence over the stop conductor *stp* and over conductor 3, through the winding of relay S from terminal 3 to terminal 6, and thence to positive battery through the lower winding of the relay R to positive battery. By the operation of the relay S over the circuit above traced, a stop impulse is sent to the line L or the loop SL, as the case may be.

At the end of the 31-millisecond interval the timing vacuum tube TVT_1 operates the relay R_1, which in turn operates the relay R_2. Relay R_2 shorts the relay R_1 and the vacuum tube TVT_1 as before, at its contact 1. At contact 2 relay R_2 operates the relay R_4, and at contact 3 it completes a momentary operating circuit from positive battery through condenser RC_2, over said contact 3 of relay R_2, over No. 2 contacts of relays S_1, S_2, S_3, S_4, S_5 and STP, and thence over the contact 1 of release relay REL and through the winding of said relay to negative battery over contact 2 of said relay REL.

The relay REL at once opens its contacts 1 and 2, thereby restoring the following relays to normal—relays STT, S_1, S_3, S_5, REL, R_4, S_2, S_4 and STP, each of these relays having its circuit connected to negative battery over the contact 2 of relay REL. In the meantime relay R_2, having short-circuited relay R_1, the latter upon releasing immediately opens the circuit of relay R_2 and restores it to normal. Relay R_3 was, of course, released by the opening of contact 2 of relay R_1 during its momentary operation. Thus all elements of the distributor VTD are restored to normal, and are ready to receive a new combination of seven pulses.

(*k*) *Operation of the mixing circuit MCT—stepping of switches*

It will be recalled that at the beginning of the operation of the vacuum tube distributor VTD, the operation of the relay STT, upon the initiation of the cycle of the operations of the distributor, closed a circuit over contact 3 of relay STT, over conductor 10, contact 6 of stop relay STP, over conductor 11, and through the winding of the stepping magnet SM_1 of the switch SW_1 of the mixing circuit MCT. The energization of this magnet does not advance the brush B_1 of the switch at this time, but said brush is advanced one step when the stepping magnet SM_1 is released upon the operation of the stop relay STP, after the five character-determining pulses have been distributed. Thus the brush B_1 of the switch SW_1 is advanced one step for each character received by the distributor.

The switch SW_1 has 22 steps, and after the brush has reached its twenty-second position the brush is advanced and comes to rest again upon the first set of contacts. While the brush was resting on the contacts of the twenty-second position of the switch SW_1, a circuit was completed over its zero wiper, from negative battery, over said wiper, over contact 22, conductor 13, normal right-hand contact of key K_1, normal left-hand contact of key K_2, and through the winding of stepping magnet SM_2 to positive battery. The stepping magnet of the second switch SW_2 is thus energized, and when the brush of the switch SW_1 passes off the contact 22 of switch SW_1 the circuit for the stepping magnet SM_2 is opened, and the brush B_2 of the switch SW_2 advances one step. It is similarly advanced a step for each additional complete rotation of the switch SW_1.

In a similar manner, each time the brush B_2 of the switch SW_2 arrives at the twenty-second position, the stepping magnet SM_3 of the switch SW_3 is energized over an obvious circuit passing over the zero wiper of the brush B_2 and contact 22 of switch SW_2. This circuit likewise is opened when the brush B_2 passes from its twenty-second position to its first position. In this manner the brush B_3 of the switch SW_3 is advanced one step each time the brush of the switch SW_2 completes a cycle.

In like manner, each time the brush of the switch SW_3 completes a cycle, it closes and then opens the circuit of the stepping magnet SM_4 of the switch SW_4 to advance the brush B_4 of the switch SW_4 one step. In this manner the brush of the switch SW_4 is advanced step-by-step until all of the code combinations have been used. When the brush of the switch SW_4 has been stepped through all of its twenty-two positions, the next step restores it to the No. 1 position, and the entire cycle of operations of the four switches may be repeated.

By actuating and then releasing the key K_1', the magnet SM_1 will advance the brush B_1 of the switch SW_1 one step. In this manner the brush may be advanced step-by-step to any position desired. By using the similar keys associated with the other switches, any one of them may be advanced step-by-step to any chosen position.

