June 7, 1966 R. HELL 3,255,313

ELECTRONIC METHOD OF AND APPARATUS FOR TRANSMITTING CHARACTERS FOR FACSIMILE SHEET PRINTING RECEPTION

Filed Dec. 24, 1959 2 Sheets-Sheet 1

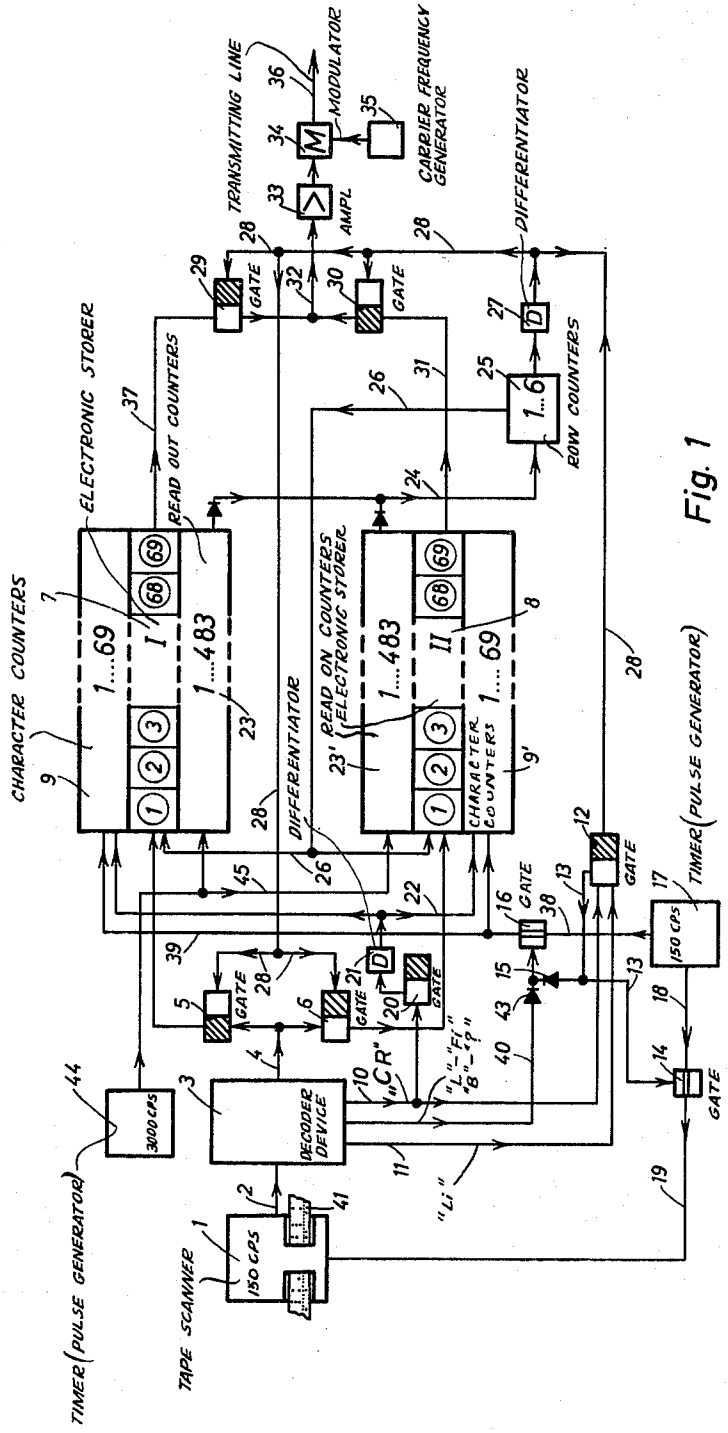


Fig. 1

ELECTRONIC METHOD OF AND APPARATUS FOR TRANSMITTING CHARACTERS FOR FACSIMILE SHEET PRINTING RECEPTION

Filed Dec. 24, 1959 2 Sheets-Sheet 2

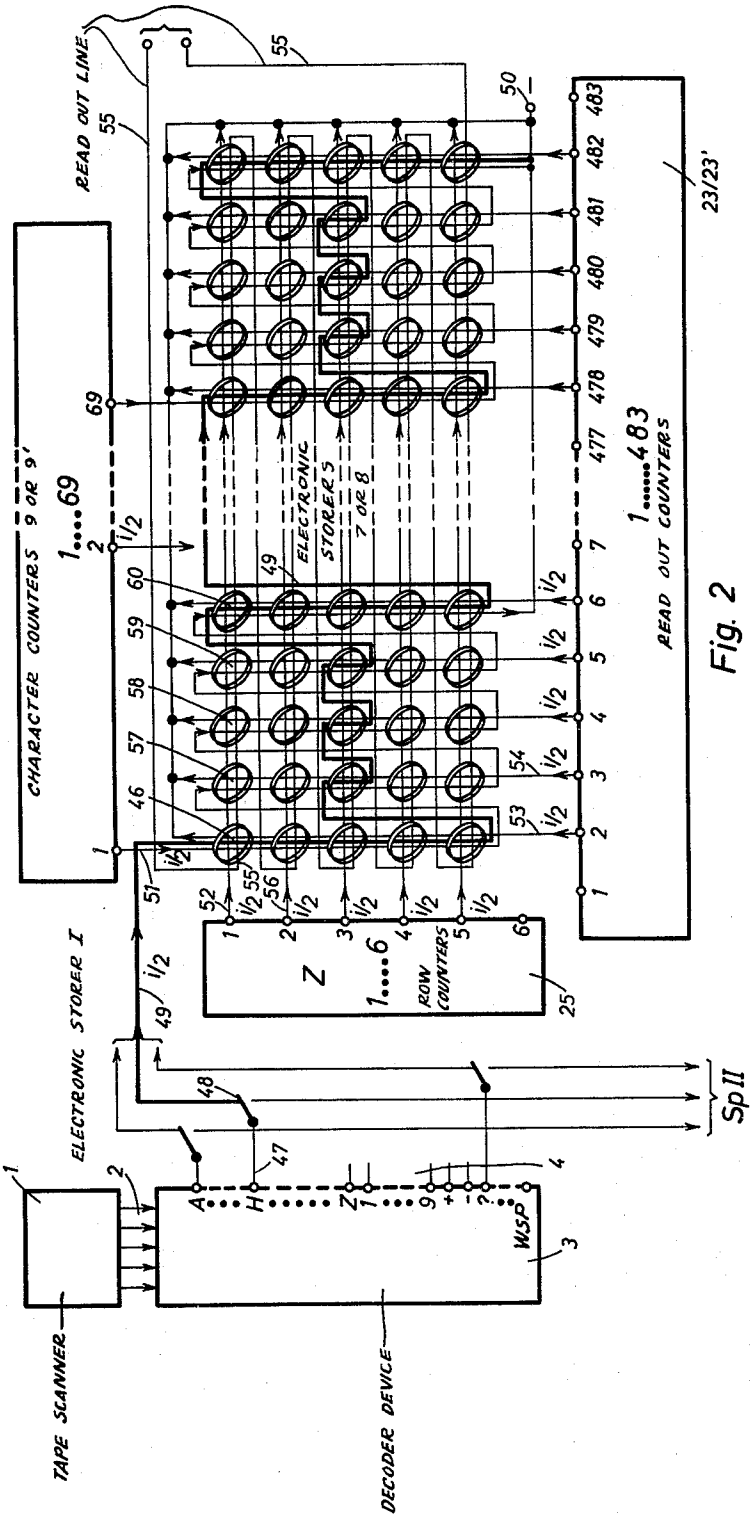


Fig. 2

United States Patent Office 3,255,313 Patented June 7, 1966

3,255,313

ELECTRONIC METHOD OF AND APPARATUS FOR TRANSMITTING CHARACTERS FOR FACSIMILE SHEET PRINTING RECEPTION

Rudolf Hell, Kiel, Germany, assignor to Dr.-Ing. Rudolf Hell Kommanditgesellschaft, Kiel-Dietrichsdorf, Germany, a company of Germany

Filed Dec. 24, 1959, Ser. No. 862,012
Claims priority, application Germany, Dec. 27, 1958, H 35,224
10 Claims. (Cl. 178—17.5)

The invention relates to an electronic method of and apparatus for transmitting characters in Hell or a similar code for facsimile sheet printer reception. The term "character" is intended to embrace the meaning attached to the words "letters," "figures" or "numerals," as well as punctuation marks or other symbols to be transmitted.

There are several kinds of Hell transmitters, Hell being the name of the originator, some operating electromechanically and other electrooptically. In the electromechanical apparatus, the black-and-white sequences produced when the mosaics of standard Hell code characters are broken up into 49 or 25 black and white scanning elements by seven columns (five without the white edging) from left to right, each such column containing seven (five without the white edging) scanning elements from top to bottom, are provided adjacent one another peripherally on a drum in the form of sequences of cams or contact segments. When a key of such a transmitter is operated, the cam sequence associated with the key character is selected by selector rods and scanned by rotation of the cam drum and the resultant pulse train is transmitted.

In the electrooptical apparatus, instead of a series of cams or contact segments being provided on a drum, a number of apertures or reflecting segments are provided which are scanned electrooptically as the drum rotates.

In a third kind of apparatus, characters are printed in Hell form on a paper tape by means of a special typewriter; the characters thus printed are scanned electrooptically in columns by a rotating slotted disc and the resultant pulse sequences are transmitted.

In another kind of apparatus, stencils formed with perforations similar to Hell characters are introduced into the path of light rays by the operation of keys and scanned in columns by means of a rotating Nipkow disc.

