The invention described in the specification and claims may be manufactured and used by or for the Government for governmental purposes without the payment to me of any royalty thereon.

My invention relates broadly to secret telegraph signalling apparatus and chiefly to means for automatically detecting mal-functioning of the cipher elements.

While it has broader applications, as will be evident from the description below, it has special reference to that type of secret telegraphy wherein the plain-text (intelligence-bearing) sequence of mark-space impulses is mixed in some fashion with an artificial (keying) sequence, the corresponding impulses of the sequences being algebraically added.

One object of my invention is to provide means at the transmitting terminal for detecting automatically the failure of the mixing circuits to mix properly the key with the plain-text.

Another object of my invention is to provide a switch that will automatically close whenever key is improperly mixed with plain-text, in order that the switch may be used to control audible and visual alarms and, if desired, may be used to stop the plain-text transmitter automatically before sufficient insecure cipher-text has been transmitted to compromise the underlying plain-text.

Other and further objects of my invention will be understood from the following specification and by reference to the accompanying drawing, which schematically represents my invention as applied to secret telegraph signalling apparatus.

Referring now to the drawing, and assuming the 5-unit Baudot code, plain-text teletypewriter signals (from a keyboard, tape, etc., not shown) enter terminals 20 and 21, and activate relay K2 in conventional fashion. The spacing element of each code combination or "character" moves tongue K10 to the spacing contact 55, thus connecting positive battery from source 55' to distributor ring 30, through brush arm B, to distributor segment 7, through the winding of magnet M and back to negative battery 55". The current flowing through magnet M trips the latch L and permits brush arm B to travel the length of commutator segment 30 under the influence of a force imparted through a slipping clutch (not shown) from a motor (not shown). Commutator segment 30 constitutes a ring which is depicted in developed form. The commutator segments designated by symbols 1 through 8 (in practice) constitute a ring concentric with ring 30.

As brush arm B starts its motion, switches SW1 through SW5 are thrown into contact with either bus 31 or bus 32 in accordance with the presence or absence of holes in a conventional teletypewriter tape containing a randomly generated sequence of characters designated as the key. As the brush arm B progresses, it sequentially switches the plain-text signal elements (or short samples thereof) to the tongues of switches SW1 through SW5 thus causing the current representing each element to travel to ground by way of bus 31 or bus 32 and through the bridge comprising resistors R10, R11, and winding 51 of polar relay K10. The polarity of winding 51 is such that positive potential applied through bus 31 causes tongue K10 of relay K10 to engage winding K6 and to thus connect positive battery from source 70 to output terminal 26 and, through resistor R15, to winding 52 of polar relay K15 thus providing a holding force that tends to hold tongue K15 engaged with whichever spring it touches. Resistor R15 limits the force exerted by winding 52 to a value less than the force exerted by winding 51. The function with negative source is similar.

If bus 31 is designated as the "marking" side and bus 32 is designated as the "spacing" side of switches SW1 through SW5, and if negative polarity of the plain-text signal is designated as "marking" and positive polarity as "spacing," then, the brush arm B is closed at terminal 26 in accordance with the following rule: likes produce a cipher mark and opposites produce a cipher space. Segments 6 and 8 are permanently connected to bus 31 and, in consequence, plain text starts and stop elements are delivered at output terminal 26 without change of polarity.

Segments 1, 2, 3, 4, 5, and 6 are usually sufficiently short so that only a short pulse is delivered to relay K10. The holding winding 52 of relay K15 holds tongue K6 in the position last assumed until a pulse of different polarity is received; thus the signal delivered at terminal 26 has the form of a conventional teletypewriter signal.

Each time that brush B starts its motion and before it reaches segment 1, the key tape is advanced one character by a mechanism (not shown) associated with the brush arm B, thus providing a new key character for the encryption of each successive plain-text character.

In the apparatus described in the foregoing, which is well known to those skilled in the art, it may happen that one or more of the "feeler pins" that sense holes in the key tape and activate switches SW1 through SW5 may stick and fail to operate, or the "feed holes" of the key tape may become torn so that the key tape fails to advance. Either of these events, if permitted to endure, would seriously compromise the security of the message. My invention serves to detect such events and other malfunctions and also to close a switch that may be used to actuate alarms and to stop the plain-text transmission whenever such mal-functions occur. The invention operates as follows:

The winding K6m of non-polar relay K6 is connected in series with bus 31, and the winding K6m of non-polar relay K6 is connected in series with bus 32. The springs K6d through K6d of relay K6 and the springs K6d through K6d of relay K7 are connected in such a manner that when winding K6m is energized and winding K6m is not energized, negative potential with respect to ground is applied from source 57 to bus 60, when winding K6m is energized and winding K6m is not energized, positive potential with respect to ground is applied from terminal 58 to bus 60 and when windings K6m and K6m have like conditions of energization, no potential is applied to bus 60.