Also, by operating a key such as K_1, the magnet SM_1 will advance the brush of the switch SW_1 step-by-step automatically. When the key K_1 is operated a self-interrupting circuit is controlled by the armature of said magnet SM_1 until the brush is advanced through a complete cycle of its No. 22 position. In this position magnet SM_1 is locked up over the zero wiper of brush B_1, contact 22 and conductor 13 until the key K_1 is released, whereupon the switch advances to its No. 1 position and there remains. The circuits by which these operations are performed are obvious, and as they form no part of the present invention, need not be further described.

(*l*) *Operation of mixing circuit MCT—scrambling action of switches SW_4 and SW_3*

It will be recalled that the five successive char-

acter-determining pulses of the code combination were applied in regular order by the vacuum tube distributor VTD to the heavy line conductors, 1 2, 3, 4 and 5 which lead to the five correspondingly numbered contacts in the upper row of the switch SW_4. The numbers applied to the corresponding five contacts in the other rows are arranged in different order for each row, and all of the contacts bearing the same number are wired together. For example, in the diagram for switch SW_4 the wiring for the No. 1 segment only is shown carried throughout the various rows of contacts of the switch. However, it will be understood that the contacts numbered 2, 3, 4 and 5 will be similarly wired through the switch, all No. 2 contacts being wired together, all No. 3 contacts being so wired, and so forth.

The result is that as the pulses pass from the heavy conductors numbered 1, 2, 3, 4 and 5, respectively, to a given set of contacts, and over the correspondingly numbered wipers of the brush B_4, the original five pulses are scrambled to transmit on to the next switch a different code combination than the one originally applied to the switch SW_4. The code combination to which the original combination is thus translated depends upon the setting of the brush B_4 and upon the order in which the contacts for that setting are arranged.

The switch SW_3 acts to further scramble the set of pulses. For example, the pulses picked up by the five wipers of the brush B_4 are transmitted over the wires numbered 1, 2, 3, 4 and 5 leading to the wipers of the brush B_3 of the switch SW_3. Here again it will be seen that the numbers applied to the five contacts corresponding to the character code combinations are differently wired in each row. Only the wiring for contacts 4 and 5 are actually shown, but it will be understood that the contacts numbered 1, 2 and 3 will also be wired through the switch. In each instance all contacts having the same number will be wired together. The result of this is that depending upon the setting of the brush B_3 of the switch SW_3, the original five pulses which have been scrambled once will be scrambled again in a different manner. The pulses thus twice scrambled are applied to the conductors 1, 2, 3, 4 and 5 leading to the correspondingly numbered wipers of the brush B_1 of switch SW_1.

(m) Operation of mixing circuit—pulse reversing operation of switches SW_1 and SW_2

It is the function of the switch SW_1 to determine in effect whether the pulses thus transmitted to the wipers of the brush B_1 shall individually be marking or spacing impulses. To this end four of the five character-determining contacts in each row of the switch SW_1 are numbered either 3 or 6, the numbers varying from row to row. All contacts numbered 3 are wired together and connected to the conductor 3 leading to terminal 3 of the relay S. Likewise all contacts numbered 6 are wired together and are connected to the conductor 6 leading to the terminal No. 6 of the relay S. This means that any of the scrambled impulses coming in over one of the conductors such as No. 1 to the wiper No. 1 of brush B_1, may be in effect reversed or not reversed in polarity, depending upon the number of the contact upon which the wiper of the brush B_1 rests. Thus a further encipherment is effected.

In order to introduce further complexity into the mode of encipherment, one of the five character-determining contacts of each row of the switch SW_1 is marked X. All of the contacts marked X in the same vertical row are wired together and in turn are wired to one of the conductors numbered 1, 2, 3, 4, and 5, leading to the wipers of the brush B_2 of switch SW_2. For example, all of the X contacts in the first vertical level to the right are connected to conductor 5. All of the X contacts in the second row to the right are connected to conductor 4, and so forth.

The five character-determining contacts of each row of switch SW_2 are marked either 6 or 3. Again all of the contacts marked 6 are wired together and to the conductor 6 leading to terminal 6 of the relay S. Likewise all of the contacts marked 3 are wired together and connected to the conductor 3 leading to terminal 3 of the relay S. Thus one of the five impulses passing through the switch SW_1 over a contact marked X will, by means of the switch SW_2, be in effect again reversed or not reversed in polarity, depending upon the setting of the brush B_2.