Perforated tape scanning can be used instead of manual keying, in which case the five-element teleprinter code must first be translated electromechanically or electronically into Hell code.

Hell tape receivers are very simple, comprising, apart from the essential amplifiers and demodulation circuit means, merely a rotating recording spindle carrying two complete turns of a printing helix, the two turns being staggered with respect to one another by half the spindle circumference, the coil being continuously inked by an ink-impregnated felt roller; an armature of a typing electromagnet, said armature being in the form of a cutting edge; and a paper tape which moves continuously between said helix and said edge and on which the two points of contact between said helix and the paper are printed when the typing edge engages with said tape, the Hell characters thus being recorded dot for dot and column for column in duplicate one above another.

Hell receivers come somewhere between start-stop apparatus and pure facsimile receivers.

There are Hell sheet receivers as well as Hell tape receivers. In the sheet receivers the recording helix is replaced by a ribbed drum, the ribs of which extend in the direction of the lines. Three recording edges are provided instead of one, the edges being secured to a chain and being so guided along the ribs that when one edge has reached the end of a line, the next edge is at the beginning of the next line. An inked ribbon is provided between the drum and the edges; a paper sheet moves between the ribbon and the drum and has the characters printed on it dot for dot in consecutive columns. The transmitter is operated with five-element perforated tape. In operation without line synchronization the last character at the end of the line is repeated at the beginning of the next line without any consideration as to the end of the word or to the division of syllables. This duplication of the end of a line at the beginning of the next line and the random interruption in the middle of a word is somewhat disturbing in reading. To obviate this disadvantage the remainder of the line after the end of a word or syllable is filled up with filling pulses which are not recorded, the next line thus beginning with the next word or syllable right at the start of the line. In such a case all the printers connected to such a transmitter must start a line with the same character, hence special control apparatus synchronized with the tape transmitter must be provided thereat. The tape to be transmitted has to be specially prepared; for instance, special line synchronization symbols must be provided since the characters are not printed twice.