Winding K6m of relay K7 is connected in series with the wire connecting segment 1 to the tongue of switch SW1. The contacts K6a and K6b of relay K7 act as a commutator to connect the potential of bus 60 to capacitor C11 only when "plain-text" current flow through segment 1 and without regard to the polarity of that current. In consequence, the polarity of the pulses applied to capacitor C11 is negative whenever switch SW1 is in the marking (M) position and it is positive whenever SW1 is in the spacing (S) position. The polarity of the successive pulses applied to capacitor C11 will re-
verse only when switch SW₁ successfully alternates the routing of plain-text pulses between busses 31 and 32. Successful relay K₁₅ alternates the routing of plain-text pulses between busses 31 and 32 because the counter EMP of the charge stored in capacitor C₁₁ opposes the potential of bus 60. However, when a pulse occurs having a polarity opposite to the polarity of the preceding pulse, capacitor C₁₁ is completely discharged and recharged in the opposite sense and the current necessary to accomplish such transition flows through the winding K₅₉/₆₀ of relay K₁₅ causing a momentary engagement of springs K₁₅₆ and K₅₉, b of 3 and 32 will require current through the winding K₅₉₆₀ of relay K₁₅, causing a momentary engagement of springs K₁₅₆ and K₅₉, b and of springs K₁₅₆ and K₅₉,d of relay K₁₅.

The mode of operation of relays K₁₂, K₁₃, K₁₄, and K₁₅ is similar in every respect to the mode of operation of relay K₁₁ as described in the foregoing. Each of these five relays, independently of the others, momentarily closes its two pairs of contact springs whenever the key tape successfully changes the routing of the associated element of the plain-text from one to the other of busses 31 and 32.

As shown in the drawing, the momentary engagement of relay springs K₁₅₆ and K₁₅₆ connects negative potential with reference to ground from source 59 to the grid C₁ of a vacuum tube 100 and to capacitor C₁ thus fully charging the latter. In a similar manner, the momentary closure of corresponding springs of one of the relays K₁₂, K₁₃, K₁₄ or K₁₅ fully charges the associated capacitors C₂, C₃, C₄ or C₅, in such sense as to maintain the potential of the associated vacuum tube grids negative with respect to their ground cathodes. Each capacitor C₁ through C₅ is provided with a short leakage path R₁ through R₅ respectively and will discharge at a rate determined by the values of these capacitors and resistors are selected to provide a time constant equal to the time required for the transmission, at a constant rate, of a quantity "N" of teletypewriter characters. The quantity N is selected to be greater than the largest number of sequential holes (or no-holes) likely to occur fortuitously in any one of the five levels of a key tape containing random characters and to be smaller than the number of characters which, if improperly deciphered in sequence in any one level, would seriously compromise the plain-text.

Each transition of switches SW₁ through SW₅ from one to the other of busses 31 and 32, recharges capacitors C₁ through C₅ respectively in the manner heretofore described. If any one of these switches fails to undergo a transition within a period equivalent to N characters, the associated one of the capacitors C₁ through C₅ will discharge sufficiently to permit the potential of the associated grid similar to the grid G₉, to approach cathode potential and thereby to allow anode conduction through winding K₉₆₀ of relay K₉₆ from positive source 24. The flow of current through winding K₉₆₀ engages contacts K₉₆₉ and K₉₆₉ thus closing a circuit between terminals 22 and 23 to which may be connected circuits capable of actuating alarms and capable of stopping the plain-text transmitter that delivers signals to terminals 20 and 21.

The momentary energizing of relay K₁₁ also engages springs K₁₄₉ and K₅₉₆₀ thus connecting negative potential from the grid G₉ of vacuum tube 101 to capacitor C₉. The momentary engagement of corresponding springs of relays K₁₂ through K₁₅ likewise connects negative potential from terminal 59 to the same grid G₉ and capacitor C₉. It is thus apparent that the transition of any one or any combination of the switches SW₁ through SW₅, respectively of conductors between busses 31 and 32 will result in fully charging capacitor C₉ and driving grid G₉ negative beyond anode current cut-off. Whenever there is no effective transition of any of the switches SW₁ through SW₅, as would be the case for a sequence of identical characters, capacitor C₉ will discharge through resistor R₉ thus permitting grid G₉ to approach cathode potential sufficiently to permit the flow of anode current through relay winding K₉₆₀ which results in actuating relay K₉₆₉ and the effect previously described. The values of capacitor C₉ and of resistor R₉ are selected to provide a time constant equal to the time required for the transmission, at a constant rate, of a quantity Q of teletypewriter characters. The quantity Q is selected to be greater than the largest sequence of identical characters likely to occur in a key tape containing random characters and to be smaller than the number of characters which, if sequentially deciphered by the same key character, would seriously compromise the plain text.

The six vacuum tubes associated with grids G₉ through G₅ are shown as dual triodes in three envelopes. The type 6SN7 vacuum tube is suitable for this purpose. It is obvious that transistors may be substituted for vacuum tubes thus saving space and eliminating the need for cathode-heater power.