To summarize, it will be seen that each combination of five character-determining pulses is subjected to a plurality of changes after leaving the distributor VTD and before arriving at the relay S. Each pulse is subjected to two scrambling operations, one by the switch SW_4 and the other by the switch SW_3. Then the pulse is subjected to a possible polarity reversal by the action of the switch SW_1 before being applied to the relay S. Moreover, in some instances (where the pulse passed through an X contact of the switch SW_1) the pulse is subjected to a further possible polarity reversal by means of the switch SW_2, before arriving at the relay S. Hence various changes will depend upon the relative setting of the brushes of the several switches. Also they will be varied for each successive character to be transmitted because of the automatic step-by-step action of the switches already described.

(n) Operation of mixing circuit MCT—paths for individual pulses

In order to more readily understand the nature of these changes, let us trace one of the character-determining pulses through the entire circuit. Assume that a code combination has been set up in the loop SL of which the first character-determining impulse is a marking impulse. Relay TR accordingly transmits a marking impulse to the relay R, which in turn causes its armature to rest on its marking contact so that negative battery is aplied to the armature. If no scrambling or reversing effects were to be introduced, this pulse would be directly applied to the terminal 3 of the upper winding of relay S, causing the relay S to transmit to the line L a marking signal. If, however, the pulse had been a spacing pulse, the armature of relay R would rest upon its spacing contact and positive battery would be connected to terminal 3 of the upper winding of the relay S to send a spacing signal.

Actually, however, the circuit as wired does not transmit the pulses from the armature of relay R directly to the upper winding of the relay S, but they are subjected to a scrambling and reversing operation. Therefore, when the relay R moves this armature, as above described, to its marking contact, negative battery is applied to the conductor ST. If the pulse in question is the first character-determining pulse, the distributor will have started through its cycle already described and the relays STT and S_1 will have been operated and locked up. When, due to the ac-

tion of the timing vacuum tube TVT_1 and the orienting vacuum tube OVT_2 the relay OR closes its contact 1, the negative current will pass from the armature of relay R over the conductor ST, over contact 5 of the relay STT, contact 8 of the relay STP, contact 1 of the orienting relay OR, contact 3 of the relay S_1, contact 4 of the relay S_2, and over heavy conductor numbered 1 to contact 1 of the upper row of the switch SW_4.

If we now assume that the brushes of the four switches are in the position shown in the diagram, the negative current will continue over the contacts of the switch SW_4 which are numbered 1, to the contact numbered 1 in the sixteenth row. At this point contact numbered 1 is out of sequence, being in the second position instead of the first. Consequently, the negative current flows from contact 1 in the sixteenth row, over wiper No. 2 of brush B_4, over conductor No. 2 leading to the wiper No. 2 of the brush B_3 to the contact marked 5 in the ninth row of switch SW_3.

All of the contacts numbered 5 in this switch are wired together, and are connected to the conductor numbered 5 leading from the switch SW_3 to the brush B_1 of the switch SW_1. Therefore, the negative current continues over said conductor No. 5 to wiper No. 5 of brush B_1, which, in this particular instance, is resting upon the contact in the second row marked X. From this contact, which is in the fifth vertical row, negative current flows over the conductor numbered 5 leading to wiper 5 of brush B_2 of switch SW_2. The brush B_2 is in the fourteenth position, and in this position brush No. 5 is resting upon contact numbered 6. The negative current, therefore, continues over the segments numbered 6 of switch SW_2 to conductor 6 leading to terminal No. 6 of relay S, and thence through the upper winding of said relay, through a 775-ohm resistance, and through the lower winding of relay R to positive battery.

If we assume that without any ciphering effect the negative current would have been applied to terminal 3 of relay S to transmit a marking signal to the line L, it is obvious that the first pulse has been reversed because it has passed through the upper winding of the relay S in reverse direction. Therefore, the relay S will send a spacing signal to the line instead of a marking signal.

