

Nov. 7, 1961

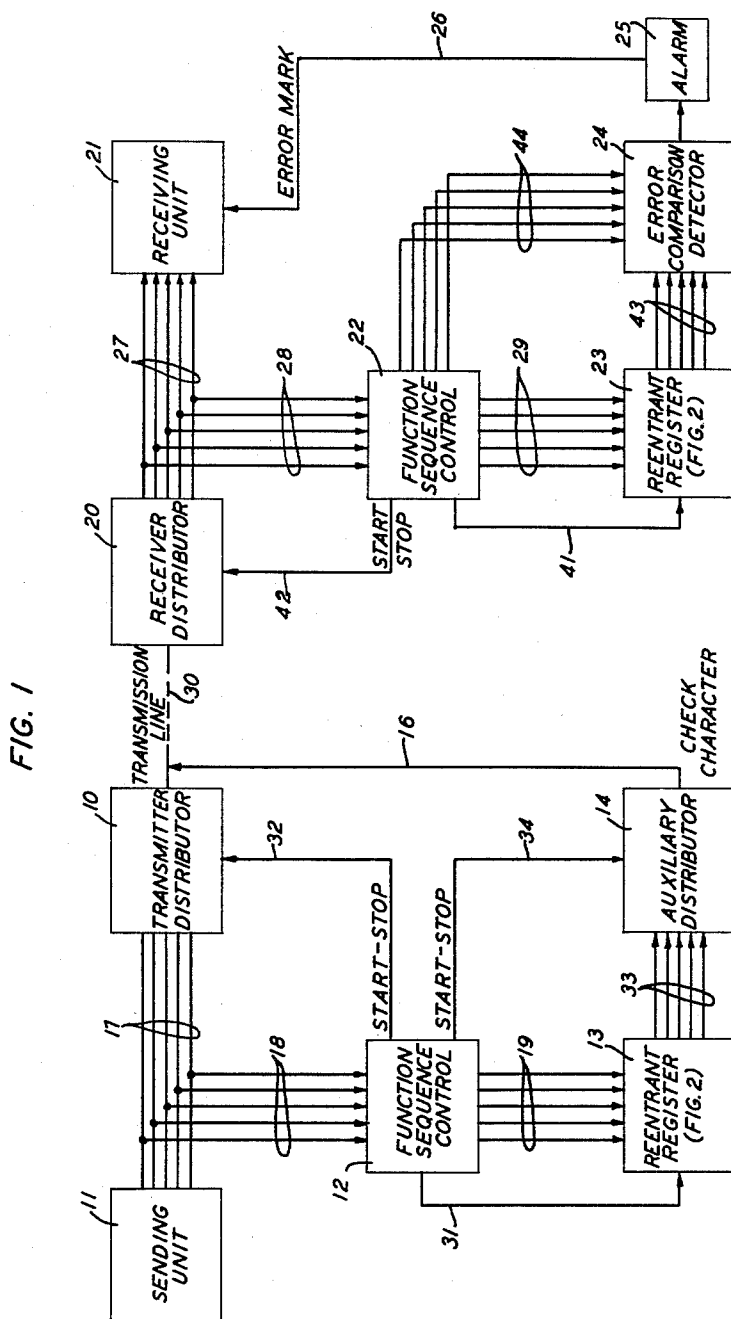
E. E. SCHWENZFEGER

3,008,003

SPIRAL ERROR CHECKING SYSTEM

Filed May 25, 1959

2 Sheets-Sheet 1



INVENTOR
E. E. SCHWENZFEGER

BY

J. P. Kearns, Jr.

ATTORNEY

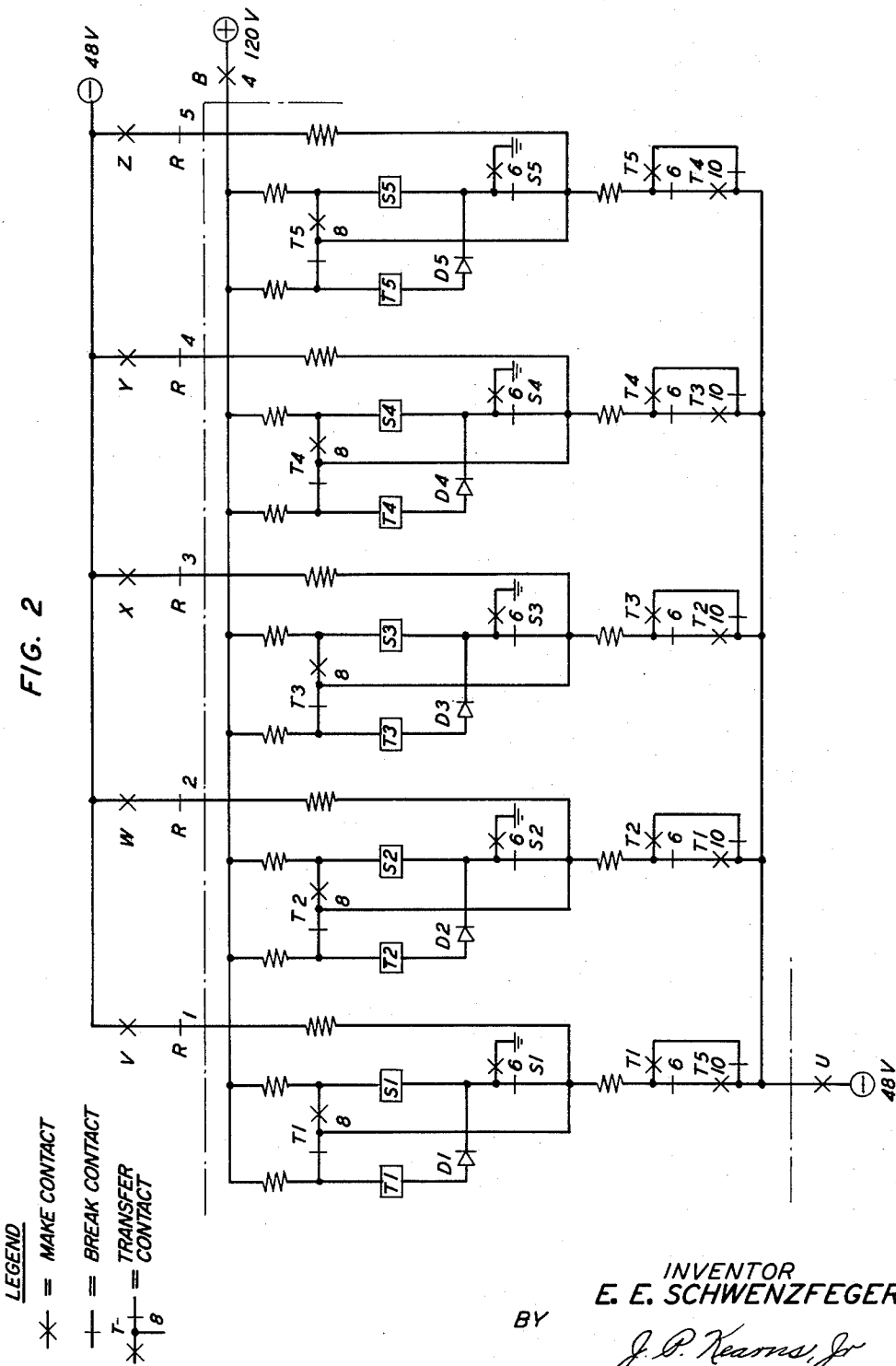
Nov. 7, 1961

E. E. SCHWENZFEGER
SPIRAL ERROR CHECKING SYSTEM

3,008,003

Filed May 25, 1959

2 Sheets-Sheet 2



INVENTOR
E. E. SCHWENZFEGER

BY

J. P. Kearns, Jr.

ATTORNEY

1

3,008,003

SPIRAL ERROR CHECKING SYSTEM

Edward E. Schwenzfeger, Bayside, N.Y., assignor to Bell Telephone Laboratories, Incorporated, New York, N.Y., a corporation of New York

Filed May 25, 1959, Ser. No. 815,661

3 Claims. (Cl. 178-23)

This invention relates in general to shift registration circuits and in particular to the adaptation of such circuits to error detection in printing telegraph systems.