In the so-called Siemens-Hell system, the operation is little disturbed by signal mutilations and there is no need to synchronize the receiver with the transmitter when working with tape. The reason for this is that while a five-element character is completely mutilated in start-stop operation if as little as one pulse of a five-element combination is lost or added due to interference, in the Siemens-Hell method the loss or addition of individual pulses hardly affects character readability since the character is printed like a picture.

Due to the double printing associated with tape operation, the text always remains readable notwithstanding faulty synchronization between the transmitter and the receiver, for if the characters extend diagonally upwards or downwards on the receiving tape, the first recording is always continued by the second where the first recording ceases and vice versa. The Siemens-Hell method is therefore excellent for short-wave radio links which are likely to be disturbed by frequent fading.

The disadvantages of the Siemens-Hell method are that the rate of information conveyance is lower than in start-stop operation (5 characters/sec. as compared with 7.14 characters/sec.) and that a greater bandwidth of 122.5 c./s. (245 bauds) is required than the 25 c./s. (50 bauds) of start-stop working. Since sheet printing is preferred for commercial operation, another disadvantage is that the sheet printing receiver is fairly complicated as compared with the very simple tape receiver and requires a ribbed roller and synchronizing equipment.

It is an object of the invention to receive (assuming a perforated-tape scanner) Hell characters on a facsimile sheet printer at a high rate of information conveyance which may be increased up to ten times the rate possible with start-stop apparatus, the main emphasis being on conference operation where a number of receivers are operated by one transmitter.

To this end, according to the invention the pulse trains associated with those characters of a line of text in Hell or a similar code which are to be transmitted are successively stored alternately in two pulse-operated line storers; pulse trains representing one scanning row of a line of text in the direction thereof are removed from a filled storer; and such pulse trains are read and transmitted to be received by a facsimile sheet printer successively row for row in the sequence in which they compose the line of text from top to bottom.

According to another feature of the invention, an apparatus for realizing the method according to the invention comprises, perforated-tape scanning means, decoding or

translating means for translating binary code into Hell code, two alternately operated pulse-operated line storers comprising groups of electronic storage elements, for instance, ring magnet cores, for electronic storage of the characters of one line of text in Hell or a similar form, a pulse generator operating as timer for perforated-tape scanning and for entering the characters into the line storer, a pulse generator operating as timer for reading the row pulses of the line storers, a periodic counter for counting the characters when the characters of a line of text are entered into the line storers, a periodic counter for counting and reading the row pulses of one row of a stored line of text, a periodic counter for counting the rows of a line of text, and electronic control means such as switches and gates for automatic control of the various steps used in the method.

By means of a combined apparatus for typing and perforating tape or by means of a hand perforator, a perforated tape is produced simultaneously as or after the original text is or has been typed on sheets in a typewriter; the tape thus produced contains, in addition to the five-hole combinations corresponding to characters, all the operating combinations such as "Letters," "Figures," "Word Space," "Carriage Return," "Line," "Bell" and "Who Is Calling?" The tape contains everything (including the physical arrangement of the characters in the lines) except for the kind of type used for the characters. After the tape has been scanned, the five-element code is decoded—that is, translated into Hell code—and the pulse trains allocated to the Hell characters representing a line of text are stored in one of two electronic pulse-operated line storers. The filled storer represents a true electrical or magnetic image of a line of text as type on the typewritten original. The only differences from the original when the text is reproduced lie in the kind of type used for the characters, which appear in Hell form, and possibly in line spacing. However, in contrast to facsimile transmission, where the character images of the original text are scanned photoelectrically in rows (parallel with the lines of text), pulse trains taken from the filled line storer and each corresponding to a scanning row of the line of text to be reproduced are scanned electronically—that is, read—in the sequence in which they form the line of text from top to bottom. The pulse trains of the various scanning rows are read (scanned) and transmitted at a uniform rate so that they can be received by a constant-speed facsimile sheet printer. Two line storers are provided to compensate for the time difference between the scanning of the tape and the entry of the characters into the storer on the one hand, and the reading and transmission of the row pulse trains on the other hand. Of course, the receiver must be placed in phase with the transmitter by start signals before transmission begins.

A modern facsimile receiver can deal with up to 3000 picture dots per second. Since a line of text contains not more than 69 characters and each character of the Hell code consists of 7 columns including the spacing columns, a row contains not more than $7 \times 69 = 483$, say, 500 picture dots. Six rows can therefore be printed per second. In the Hell system a line of text consists of five rows (without interline spaces), consequently approximately 5/6 second is required to print five rows—that is, one full line of text—containing 69 characters. The receiving capacity is therefore approximately 70 characters/sec. The tape contains operating symbols as well as the character symbols. The greatest accumulation of control symbols, namely, Letters and Figures, occurs when letters continuously alternate with figures or symbols. The perforation combination are then about 50% control symbols and 50% characters. Carriage Return and Line occur only at the end of a line of text. Tape scanning can therefore proceed at a rate of about 140–150 hole combinations per second, a speed which modern photoelectric scanners can readily provide.

The calculation shows that the rate of information conveyance is about ten times greater than for start-stop apparatus and about twelve times greater than for Hell sheet printers. However, the bandwith required is considerably greater—about 1500 c./s. (3000 bauds), a normal figure for facsimile telegraphy.