Now let us assume that the distributor has advanced in its cycle to transmit the second character-determining pulse. Under these conditions not only relays STT and S_1 are locked up but relay S_2 has been operated and locked up. Let us assume that the second pulse transmitted by the relay R is a spacing pulse. Then positive current will be transmitted over the armature of relay R, over conductor ST, over contact 5 of relay STT, over contact 5 of relay STP, over contact 1 of the orienting relay OR, over contact 3 of relay S_1, over contact 3 of relay S_2, and over contact 4 of relay S_3 to heavy conductor No. 2 leading to the No. 2 contacts of the switch SW_4.

With the brush B_4 in the position shown, the positive battery coming over heavy conductor 2 will be applied to the third character-determining contact of the sixteenth row. From this point the current flows over wiper No. 3 of brush B_4, over the conductor marked No. 3, and over wiper 3 of brush B_3 to contact numbered 1 in the ninth horizontal row of the switch SW_3. From this contact the positive current passes over the No. 1 contacts of the switch SW_3 over the conductor numbered 1 leading from the switch SW_3 to the switch SW_1, over wiper No. 1 of the brush B_1 of the switch SW_1 to the contact numbered 3 in the vertical row of contacts of the switch SW_1.

This contact is the second from the left, thus being in effect the first character-determining contact for that switch. From this contact numbered 3 the positive current goes to conductor No. 3 leading to terminal 3 of relay S, thence through the upper winding of said relay, through a 775-ohm resistance, and through the lower winding of relay R to negative battery. Since the positive current flow above traced passes through the upper winding of the relay S in the normal direction, it causes relay S to send a spacing signal to the line L.

The original signal initiated by the relay R was also a spacing signal. Thus it is seen that after the various scrambling and reversing operations, this particular pulse comes out without change. However, it will be recognized that in some other setting of the switches it might have been applied to the conductor 6, in which case the current would flow through the upper winding of the relay S in reverse direction, thus sending a marking signal instead of a spacing signal.

Without following through the other three character-determining impulses of the code combination, it will be evident that each of the pulses is subjected to successive scrambling and reversing operations which may result either in transmitting the pulse normally or in reversing it, depending upon the setting of the switches. For certain settings the scrambling and reversing operations will in effect merely cancel each other out with respect to some pulses. In the case of other pulses, with the same setting the scrambling and reversing effects may not cancel each other out, in which case the pulses affected will be reversed.

However, what happens to any given pulse depends upon the setting of all the switches of the mixing circuit MCT. As there is an enormous number of possible settings of the switches, each successive code combination will be scrambled in some arbitrary but different manner, because the switches change their relative settings a step at a time each time a new code combination is transmitted. Moreover, if a code combination corresponding to a particular character is sent by the relay R and is enciphered in a particular way, then if that character is at once repeated, the setting of the switches will be changed and it will be enciphered in a different manner.

Summarizing the effect of the mixing circuit MCT as a whole, it may be thought of as substituting for the real character combination some other combination determined by the setting of the switches of the mixing circuit. This combination, determined by the mixing circuit, is varied each time another character is transmitted. Moreover, the variations introduced by the mixing circuit follow each other in an arbitrary order. Furthermore the complete sequence of successive enciphering character combinations set up by the mixing circuit will not be repeated in the same order until the several switches have been stepped through all of the enormous number of possible relative positions of which they are capable.

It will be understood, of course, that the numbered connections applied to the contacts of the switches are suggestive only and that they may

be arranged in many other different combinations.

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 signaling system, a common circuit upon which a plurality of combinations of impulses are impressed, said code combinations comprising a cycle of successive impulses uniform in number but variable in character, means to encipher said code combinations by varying the character of component impulses in an arbitrary manner, and a distributor for transferring the impulses of a code combination one at a time from said common circuit to individual circuits of a group of circuits, said distributor including a vacuum tube and associated timing circuits so related that said vacuum tube will produce a succession of timed intervals one corresponding to each impulse of a code combination.

2. In a signaling system, a common circuit upon which a plurality of combinations of impulses are impressed, said code combinations comprising a cycle of successive impulses uniform in number but variable in character, means to encipher said code combinations by varying the character of component impulses in an arbitrary manner, and a distributor for transferring the impulses of a code combination one at a time from said common circuit to individual circuits of a group of circuits, said distributor including a vacuum tube and associated timing circuits so related that said vacuum tube will produce a succession of timed intervals one corresponding to each impulse of a code combination, and means operating to cause said vacuum tube to produce at least one timed interval in the code cycle differing in duration from the others.

