The Eastman Kodak Multiple-Stylus Electronic Printer

R. G. THOMPSON & C. E. HUNT, JR.

The Eastman Kodak multiple-stylus electronic printer prints, at high speed, outputs from electronic computers, insurance premium notices, utility bills, addresses on magazine labels, addresses on cards and envelopes, and so forth. High-speed printed communication is also a field for this printer, as it can be operated by remote control, without synchronization.

This nonphotographic electromechanical printer operates from a coded signal, supplied from any suitable source, such as from the holes in automatically fed punched cards, film, perforated tape, magnetic tape or magnetic wire, radio, coaxial cable, electronic computer, electronic storage, and so forth. The coded signal releases a predetermined sequence of operations to print the entire built-up rectangular-dot character, automatically, from a 5- by 7-dot rectangle, made up of 35 rectangular dots, five rows of seven dots each for serial print, or seven rows of five dots each for parallel or columnar print, as shown in Figure 1.

Every character is connected permanently into a 35-switch electronic matrix printing storage which operates the printing styli. The number, variety, and form of characters desired are provided for in the electronic decoder and electronic matrix connections. Current models have single-case billing-type letters and numerals and special characters.

The printing is done by a single row of five or seven styli, each stylus being operated by an independent polarized relay to print or not print (yes or no) rectangular dots, in accordance with the predetermined pattern of the amplified signals released from the electronic matrix. These styli strike impact blows on carbon paper to print rectangular-shaped carbon dots, row by row, on the paper under the carbon paper, for the character signaled, as the paper and the carbon paper at one-fourth the paper speed, pass between the anvil and the styli. Heat fixes the carbon impressions.

Current models print on ordinary paper, 0.003 inch thick in 4,200-foot-long rolls of the desired width, which is run continuously at speeds up to 50 inches per second under the printing styli assemblies. One-time carbon paper from a separate roll is run between the styli and the paper. Thick cards and thick paper, or sheets, can also be printed.

The printing speed is 300 to 400 characters per second for each printing assembly, as much as 20 times the maximum speed of automatic typewriters. Six hundred 4-line address labels, of 96 characters each, can be printed per minute.

Adding printing heads increases the output proportionately as follows:

<table>
<thead>
<tr>
<th>Number of character per minute = Number of printing heads ( \times 400 \times 60 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Printing Heads</td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>4</td>
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<td>6</td>
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<td>100</td>
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</tbody>
</table>

Patents have been allowed, without any references, covering the multiple-stylus printing and the electronic matrix control.

The multiple-stylus electronic printer can be made in various forms and combinations for the particular performance and service required; for serial or parallel printing, different numbers of lines or columns, different signal sources, and so forth. The electronic printer described in this paper is now in process for the Eastman Kodak advertising department, where it will be used to print desk strip for publications and direct mail.

General

The multiple-stylus electronic printer prints desk strip from the signals received from the holes in punched cards at the rate of 36,000 to 42,000 addresses per hour. There are two separate principal units, the printer, and the electronic unit, connected by cables. These two separate units are built into two metal cabinets, shown in Figure 2.

The printer consists of two sections, driven by the same motor, through a variable-speed transmission. One section, the end-card feed and card reader, is a special, positively operated card feed with the addition of a photoelectric reading station, to read all the holes in all the columns of the tabulating card. The signals from the holes in the card are transmitted to the electronic unit by cables. The other section of the printer prints the tape in accordance with the grouped signals received from the electronic unit, and consists of the stylus-printing assemblies, the desk strip paper rolls, carbon paper rolls, feeds, controls, and so forth.

The electronic unit stores the signals received from the cards, rearranges them in the proper sequence for printing, then decodes the signals, and translates them in predetermined combinations and sequences of signals for the printing styli to print the corresponding characters, as shown in Figure 3.

The pluggable connection panel provides considerable flexibility in the location of the printing from any one of the columns. An additional feature is a receptacle for a fixed card which may be plugged in to print the name of a city or state, or any other information common to a large number of cards.