In a copending application Serial Number 815,712, filed May 25, 1959, W. R. Young, Jr. discloses a method for the detection of errors arising in the transmission of telegraph messages encoded in the standard five-unit Baudot code comprising permutations of marking and spacing elements. This method requires a cumulative count of marking elements from character to character on each of the five code levels with a shift in levels inserted between each character for the purpose of increasing the statistical probability of detecting all errors with a minimum of redundancy. Because a group of lines joining successive code element levels illustrating the Young error checking method (as shown in FIG. 2 of that application) on a punched telegraph tape forms a helical pattern, the method has been designated the spiral error checking method. The apparatus disclosed in that application includes a multibank rotary distributor which physically and externally breaks the input connections to the counting register between each character while shifting to the next count levels. The present application describes an improvement upon this apparatus by eliminating the external rotary distributor and obviating the physical interruption of input connections to the counting register. According to this invention the intercharacter level shift is performed internally in the counting register at a considerable increase in speed of operation.

It is the principal object of this invention to simplify the apparatus required for the practice of the spiral-shift error detection method for printing telegraph systems.

It is another object of this invention to accomplish the spiral-shift error detection method without physical interruption of the character-code input leads.

An advantage of this invention is an increase in speed and reliability of operation of apparatus for the detection of errors in the transmission of message text over teletypewriter networks in a manner which is compatible with existing terminal equipment.

Further objects and advantages of this invention will become apparent from a consideration of the following description taken together with the figures of the drawing in which:

FIG. 1 is a block diagram showing two terminals of a teletypewriter transmission system including apparatus necessary to practice the spiral error detection method; and

FIG. 2 is a detached-contact schematic diagram of an all-relay counting register which provides a fast-operating internal shifting arrangement.

FIG. 1 is a simplified representation of a teletypewriter transmission system including a transmitting station and a receiving station, each modified to practice the spiral-shift error detection method disclosed in the above-cited

2

copending application in accordance with the system of this invention. The left half of FIG. 1 shows a sending station and the right half, a receiving station. The two stations are connected by a transmission line 30, which may be either a physical line or a carrier channel.

The sending station includes the basic units of a teletypewriter transmitting terminal, namely: a sending unit 11, which may be either a tape reader or a keyboard unit; a transmitter-distributor 10, which may be a conventional start-stop rotary distributor; and a control unit 12, which contains function character recognition equipment, commonly known as the stuntbox, for controlling the operation of the transmitter-distributor. In addition to these conventional units a counting register 13 for generating the error-check character and an auxiliary distributor 14 for applying the check character to the outgoing transmission line at the end of a block of text are provided.

The receiving station similarly includes the basic units of a teletypewriter receiving terminal, namely: a receiving-distributor 20, which may again be a conventional start-stop rotary distributor; a receiving unit 21, which may be either a tape reperforator or a page printer; and a control unit 22, which may be the usual stuntbox. In addition to these basic units there are provided a counting register 23, substantially identical to that shown at the sending station in block 13, for generating the receiver check character; an error comparison detector 24 for comparing the transmitted and received check characters; and an alarm unit 25 actuated by detector 24 when there is lack of agreement between the two check characters.

In operation, the marking and spacing elements comprising message characters generated in the sending unit 11 on five parallel code levels are connected to the distributor 10 over leads 17. Distributor 10, under the control of stuntbox 12, by way of lead 32, converts the message character into a sequence of marks and spaces for application to line 30. Stuntbox 12 detects each character emitted by the sending unit over leads 18. If it is a function character, recognition is effected and control signals are emitted accordingly. Likewise, if it is a message character, the stuntbox 12 allows the distributor to operate and advances the tape in the sending unit in a well known manner. In accordance with this invention stuntbox 12 is modified to perform additional control functions in generating an error-checking character at the end of each block or line of message text. At the beginning of each line of message text, as distinguished from the address code material, a line-feed function character occurs. This character is recognized by the stuntbox 12 and by means of control lead 31 enables the register 13 and allows the latter to commence counting marks in the message text. The marking impulses occurring on the five code levels are applied to the register 13 over leads 19.

Register 13 is assumed to comprise a two-state or bistable memory device for each code level. For example, five two-relay flip-flops are shown in FIG. 2 and will be described in detail below. These flip-flops are interconnected in the form of a re-entrant or recycling counter so that upon application of a shifting pulse, all registrations will be shifted one position to the right. It is assumed initially that all flip-flops are in the reset or

off state. Therefore, on receipt of the first code character certain flip-flops will be placed in the set state. At the end of the message character a shift pulse is delivered by way of lead 31 to shift all set states one position to the right. On the second character, marks on the first code level are effectively added to the mark on the fifth code level of the preceding character. Again a shift is made following registration of the character. A binary count only is registered representing the oddness or evenness of the least significant digit in the cumulative count. The counting and shifting sequence continues in a uniform manner until the end of the line when the carriage-return function character is recognized by stuntbox 12.