3. In a signaling system, a common circuit upon which a plurality of combinations of impulses are impressed, said code combinations comprising a cycle of successive impulses uniform in number but variable in character, means to encipher said code combinations by varying the character of component impulses in an arbitrary manner, and a distributor for transferring the impulses of a code combination one at a time from said common circuit to individual circuits of a group of circuits, said distributor including a vacuum tube and associated timing circuits so related that said vacuum tube will produce a succession of timed intervals one corresponding to each impulse of a code combination, all of said timed intervals but one being of equal duration.

4. In a signaling system, a common circuit upon which a plurality of combinations of impulses are impressed, said code combinations comprising a cycle of successive impulses uniform in number but variable in character, means to encipher said code combinations by varying the character of component impulses in a random manner, and a distributor for transferring the impulses of a code combination one at a time from said common circuit to individual circuits of a group of circuits, said distributor including a vacuum tube and associated timing circuits so related that said vacuum tube will produce a succession of timed intervals one corresponding to each impulse of a code combination, and means operating at the end of each interval to shift the connection of said common circuit to a different one of said individual circuits.

5. In a signaling system, a common circuit upon which a plurality of combinations of impulses are impressed, said code combinations comprising a cycle of successive impulses uniform in number but variable in character, means to encipher said code combinations by varying the character of component impulses in an arbitrary manner, and a distributor for transferring the impulses of a code combination one at a time from said common circuit to individual circuits of a group of circuits, said distributor including a vacuum tube and associated timing circuits so related that said vacuum tube will produce a succession of timed intervals one corresponding to each impulse of a code combination, means operating to cause said vacuum tube to produce at least one timed interval in the code cycle differing in duration from the others, and means operating at the end of each interval to shift the connection of said common circuit to a different one of said individual circuits.

6. In a signaling system, a common circuit upon which a plurality of combinations of impulses are impressed, said code combinations comprising a cycle of successive impulses uniform in number but variable in character, means to encipher said code combinations by varying the character of component impulses in an arbitrary manner, and a distributor for transferring the impulses of a code combination one at a time from said common circuit to individual circuits of a group of circuits, said distributor including a vacuum tube and associated timing circuits so related that said vacuum tube will produce a succession of timed intervals one corresponding to each impulse of a code combination, all of said timed intervals but one being of equal duration, and means operating at the end of each interval to shift the connection of said common circuit to a different one of said individual circuits.

7. In a signaling system, a common circuit upon which a plurality of combinations of impulses are impressed, said code combinations comprising a cycle of successive impulses uniform in number but variable in character, and a distributor for transferring the impulses of a code combination one at a time from said common circuit to individual circuits of a group of circuits, said distributor including a vacuum tube and associated timing circuits so related that said vacuum tube will produce a succession of timed intervals one corresponding to each impulse of a code combination, and means operating to cause said vacuum tube to produce at least one timed interval in the code cycle differing in duration from the others.

8. In a signaling system, a common circuit upon which a plurality of combinations of impulses are impressed, said code combinations comprising a cycle of successive impulses uniform in number but variable in character, and a distributor for transferring the impulses of a code combination one at a time from said common circuit to individual circuits of a group of circuits, said distributor including a vacuum tube and associated timing circuits so related that said vacuum tube will produce a succession of timed intervals one corresponding to each impulse of a code combination, means operating to cause said vacuum tube to produce at least one timed interval in the code cycle differing in duration from the others, and means operating at the end of

each interval to shift the connection of said common circuit to a different one of said individual circuits.

9. In a signaling system, a common circuit upon which a plurality of combinations of impulses are impressed, said code combinations comprising a cycle of successive impulses uniform in number but variable in character, and a distributor for transferring the impulses of a code combination one at a time from said common circuit to individual circuits of a group of circuits, said distributor including a vacuum tube and associated timing circuits so related that said vacuum tube will produce a succession of timed intervals one corresponding to each impulse of a code combination, means operating to cause said vacuum tube to produce at least one timed interval in the code cycle differing in duration from the others, and a second vacuum tube and associated timing circuit so adjusted as to send a pulse of predetermined length during a particular period of each of said timed intervals.