The rate at which the tape is scanned and the rate at which the Hell pulse trains are entered into the line storer must be greater than the rate at which the row pulse trains are removed from the line storers for reading and transmission, first because there are more hole combinations than characters, due to the presence of the operating symbols, and second to ensure that the entering of row pulse trains into the empty storer has definitely ended when such storer has to be read—that is, when the contents of the previously filled storer have been read. The rhythm of reading cannot be altered; it must be completely uniform to correspond to the uniform rate of printing of a facsimile receiver, unless the same is operated on a line-start-stop basis, although such a step does not appear advisable. The line feed of the sheet printer is greater than usual, being about 0.5 mm., since the breaking-up of a line of text into five scanning rows is much coarser than in the scanning of pictures.

A difficulty arises in connection with the symbol Carriage Return not preceded or followed by Line, for it means that a line of the original text has been wholly or partly written over, perhaps to insert or to delete some matter. This case may occur in teleprinter operation, at least theoretically. Since the change-over to the empty storer is initiated only by the Line signal, the same storer would be overstored if Carriage Return arrived alone, and this may very easily occur in the places where storage elements have remained empty during the preceding entering operation. As a rule, therefore, the full storer of the preceding line of text should have been read long before the storer already filled during the reading period has been refilled. However, the rhythm of reading must not be disturbed, and to allow for the time factor the receiver must print an empty line of text consisting of 5 scanning rows and not existing in the original. To obviate these disadvantages the appearance of the Carriage Return symbol automatically leads to the entering operation being changed over to the read (empty) storer, with the result that the receiver prints a new line of text for the overwritten line of the original. For the rest, every endeavor should be made to obviate such occurrences when the tape is prepared, by ensuring that the Carriage Return symbol is always preceded or followed by the Line symbol.

If the original contains an incomplete line of text, for instance, in the form of one word at the beginning of the line, the entering or storing operation stops after such word. However, the whole line storer is read from front to back; in this case the storer contains mainly idling pulses.

If the Line symbol appears without a preceding or following Carriage Return symbol, for instance, to indent the next part of the text, the storing of the next line into the idle line storer starts in the storage group following the last occupied storage group of the filled line storer. Here again the whole line storer, although filled at the beginning with idling pulses, is read.

An embodiment of the invention is illustrated in the form of block schematic diagrams in the drawings, wherein

FIG. 1 illustrates the circuit arrangement of a complete transmitter, and

FIG. 2 illustrates the circuit arrangement of a line storer.

FIG. 1 illustrates a device for scanning tapes perforated in five-element teleprinter code. The scanned five-element hole combinations of a perforated tape **41** are supplied to an electronic decoder **3** over a cable **2** which, in line with five-element code, comprises five

conductors. The five-element combinations are decoded—that is, translated into Hell code—in the decoder 3 in known manner. The decoder 3 has 49 outputs corresponding to the 47 different characters (letters, figures and symbols) and the word space symbol, each such output being allocated to one such character. Over the line 10 extending from the decoder 3 are transmitted symbols designating respectively carriage return, letter, figure, bell, who's there?, indicated in FIG. 1 respectively by "CR," "L," "Fi," "B" and "?." Reference "Li" applied to line 11 indicates that the symbol for "line" is transmitted thereover. When a five-element combination is scanned, which is meaningful only because preceded by one of the two combinations Letters or Figures (change of character case), the output terminal associated with the character scanned undergoes a brief potential variation. Such potential variations, however, do not appear at the rhythm at which the five-element combinations of the tape are scanned, and the rhythm is interrupted when any of the operating combinations Letters, Figures, Carriage Return, Line, Bell or Who Is Calling?, to which no characters are allotted, are scanned. The outputs for Letters, Figures, Bell and Who Is Calling?, on the one hand, and for Carriage Return and Line, on the other hand, are brought out of the decoder 3 separately from the other outputs, and the potential variations which the output terminals associated with the operating combinations undergo when the same are scanned are used for control operations which will be described hereinafter. The 47 character outputs and the output for "Word Spacing" (WS*p* in FIG. 2) are connected by a 48-conductor cable 4 to change-over switches or gates 5, 6; 48 pairs of such gates are provided but only one pair is shown. The gates 5, 6 are opposed two-state flip-flops, that is, the gate 5 is open when the gate 6 is closed and vice versa. The gates are controlled from the output side and the control operation will be presently described.

Electronic line storers 7 (I) and 8 (II) for the Hell characters are of identical construction and are shown separately in FIG. 2. They will be described in detail later in order to avoid interrupting the course of the description at this point. A line of text contains not more than 69 characters. A line storer accordingly comprises 69 adjacent storage element groups in the form of square matrices each containing 25 storage elements. The reason for this is that the character area of a Hell character consists (not including the white edge which is devoid of image elements) of 25 image elements. A filled line storer represents an electrical or magnetic image of a line of text in Hell characters. The storers 7, 8 are used alternately; for instance, while a new line of text is being entered in the storer 7, the preceding line of text stored in the storer 8 during the preceding cycle is read out row-wise (parallel with the direction of the line of text) and downwards and each row is read from left to right. The character pulses supplied through the cable 4 and gates 5 to the storer 7 coincide successively with counting pulses delivered by a character counter 9 which counts periodically from one to sixty-nine. For the first character to be entered into a line storer, the first output of the counter 9 carries a voltage so that the associated Hell character is entered into the storer 7 in the circled place 1. The next character is entered by the second step of the counter 9 into the circled place 2 in the storer 7, and so on until after not more than sixty-nine steps of the counter 9 the characters of one line of text have been stored in the storer 7. However, a line storer must not be filled completely with character pulses, particularly where the line of text to be stored is not completely filled with characters, as is usually the case. In such a case the remainder of the line storer is filled with idler pulses which do not need to be specially stored but merely cause the corresponding storage elements to remain in their initial state which is one of their two possible states.