The drawing depicts only an embodiment of my invention. Many variations of the basic principles of the invention will be apparent to those skilled in the art.

I claim:
1. Apparatus for detecting malfunctions in telegraph systems wherein each of a plurality of character elements is represented by either of two conditions and wherein successive corresponding elements should change from one of the conditions to the other condition within a predetermined time, which comprises energy storage means associated with each element, sources of potential of opposite polarity, means energized by an element of one condition for impressing a potential of one of the polarities on the energy storage means and by an element of the other condition for impressing a potential of the opposite polarity on the energy storage means, an amplifier including a control electrode associated with each element, means connected to and controlled by the energy storage means for applying a conduction-preventing potential to the control electrode dependent upon the occurrence of successive corresponding elements of opposite condition and the attendant application of potentials of opposite polarity to the energy storage means, and means connected to each control electrode for generating a potential which is capable of rendering the associated amplifier conductive upon the failure of occurrence of corresponding elements of the two conditions within the predetermined time.

2. Apparatus for detecting malfunctions in telegraph systems wherein each of a plurality of character elements is represented by either of two conditions and wherein successive corresponding elements should change from one of the conditions to the other condition within a predetermined time, which comprises first relay means associated with each elemental condition and energized upon the occurrence thereof, energy storage means associated with each element, sources of potential of opposite polarity, first contact means actuated upon the energization of each of the first relay means for connecting one of the potential sources to the energy storage means upon the occurrence of an element of one of the conditions and for connecting the source of opposite potential to the energy storage means upon the occurrence of an element of the other condition, second relay means connected to each energy storage means and energized only by the successive application thereto of the potentials of opposite polarity as a result of the occurrence of unlike elements, an amplifier including a control electrode associated with each element, a source of conductance, second contact means actuated by the second relay means upon the energization thereof and connecting, upon the actuation thereof, the conduction-preventing potential to the control electrode of the associated amplifier each time successive elements of unlike conditions occur, and means connected to the control electrode of each amplifier for rendering
the amplifier conductive upon the failure of occurrence of unlike elements within the predetermined time.

3. In combination with the apparatus defined in claim 2, an amplifier including a control electrode associated with all elements, third contact means actuated by the second relay means upon the energization thereof and connecting, upon the actuation thereof, the conduction-preventing potential to the control electrode of the amplifier associated with all elements each time any unlike corresponding elements occur successively, and means connected to the control electrode of the amplifier associated with all elements for rendering such amplifier conductive upon the successive occurrence of like elements for a second predetermined time.

4. Apparatus for detecting malfunctions in telegraph systems of the type wherein each element of the character of a message signal is mixed with an element of a keying signal to encipher the message signal, which comprises means associated with each keying signal element for providing two conditions of such element, energy storage means associated with each enciphered element, sources of potential of opposite polarity, means connecting a predetermined one of the potential sources to each energy storage means in accordance with the condition of the associated keying element, an amplifier associated with each element of the enciphered signal and including a control electrode, means energized by the potential of the energy storage means for applying conduction-preventing potentials to the control electrode of the amplifier each time the potentials of opposite polarity are applied to any of the storage means, means connected to the control electrode of each amplifier for rendering such amplifier conductive upon the failure of opposite potentials being applied to the storage means for a predetermined time, and utilization means connected to each amplifier and energized by the rendering conductive of such amplifier.

5. Apparatus for detecting malfunctions in telegraph systems of the type wherein each element of a telegraph message signal is mixed with an element of a keying signal to produce an enciphered telegraphic signal, which comprises switching means associated with each keying signal element and movable between two positions depending upon which of two elemental conditions the keying signal element is to mix with the associated message signal element, sources of potential of opposite polarity, storage means associated with each mixed element, means controlled by the position of the switching means for connecting a predetermined one of the potential sources to the storage means, relay means connected to each of the storage means and energizable upon the application to the storage means of succeeding potentials of opposite polarity, first electron discharge means including a control electrode associated with each element of the mixed signal, first contact means controlled by the relay means for applying conduction-precluding potentials to the control electrode of the first electron discharge means each time potentials of opposite polarity are applied to the storage means, means connected to the control electrode of the first electron discharge means for impressing thereon a potential capable of rendering the electron discharge means conductive upon the failure of occurrence of the potentials of opposite polarity within a first predetermined length of time, second electron discharge means including a control electrode, second contact means energizable by each of the relay means for applying conduction-precluding potentials to the control electrode of the second electron discharge means each time any of the relay means is energized by the application of potentials of opposite polarity to the relay means, means connected to the control electrode of the second electron discharge means for impressing thereon a potential capable of rendering the second electron discharge means conductive upon the failure of occurrence of any of the potentials of opposite polarity within a second predetermined length of time, and utilization means connected to the electron discharge means and energizable upon the conduction of any one of the electron discharge means.

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