The auxiliary distributor 14 is connected to the output of the register 13 by leads 33. Distributor 14 may be of the same general construction as transmitter-distributor 10, or of some alternative structure such as that shown in FIG. 4 of the cited copending application. This distributor converts the check character standing in register 13 from parallel to serial form and applies it to line 30 by way of lead 16. Distributor 14 is under the control of a start-stop pulse over lead 34 from control 12. Distributor 14 operates once between the recognition by control 12 of carriage-return and line-feed function characters. For further economy of equipment usage it will be recognized that the functions of the auxiliary distributor 14 and the transmitter-distributor 10 may be combined in one unit. For reasons of simplicity of explanation the two distribution functions are shown in separate blocks.

The receiving station shown in FIG. 1 includes functional elements similar in structure to those found in the transmitting stations. Receiver distributor 20 converts the incoming serial pulse trains into parallel form on five code levels and delivers signals on lines 27 to a receiving unit 21 and on lines 28 to function sequence control or stuntbox 22. Receiving unit 21 may be a conventional tape reperforator or a page printer.

Auxiliary equipment necessary to the practice of error detection includes counting register 23, error comparison detector 24, and alarm 25. Register 23 is identical to element 13 shown in the transmitting section of FIG. 1. Incoming message characters are supplied to register 23 through control 22 in the same manner as outgoing characters are furnished to register 13 in the transmitter. At the beginning of a message line the flip-flops of register 23 are all in the reset state. The first character marks are stored, the universal pulse over line 41 shifts all marks one place to the right, the second character marks are added to the shifted first character marks, and so forth, until the carriage return character is recognized. At this time control 22 establishes circuit paths over leads 44 to detector 24 in preparation for the receipt of the check character from the transmitter. Also a signal pulse over lead 41 causes the accumulated odd-even count standing in register 23 to be transferred to detector 24. Detector 24 may comprise two sets of five relays operated by the signals on lines 43 and 44, respectively, with relays in each set for corresponding code levels having interconnected transfer contacts such that when two corresponding relays are in the same state no closed path is provided to the output over any of the leads.

If the two characters agree, no output results from the detector. If there is no agreement, an impulse is delivered to alarm 25, which may give a visual or audible signal or both. In addition, alarm 25 may be constructed to send an impulse over lead 26 to receiving unit 21, which may be there translated into a special error mark to be imprinted on either the page copy or a reperforated tape.

Additional functions may be built into the control 22 by well known techniques, such as a print-suppress function to prevent the check character from being imprinted on the received copy.

Referring now to FIG. 2, there is shown in detached contact schematic diagram form a five-stage all-relay shift

register according to this invention. The detached contact schematic diagram is believed now to be a well known type of graphical representation which greatly simplifies the presentation of relay circuits on which a large number of contacts are shown. All contacts are shown in their functional positions rather than in relation to their associated operating coils. Make contacts are represented by crosses and break contacts by a single line perpendicular to the lead in which the contact lies. Each contact has associated with it a designation corresponding to its operating coil. A detailed description of the detached contact type of schematic drawing has been published in the Transactions of the American Institute of Electrical Engineers, Communications and Electronics Section No. 20 at pages 505 to 513 in September 1955 by F. T. Meyer. The legend adjacent to FIG. 2 makes this clear.

Each stage of the register shown in FIG. 2 comprises a pair of electromagnetic relays designated S and T and a diode D. The upper ends of the operating coils of the S and T relays are connected by way of a resistor to a source of positive potential designated 120 volts as shown by the encircled plus sign. A make contact B4 controlled by a function relay (not shown) in the stuntbox enables the S and T relays during message transmission and upon its release disables these relays. An input pulse to set a pair of S and T relays is furnished from character code level relays located in the stuntbox represented here by the make contacts of relays V through Z (not shown) connected to a source of negative potential designated 48 volts. In addition, a break contact of an R relay, also located in the stuntbox but not shown in FIG. 2 because of its conventional nature, may be operated to prevent counting, for example, certain non-message characters in the address code or between message lines.