The last character of a line of text can be followed on the tape either by the hole combination Line alone or by the hole combination Carriage Return in association with Line. Line alone means that the line of text coming to an end was incomplete and the next line of text is indented by as many places as the preceding line contained characters. In such a case all that is necessary is to change over the line storer and there is no need to reset the counter 9 to 1, for the next line of text starts to be entered into the empty storer at the place where the entering of the preceding line of text stopped. In the second case the combination of Carriage Return with Line means that, in addition to the line change and associated change-over from one storer to another, the new line has characters (including any empty spaces) right from the beginning, and that the empty line storer should accordingly be filled right from the beginning with character pulses (including any idler pulses). In this case the storer counter 9 or 9′ must be reset to 1 in order that the new line of text may start to be entered into the empty storer at the beginning thereof. In both cases, however, further entering into the filled storer must stop temporarily. To this end, the potential variations produced at the associated outputs of the decoder 3 when the combination Carriage Return and/or Line is scanned pass as pulses through connections 10 and/or 11 to a gate 12 and bring the same into the operative position. A voltage is thereby applied to a lead 13, with the result that a gate 14 and, by way of a decoupling member 15, a gate 16 are closed. Stepping pulses delivered by a timer 17 (150 cycles per second) through leads 18, 19 to the tape scanner 1 are therefore cut off and the same stops. Also, as the hole combination Carriage Return is scanned, a gate 20 is changed over by the pulse in the lead 10 and, by way of a differentiator 21, delivers a pulse to a lead 22 which resets the counters 9 and 9′ to 1.

While the storer 7 (I) is being filled, the line of text previously stored in the storer 8 (II) is removed (read). To this end, a reading counter 23′ is provided with a counting period of 483 steps. Since a complete line of text consists of not more than 69 characters, including spaces, each Hell character consists of 5 columns of image elements, and there are two empty columns between every two letters as spaces, the various stored row pulses are read (parallel with the lines of text) in $69 \times 7 = 483$ pulses. A line of text consists of 5 scanning rows (without line spacings). Hence a line of text stored in the elements (1)–(69) of the storer 8 is read as follows:

The reading counter 23′ reads the first row (starting from the top), by executing 483 separate steps. After the first row has been read, a pulse passes through a lead 24 to a row counter 25 having a counting period of 6 steps, and the counter 25 brings into operation, through a connection 26, the second row of the storer 8. The reading counter 23′ counts the 483 storage elements of the second row, whereafter another pulse is sent through the lead 24 to the row counter 25 and a pulse applied to a lead 26 brings the third row into operation. This operation is repeated until, after the fifth row has been counted and the row counter 25 has performed its sixth step, a pulse is applied to a lead 28 through a differentiating member 27. The gates 5, 6 are therefore changed over — that is, the pulses delivered by the decoder 3 through the cable 4 are supplied for the next storage operation to the storer 8 and no longer to the storer 7. Simultaneously, gates 29, 30 are changed over through the lead 28 to interrupt the output of the storer 8 which was previously connected to a transmitting line 36 by way of a lead 31, gate 30, lead 32, amplifier 33 and modulator 34 in which the pulses of a carrier frequency delivered by a carrier generator 35 are modulated. Due

to the operation of the gate 29, the output of the storer 7 is connected through a lead 37 and the gate 29 to the lead 32 and therefore to the transmitting line 36. The pulses applied to the lead 28 also return the gate 12 to the normal position, with the result that the gate 14 is opened through the lead 13 and the tape scanner 1 is restarted to initiate the second cycle of operations. In a manner similar to that just described, the characters scanned in the tape scanner 1 pass through the decoder 3 and gate 6 to the storer 8 while the storer 7 is being read by the reading counter 23. As already stated, the row counter 25 is stepped on by way of the lead 24 after the reading of each row until five rows have been read, whereafter a pulse is applied through the differentiator 27 to the lead 28. The gates 5, 6, 29 and 30 therefore return to the initial state shown. Also, the gate 12 returns to its original state and thus opens the gates 14, 16. The storers 7 (I) and 8 (II) have again changed over their functions and the initial state has again been restored. Directly after this change-over, further scanning of the perforated tape and the storing of the character pulses into the storer 7 (I) are effected. However, reading-out from the storer 8 (II) starts only when the counter 23' has counted idly (without reading) from 1 to 483 a sixth time to reset the row counter 25 to 1. This break in operation of about ⅙ of a second is necessary to give the facsimile receiver time to advance one line.

In the embodiment shown, the counters 9 and 23 are alloted to the storer 7 (I) and the counters 9' and 23' are allotted to the storer 8 (II). In practice only one set of counters is provided for alternate control of these storers.

The operation of the counters is controlled by timers. The counters 9 or 9' are controlled by the timer or pulse generator 17 which supplies timing pulses thereto through a lead 38, the gate 16 and lead 39.

The timer 17 also controls the timing of the advance of the tape scanner 1, for as a hole combination representing a character is scanned, so a storage group of the storer 7 or 8 is filled with character pulses. The timing frequency of the generator 17 is so great that the entering of the character pulses of a line of text has definitely ended when the reading-out of the other (full) storer has ended. At least 69 steps are necessary to scan the hole combinations for the characters (including spaces) of a full line of text, provided that there is no change of character in the line. So far no consideration has been given to the tape possibly containing combinations representing characters or symbols not to be printed by the receiver, such as Letters, Figures, Bell or Who Is Calling? So far as the entering of the characters into the storer is concerned, the appearance of such combinations leads to a time loss of one timing pulse period. In the worst possible case 50% of the combination scanned may be operating combinations, that is, where the nature of the characters changes after every character, for instance, *a* 1 *b* 2 *c* 3 . . . , or *a, b, c,* . . . and so on. In such a case, at a scanning frequency of 138 c./s. $2\times69=138$ hole combinations are scanned per second, but only 69 characters per second are entered into the storer. A timing frequency of 150 c.p.s. is selected in order to ensure that the time required to store the characters of a line of text is definitely shorter than the time required to read one line of text including the pause for line advance of the receiver.