10. In a signaling system, a common circuit upon which a plurality of combinations of impulses are impressed, said code combinations comprising a cycle of successive impulses uniform in number but variable in character, and a distributor for transferring the impulses of a code combination one at a time from said common circuit to individual circuits of a group of circuits, said distributor including a vacuum tube and associated timing circuits so related that said vacuum tube will produce a succession of timed intervals one corresponding to each impulse of a code combination, and means operating to cause said vacuum tube to produce at least one timed interval in the code cycle differing in duration from the others, a second vacuum tube and associated timing circuit so adjusted as to send a pulse of predetermined length during a particular period of each of said timed intervals, and means to shift said period to various portions of said intervals.

11. In a signaling system, a common circuit upon which a plurality of combinations of impulses are impressed, said code combinations comprising a cycle of successive impulses uniform in number but variable in character, and a distributor for transferring the impulses of a code combination one at a time from said common circuit to individual circuits of a group of circuits, a multipoint switch having connections at each point to extend said individual circuits separately to a second group of individual circuits, the connections between circuits in said groups varying from point to point of said switch, a relay for transmitting marking and spacing pulses to another common circuit, an additional multipoint switch having connections at each point to connect certain circuits of said second group to said relay so as to cause it to send marking pulses for a given set of connections between the circuits of the two groups, and having other connections at each point to connect other circuits of said second group to said relay so as to cause it to send spacing pulses for said given set of connections between circuits of the two groups, said connections of said additional multipoint switch varying from point to point.

12. In a signaling system, a common circuit upon which a plurality of combinations of impulses are impressed, said code combinations comprising a cycle of successive impulses uniform in number but variable in character, and a distributor for transferring the impulses of a

code combination one at a time from said common circuit to individual circuits of a group of circuits, a plurality of multipoint switches each having connections at each point through which said individual circuits may be separately extended to a second group of individual circuits, the connections between circuits in said groups varying from point to point in each of said switches, a relay for transmitting marking and spacing pulses to another common circuit, an additional multipoint switch having connections at each point to connect certain circuits of said second group to said relay so as to cause it to send marking pulses for a given set of connections between the circuits of the two groups and having other connections at each point to connect other circuits of said second group to said relay so as to cause it to send spacing pulses for said given set of connections between circuits of the two groups, said connections of said additional multipoint switch varying from point to point.

13. In a signaling system, a common circuit upon which a plurality of combinations of impulses are impressed, said code combinations comprising a cycle of successive impulses uniform in number but variable in character, and a distributor for transferring the impulses of a code combination one at a time from said common circuit to individual circuits of a group of circuits, a multipoint switch having connections at each point to extend said individual circuits separately to a second group of individual circuits, the connections between circuits in said groups varying from point to point of said switch, a relay for transmitting marking and spacing pulses to another common circuit, an additional multipoint switch having connections at each point to connect certain circuits of said second group to said relay so as to cause it to send marking pulses for a given set of connections between the circuits of the two groups, and having other connections at each point to connect other circuits of said second group to said relay so as to cause it to send spacing pulses for said given set of connections between circuits of the two groups, said additional switch also having at least one connection at each point extending to a second additional multipoint switch, said second additional switch having connections to said relay at each point to determine whether a given pulse sent therethrough will cause said relay to send a marking or spacing pulse, said connections of both said additional multipoint switches varying from point to point.

14. In a signaling system, a common circuit upon which a plurality of combinations of impulses are impressed, said code combinations comprising a cycle of successive impulses uniform in number but variable in character, and a distributor for transferring the impulses of a code combination one at a time from said common circuit to individual circuits of a group of circuits, a plurality of multipoint switches each having connections at each point through which said individual circuits may be separately extended to a second group of individual circuits, the connections between circuits in said groups varying from point to point in each of said switches, a relay for transmitting marking and spacing pulses to another common circuit, an additional multipoint switch having connections at each point to connect certain circuits of said second group to said relay so as to cause it to send marking pulses for a given set of connections between the circuits of the two groups, and

having other connections at each point to connect other circuits of said second group to said relay so as to cause it to send spacing pulses, said additional switch also having at least one connection at each point extending to a second additional multipoint switch, said second additional switch having connections to said relay at each point to determine whether a given pulse sent therethrough will cause said relay to send a marking or spacing pulse, said connections of both said additional multipoint switches varying from point to point.

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