Assume now that all S and T relays are released and that a mark occurs on code level one during the transmission of the first message character. Make contact V closes negative battery through break contact R1 and the resistor shown to the break portion of transfer contact S1-6 and to the tongue of transfer contact T1-8. Negative battery through the break portion of contact S1-6 connects to the lower end of relay S1 causing it to operate, and through the break portion of contact T1-8 to the upper end of relay T1 preventing it from operating. Immediately contact S1-6 operates to connect the lower end of relay S1 to ground, thereby locking it operated. As long as the input pulse remains relay T1 is kept from operating because diode D1 is biased in the reverse direction by the negative potential on its anode. At the end of the input pulse negative battery is removed from the upper end of relay T1 which then operates immediately from positive battery through the resistor shown, diode D1 (now forward biased), and ground through contact S1-6. Contact T1-8 now operates to transfer the input lead to the upper end of relay S1. Both relays S1 and T1 are locked operated on contact S1-6 to ground.

Considered as individual units each pair of S and T relays operates in the manner just described. It is seen that the S relay is made fast operating because a potential of 168 volts is applied to its operating coil, while the holding potential is reduced to 120 volts. It is understood that these values are illustrative only, and are not to be considered as limiting the invention. Diode D1 insures that the full current inrush is available to operate relay S and that relay T operates only after relay S is fully operated and the input code pulse has terminated.

A shift path is provided to each pair of relays through a resistor, a first set of transfer contacts T6 and a second set of transfer contacts T10. It will be noted that the first set of such transfer contacts is on the T relay of the same code level, but that the second set of transfer contacts is on the T relay one code level to the left. For example, on the first code level contacts T1-6 are interconnected with contacts T5-10. The five groups of S and T relays are thus formed effectively into a closed

5

loop and may be considered as a ring counter or re-entrant register as the legend on blocks 13 and 23 of FIG. 1 indicates.

Assume that the first message character registered was a "Y" having marks on levels one, three and five. Therefore, relay pairs S1—T1, S3—T3 and S5—T5 are locked operated just as described above for level one. A shift pulse now occurs, represented by operation of the standard U (universal) relay in the stuntbox. This occurs immediately after each message character. The lead including make-contact U corresponds to the shift leads 31 and 41 connecting control blocks 12 and 22 to registers 13 and 23, respectively, in FIG. 1. Negative battery therefore appears on the shift lead running across the bottom of FIG. 2.

On the first level contacts T1—6 and T5—10 are both in the make condition, no path exists from the shift lead to the operating coils of relays S1 and T1, and therefore these relays do not change their state.

On the second code level, which was assumed non-operated, contact T2—6 is in the break condition and contact T1—10 is made. Therefore, a path exists from the shift lead to the lower end of relay S2. Relay S2 therefore operates, locks to ground on contact S2—6 and relay T2 will operate on termination of the shift pulse.

On the third code level, assumed operated, contact T3—6 is operated and contact T2—10 is non-operated. Thus, a path from the shift lead through the break portion of contact T2—10, to make portion of T3—6 and the resistor extends to the upper end of relay S3. Contact T3—8, being made, allows negative battery at the upper end of relay S3 to reverse the current through the coil to ground and the relay quickly releases, thereby removing ground from the lower end of relay T3. Relay T3 remains operated as long as the shift pulse remains, however.

The effect of the shift pulse on the fourth and fifth registration levels is evidently the same as that on second and third levels just described. Therefore, upon the release of the shift pulse relay, pairs S1—T1, S2—T2 and S4—T4 will stand operated and relay pairs S3—T3 and S5—T5 will be released. Effectively, then, the 1—3—5 count has been shifted one place to the right to a resultant 1—2—4 count. The first through fifth levels of next coded message character will thus be added to the second through fifth and first levels, respectively, of the first character. The sequence of counting and shifting continues until the R relay is operated at the end of a message line. Additional transfer contacts on the S relays (not shown) may be used as readout contacts.

After the check character has been transmitted at the sending end or the error comparison has been made at the receiving end, the B relay is released, positive potential is removed and all operated S and T relays are released. The function of the diode D in preventing the T relay from operating until termination of the shift pulse insures that transfer contacts on adjacent levels cannot produce a double shift during the period of a single shift pulse.