The operating combinations must not effect stepping of the counters 9 or 9' as the characters are being entered into a storer. To this end, when the combinations Letters, Figures, Bell and Who Is Calling? are scanned the corresponding output of the decoder 3 is connected, through a lead 40 and decoupling element 43, to the control input of the gate 16 which closes during the presence of any of the last mentioned combinations so that the next timing pulse delivered by the timer 17 cannot reach the counter 9 or 9' and the same therefore remains stationary. This consequently ensures that there is no advance to the next storage group of the storer 7 or 8 and that no unwanted space is stored. After such an operating combination has been scanned, voltage ceases to be applied to the lead 40 and this change in potential reopens the gate 16 so that the next timing pulse from the timer 17 passes to the counter 9 or 9' which are therefore stepped on to effect further counting.

A timer or pulse generator 44 for the reading counter 23 and 23' supplies timing pulses thereto through a lead 45. On the basis of the previous calculations the frequency of the reading out counter should be 3000 cycles per second (c.p.s.) to correspond to the required receiver printing speed of about 70 characters or symbols or one line of text per second. Conveniently, since the timer 17 must be synchronized with the timer 44, the frequency thereof is an integral multiple of the frequency of the timer 17. Since 483 timing pulses are required to read the pulses of a full line of text but, at the chosen reading frequency of 3000 c.p.s., 500 timing pulses per row are available, 17 idle timing pulses per row remain which do not lead to a reading.

The facsimile receiver, after printing a line of text—that is, 5 rows—makes a rapid line spacing movement corresponding to the height of one or two lines of text, suitable gears being known for this purpose. The time for such line spacing in the receiver can be made available by causing the counter 23 or 23' of the transmitter to count a sixth time from one to five hundred, for which about ⅙ of a second is available. There is no need for the receiver to be synchronized by the transmitter if the receiver drive is stabilized, for instance, by a tuning-fork-controlled oscillator as is customary in picture telegraphy. If the receiver speed cannot be made sufficiently constant, periodic line synchronizing signals for advancing the line of text (but not the row) can be transmitted by the transmitter to the receiver.

The further details concerning the operation of the counters 9, 23 associated with the storer 7 (I) and of the counters 9', 23 associated with the storer 8 (II) can be gathered from FIG. 2 which illustrates the main elements of a storage matrix consisting of ferrite ring storage cores. A Hell character or symbol is built up in a rectangular field from rectangular image elements in which the image elements are arranged in seven rows and seven columns each consisting of seven elements. The 1st (top) and 7th (bottom) row and the 1st (left) and 7th (right) column are not occupied by characters and form the spacings between characters and between lines of text in the reproduction. Hence only 5 rows and 5 columns each consisting of 5 image elements remain for the character so that only 25 image elements participate in forming the character. Accordingly, a storage group matrix for storing one character comprises 25 ring cores which are disposed, in accordance with the character field, in five rows one above another and in five adjacent columns, each such row and column consisting of 5 rings. The operation of such ring cores is known. Due to their substantially rectangular hysteresis loop, the core flip-flops into one of its two states of remanent magnetic saturation when a specific level of excitation is reached, the core flip-flopping into the other state of remanent magnetic saturation when an equivalent excitation is produced in the other direction. The cores are energized by magnetizing currents flowing through wires extending through the rings. An information bit is stored and read out in known manner by coincidence of two partial currents which flow through two wires passing through the ring and which cause the core to flip-flop magnetically. There are two important phases in the operation of the storers, namely, entering of data into the storer, and removal of data therefrom, that is, the reading-out of the binary data or removal of the stored character pulses.

(1) *Entering of data into the storer (Storing)*

Each of the two storers **7** and **8** can store 69 characters including any spaces present. Since the two storers are filled and read out alternately as the transmitter operates, they must be able to store a total of $2\times69=138$ characters. A storage group matrix of 25 ring cores is required for each of the 138 characters to be stored, hence $138\times25=3450$ ring cores are required. Also, it must be possible for any of the 47 different characters to be stored in any of the storage group matrices.

The example under consideration shows the wiring for the letter H. The corresponding output **47** of the decoder **3** is connected to a wire **49** through a gate **48** which is shown here as a mechanical switch. The wire **49** extends, corresponding to the shape of the letter H, through all the rings of the first column, through the three central rings of the central row and through all the rings of the 5th column of the first matrix. The sequence in which the wire passes through the rings concerned is, of course, unimportant. The wire **49** extends in exactly the same way through the corresponding rings of all the other matrices and terminates at a negative terminal **50** of a current source. At the instant when the decoder **3** delivers the letter H, a current $i/2$ flows through the lead **49** in the direction indicated by an arrow. When the character counter **9** actuates, for instance, the first storage group, the current $i/2$ also flows through a lead **51** which extends through all the 25 rings of the first storage group. The direction in which the current flows through the rings is the same as the direction in which the current flows through the lead **49**. In all those rings through which the two wires **49** and **51** extend, the effects of the two component currents $i/2$ add up to the effect of the total current i which can change ring magnetization. None of the other ring groups are affected, since the current $i/2$ flowing in the remainder of the rings cannot cause a change in the magnetic state. Another following letter would cause a current $i/2$ to flow through a letter image lead which extends, in accordance with the changed image, through a different group of rings and which is associated in the same way with all the 69 or 138 ring core groups. However, the character counter **9** has meanwhile prepared the second storage group of the storer **7** so that the second ring core group is preenergized by the current $i/2$ which flows through a lead corresponding to the lead **51**. There is therefore coincidence between the current in the lead corresponding to the lead **51** and the current flowing through the character element lead associated with the character, so that those rings of the second ring core group which are associated with the new character element are magnetized. All the storage groups are in this manner successively similarly filled with character pulses or idling pulses and due to the position of the magnetized cores is produced an exact magnetic image of the characters of a line of text. It may also be mentioned that the scanning of the hole combination corresponding to Word Space, which is transmitted through one of the leads **4** (FIG. 1), effects stepping of the character counter **9** but does not actuate a character element lead to enter a character into a storage group. Such a space storage group is therefore not filled with pulses as it must remain free so that the space may be read out during transmission.

(2) *Removal of data from the storer (Reading Out)*

As the characters are transmitted, the magnetic character image must be read and translated into transmission pulse trains of a kind adapted to control a facsimile sheet printer. To this end, all the rings of the storer **7** are read from left to right along the rows (parallel with the line of text). From each of the outputs **1–5** of the row counter **25** (the output **6** thereof is not connected to the storer) extends a wire through all the rings of the associated row. A voltage is successively produced at these outputs and current flows successively through the rings of consecutive rows. In the time during which a voltage occurs at a row counter output, for instance at the first output (lead **52**), the reading counter **23** makes a complete count from 1 to 483 and, as it does so, applies successively a voltage to all its outputs. A coincidence occurs thereby between the currents in the output lead **52** and the currents in the leads **53**, **54** and so on connected to the outputs **2**, **3** and so on. Nothing happens upon the 1st, 7th and 8th, 14th and 15th, 21st and 22nd, and so on, step of the counter **23**, since the 1st, 7th and 8th, 14th and 15th, 21st and 22nd, and so on, outputs thereof to which the intercharacter spaces are allotted are not connected to the storer. Hence there is a short pause equal to the length of one counting pulse period of the reading counter **23**, and during such pause no rings are sampled; also, the pause causes the receiver to note half an intercharacter space. Upon the 2nd reading step of the counter **23** voltage is applied to the lead **53** so that a current $i/2$ flows in the direction indicated by an arrow. A similar current $i/2$ also flows through the lead **52** from the counter **25** so that the ring **46** at the place where the wires **52**, **53** cross one another receives the full current i required for magnetization. This changeover represents a magnetic image of the associated (black) image element of the letter H. While characters were being entered into the storer, the ring **46** was magnetized by currents flowing through the leads **49** and **51**, such currents being oppositely directed to the currents flowing in the leads **52** and **53**, and so the ring **46** is now magnetized back to its original state. A voltage pulse is thereby produced in a reading line **55** which extends through all the rings of the storer. Upon the next step of the reading counter **23** a voltage is applied to its third output terminal—that is, the lead **54**—and the current $i/2$ flows through the rings of the second column in the direction indicated by an arrow. Coincidence exists now with the current $i/2$ flowing through the lead **52**, with the result that the second ring **57** of the first row is sampled. The current would suffice for reversal of magnetization, but since the ring **57** was not magnetized during the storage of the character H, no reversal of magnetization occurs and, accordingly, no pulse appears in the reading line **55**. Similarly, the third and fourth rings **58** and **59** respectively in the first row, which rings are supplied with currents $i/2$ when the counter **23** is at the fourth and fifth step respectively, do not produce pulses in the reading line **55**, since the rings **58**, **59** were not magnetized when the character H was stored. However, the sixth step of the counter **23** reverses the magnetization of the fifth ring **60** of the first row since the ring **60** was magnetized during the storage operation. Thereafter, as the counter **23** passes through the seventh and eighth steps and so on up to the four hundred and eighty-third step, voltages appear successively at the corresponding outputs and produce currents in the corresponding output leads and preenergize the rings of the associated column, if such is present, with the current $i/2$. Whenever a ring magnetized during the storage operation is sampled during reading, the magnetization of such ring is reversed so that a voltage pulse is applied to the reading line **55**. After the rings of the last column have been read (step 482 of the reading counter **23**), the counter **23** delivers to the row counter **25** a pulse which changes the row counter over to output **2**. A voltage appears now on the lead **56** to produce therein a current $i/2$. This current flows through all the rings of the second row of the storer **7**. Simultaneously, the counter **23** starts a new counting period which, starting with the idle position **1** and continuing with the second position (line **53**), energizes all the rings of consecutive columns successively with the current $i/2$. There are then consecutive coincidences between the currents in all the rings of the second row with the currents in the rings of consecutive columns. All those rings, the magnetization of which was reversed during the preceding storage operation, therefore return

to their initial magnetic state and thus each produces in the reading line **55**, which extends through all the rings of the storer **7**, a pulse which passes to the transmitting line **36** (FIG. 1). Similarly, as the row counter **25** passes through its third, fourth and fifth steps, voltages appear successively at the corresponding outputs of the counter **25**, and coincidence between the currents flowing in the third, fourth and fifth output lines of the counter **25** and the currents flowing in the various output lines of the reading counter **23** lead to a reversal of the magnetization of those rings which underwent magnetization when the characters were stored. As already stated, the reversal of magnetization of each ring effects a pulse being applied to the reading line **55**. After the fifth row has been read the reading counter **23** passes through all its steps for the sixth time but without any effect since there is no sixth row. The purpose of this sixth counting cycle is merely to gain about 1/6 of a second, the time required to read a row, to give the receiver time to perform a rapid line advance. Upon the termination of this sixth counting cycle the row counter **25** delivers a pulse which changes over the storer **7** just sampled to "store" and places the storer **8** just filled to "read." The operations described for storing and reading a line of text are repeated during the next cycle of the printer but with storers exchanged.