It will be evident upon further consideration that the intercharacter shift could be made to extend over more than one code level or in the opposite direction by placing the T—10 contacts of each relay pair in other than the next succeeding relay pair.

FIG. 2 represents a simple, economical, illustrative embodiment of a counting register having utility in the error checking method disclosed in the cited copending application, is an improvement over the shifting distributor there shown, and is compatible with the standard teletypewriter stuntbox. No external connections between the transmitting and receiving distributors and the registers need be broken. Faster operation is possible because of the current reversal through the S relay on shifting from the On to the Off state. It will be readily appreciated that the re-entrant all-relay register of this

6

invention will have general utility wherever such counters are used as in relay computers for use as a memory device. The number of stages may be made as many as desired, ten, for example, in a decimal counter. Other modifications within the scope of the following claims will become apparent to those skilled in the art.

What is claimed is:

1. An odd-even counting register for character-representing signals of equal length comprising a plurality of pairs of electromagnetic relays, a diode for each of said relay pairs interconnecting the operating windings thereof at one end, a first potential source connected to the other end of the said operating windings, a second potential source of opposite polarity from said first source, an operating path for each of said relay pairs, means for selectively connecting said second potential source to certain of said relay pairs in accordance with the character-representing signals by way of said operating paths, a first set of transfer contacts on one relay in each of said pairs for providing a locking connection to ground upon actuation of said one relay, a second set of transfer contacts on the other relay in each of said pairs, said first contact set completing the associated operating path to said one relay to allow its operation and said second contact set completing said operating path to inhibit said other relay by back-biasing the associated diode in the event of a pair of initially released relays, said second contact set completing said operating path to said one relay to allow its release in the event of a pair of initially operated relays, a shifting path common to all said pairs, contact sets connecting said shifting path individually to each of said pairs of relays, one contact set being operated by said other relay in the associated relay pair and the other contact set being operated by said other relay in an adjacent relay pair, and means for connecting said shifting path to said second potential source momentarily between character signals to transfer the condition of each pair of relays to the next succeeding pair in accordance with the condition of said last-mentioned contact sets.

2. A recycling binary counter for a train of impulses comprising a first and second relay, a first potential source of one polarity with respect to a ground reference potential connected to one end of the operating windings of said relays, a second potential source of polarity opposite to that of said first source, means for causing the sequential actuation of said first and second relays upon occurrence of a first input impulse from said second source comprising first contact means on said first relay for closing a path from said second source to the other end of the operating winding of said first relay thereby rapidly operating said first relay, second contact means on said second relay for closing a path to the one end of the operating winding of said second relay, a diode interconnecting the other ends of the operating windings of both said relays, said input impulse backbiasing said diode thereby preventing the immediate actuation of said second relay, third contact means on said first relay for closing the other end of the operating winding thereof to a ground point upon actuation, said third contact means providing an operating path for said second relay upon termination of said first impulse, and means for reversing the current through said first relay upon occurrence of a second impulse comprising a fourth contact means on said second relay providing a path for said second impulse to the one end of the operating winding of first relay, said second impulse breaking the ground connection for both of said relays.

3. In combination, a printing telegraph system using a fixed length permutation code of binary signal elements for each message character including a transmitter, a receiver and a transmission line joining said transmitter and receiver, and means for detecting errors in transmission between said transmitter and receiver comprising at said transmitter and receiver a plurality of bistable elec-

7

tromagnetic relay pairs equal in number to the number of code levels in a message character; input connections to each of said pairs for signal elements on the several code levels for changing the state of said pairs according to the aspect of the signal element impressed thereon; means for transferring the state of each relay pair to a next adjacent pair in response to a shift pulse occurring between message characters further comprising a shift connection to each of said pairs, contact sets on each of said pairs operable in the shift connection of an adjacent pair to form said pairs effectively into a closed loop, and a transfer connection common to said shift connections for applying said shift pulse thereto; means for convert-

8

ing the states of said pairs into a check character in response to an end of block signal; and means for comparing the check character from said transmitter with that of said receiver.

5

References Cited in the file of this patent

UNITED STATES PATENTS

1,972,326	Angel -----	Sept. 4, 1934
2,653,996	Wright -----	Sept. 29, 1953
2,739,301	Greenfield -----	Mar. 20, 1956
2,862,054	Curtis -----	Nov. 25, 1958

10