47 different character image leads **49**, corresponding to the 47 different characters, extend through each of the 69 ring core storage groups. Where the characters are in Hell form, there are a few (black) image elements forming part of only one or of a reduced number of characters. On the other hand, there are a few (black) image elements which form part of almost every character. At the outside, therefore, 47 different character image leads **49** may extend through one ring of a storage group. Four more leads are required for the storing and reading so that not more than 51 wires will extend through a ring. It would consequently appear to be an involved matter to wire the ring cores for, as previously stated, 3450 of them are required.

Alternative storage possibilities exist however. For instance, a character can be stored in accordance with a system of coordinates in a storage group matrix consisting of 25 storage elements.

This requires the use of an electronic translator for translating five-element code into Hell code so that, when a hole combination corresponding to a character is scanned, the associated Hell pulse train of 25 pulses appears at the appropriate output of the translator. By means of two counting switches, one of which periodically counts through the ring rows from one to five at a frequency of $150 \times 25 = 3750$ c./s., while the other periodically counts through the ring columns from 1 to 483 at $3750/5 = 750$ c./s., the Hell pulse trains are distributed to the various columns of the storage groups physically in five-pulse groups and are entered into the line storer. In this case only five wires extend through each ring, but the translator is much more complicated than the relatively simple decoder **3** which merely effects decoding of the five-element combinations. Consequently the expenditure on either of the two storage systems described is about the same.

Changes may be made within the scope and spirit of the appended claims which define what is believed to be new and desired to have protected by Letters Patent.

I claim:

1. Method of transmitting characters in code for facsimile sheet printer reception, comprising the steps of forming pulse trains associated with the characters of a line of text in such code which are to be transmitted, successively alternately separately storing said pulse trains alternately removing stored pulse trains representing a scanning row of a line of text in the direction thereof, and reading and transmitting such pulse trains to be received by a facsimile sheet printer successively row for row in the sequence in which they compose the respective line of text from top to bottom, entering pulse trains for storage in place of removed pulse trains while previously stored pulse trains are being transmitted, and temporarily discontinuing the entering of pulse trains before the previously stored pulse train has been read.

2. Method of transmitting characters in code for facsimile sheet printer reception, comprising the steps of forming pulse trains associated with the characters of a line of text in such code which are to be transmitted, the pulse trains being supplied by a tape perforated in conventional teleprinter code, successively alternately separately storing said pulse trains, alternately removing stored pulse trains representing a scanning row of a line of text in the direction thereof, and reading and transmitting such pulse trains to be received by a facsimile sheet printer successively row for row in the sequence in which they compose the respective line of text from top to bottom, entering pulse trains resulting from the scanning of the hole combinations for carriage return and line change for storage in place of a pulse train just read and simultaneously interrupting the tape scanning until the reading and transmission of a previously stored pulse train has terminated.

3. Apparatus for transmitting characters in mosaic line code for facsimile sheet printer reception, comprising a scanner for scanning perforated tape, a decoding device connected with said scanner for processing binary code, two alternately operable pulse actuated line storers comprising respectively groups of electronic storage elements for storing the pulse train signals denoting the characters of a line of text to be transmitted, circuit means including gates for connecting said decoding device alternately with the respective storers, a character counter for each line storer, a read out counter connected with each line storer, a first pulse generator, circuit means including gate means connecting said first pulse generator with said scanner to control the timing of the operation thereof and also connected over further gate means with said character counters to control the entering of signals from said decoding device into the respective line storers, a second pulse generator connected with said read out counters to control the reading out of signals from the line storers, and means for scanning the stored pulse train signals in a plurality of scanning rows, a row counter operatively connected with the line storers and the read-out counters for counting the scanning rows of a line of text and controlling switching of the scanning means from one scanning row to another.

4. Apparatus according to claim **3**, comprising means responsive to pulse trains resulting from the scanning of the hole combinations for carriage return and line change for controlling the switch-over from one line storer to the other, and means for simultaneously interrupting the tape scanning until the reading and transmission of the pulse trains from the filled storer have terminated.

5. Apparatus according to claim **3**, wherein the line storers for the pulse trains comprise only those storage elements which are actually required to represent all the characters, inter-word spaces being replaced by idler pulses incident to the storing and reading of the row pulses.

6. Apparatus according to claim **3**, wherein vacant lines are produced between two text lines, comprising means for automatically advancing the receiver recording sheet, after a text line has been printed, by a step corresponding to the desired line spacing.

7. Apparatus according to claim **3**, comprising means for transmitting prior to the transmission of information special starting and phasing signals for starting and phasing the receivers.

8. Apparatus according to claim **3**, wherein said decoding device effects decoding of the five-element combinations of the tape, and wherein all those storage elements which are concerned in the electronic representation of the character are simultaneously filled.

9. Apparatus according to claim 3, comprising a five-element-to-mosaic line code translator for effecting the supply of the pulses of a character to the respective line storers with consecutively filling of all those storage elements which are concerned in the electronic representation of the character.

10. Apparatus according to claim 3, wherein pulse train signals from said decoding device are entered into an empty storer while pulse train signals previously entered into the other filled storer are being transmitted, and means for controlling the gate means in the connection between said first pulse generator and said scanner for temporarily stopping the latter to discontinue supply of character signals when the empty storer has been filled before the filled storer has been read out.

References Cited by the Examiner

UNITED STATES PATENTS

2,304,775	12/1942	Blanton	178—3
2,369,662	2/1945	Deloraine et al.	178—30
2,848,535	8/1958	Hunt	178—30
2,905,930	9/1959	Golden	340—172.5
2,932,692	4/1960	Hunt	178—30

NEIL C. READ, *Primary Examiner.*

STEPHEN M. CAPELLI, NEWTON N. LOVEWELL, *Examiners.*

B. KONICK, A. J. DUNN, *Assistant Examiners.*