The entire 4-line address is punched in one card, or this may be divided so that the first three lines of the address are carried on the address card, and all or part of the fourth line on the fixed card, and so forth.

Checking circuits are incorporated so that if a signal is lost in the machine, through the malfunctioning of a tube or other component, an error signal will be generated which will light a lamp and shut down the machine. Further, instead of printing an incorrect letter or number at this point, an unmistakable mark will be made on the tape to indicate the location of the error.

Printer

The printer unit, shown in Figure 4, consists basically of the multiple-vibrator and printing-styli assemblies, shown in Figure 5, the paper and carbon paper feeds, with associated supply and take-up reels, mechanically coupled to the special card feed and card reader.

The whole unit is driven by a master variable-speed drive. The card feed is directly coupled to the drive, but the printer section is driven through a Warner magnetic clutch brake, which is engaged after the first card is in position and disengaged when the last card runs out, or when the cards are lifted to stop feeding the cards, in order to print desk strip with no blanks.

From the collection of the Computer History Museum (www.computerhistory.org)
Additional features are the individual take-up torque motors for paper and carbon paper, flying punch for piercing holes in the paper between address labels, drying lamps for setting the carbon print, and suction for disposing of paper punchings made by the flying punch. The speed can be varied within reasonable limits by adjusting the master speed ranger. Relays and controls for the printer are mounted underneath, inside the cabinet.

The printing is done by a single row of seven styli, which are actuated by the polarized multiple-vibrators, as shown in Figures 5 and 6. There is one vibrator for each stylus, seven styli for each line, and the multiple-vibrator is assembled as a single unit, with one permanent magnet which furnishes the magnetic field which passes through the air gaps of all the vibrators in series. Thus, the permanent field direction is the same on both sides of the movable armature. Current passing through the coil of a unit induces a field which travels through the stationary core to the movable armature, then through the air gaps, and back through the laminations to the stationary core.

Thus, the field from the coil is in opposite directions on each side of the movable armature. On one side it will assist the permanent magnet field, and on the other side it will oppose it. This creates an unbalance which will pull the armature to one side. Reversal of current in the coil will reverse its field, assisting the permanent field on the opposite side, pulling the armature in the opposite direction. The individual vibrators for each stylus have two adjustments. Each individual blade has adjusting screws, and the frame for each unit of seven can be raised or lowered as a group.

The punched cards are stacked in a hopper, or feeder magazine, about 700 at a time. The card is fed positively, sideways, by two mechanical pushers, from the bottom of the stack in the feeder magazine, into the cross feed, where the card is fed endwise by a mechanical pusher to engage rollers which pass the card through the 24-photoelectric-tube reading section, consisting of four reading stations of six photoelectric tubes each. A 50-candlepower auto lamp provides light to pass through the holes in the card to energize the photoelectric tubes, to produce electric-code signals for the holes punched in the cards. The columns are sensed sequentially.

A toothed wheel is driven in front of an additional photoelectric tube to supply timing pulses for each card column. Another toothed wheel is mounted on the
printer and is driven by it, to supply pulses for printing.

A feature of this system is the fixed-card reader, a stationary unit entirely separate from the card feed itself, in which the fixed card for the city and state for a given group of cards is placed, manually. This fixed card for the city and state remains in the fixed-card reader for printing the fourth line of the address during the time that all the cards in that area are read.

Pins, actuated by springs, pass through the holes in the city and state section of the card, for the fourth line, and these signals from the fixed card are correlated with the signals from the automatically fed 3-line address cards for the first three lines of the address, to print the entire 4-line address.

**Electronic Unit**

The electronic unit, shown in Figure 7, is contained in a separate cabinet, and initiates and controls all printing operations. All signal switching in the unit is done electronically, relays being used only for power supply switching, interlocking, and motor starting. A great deal of flexibility is incorporated by means of a plug panel, which allows the printing position of any card column to be shifted at will.

Each of the four reading stations located on the card feeder sends out a group of from none to three signals from its six photodetector tubes as each column of card passes. A toothed wheel, rotating in synchronism with the card feed, sends out pulses by means of a photodetector tube and light source, each pulse coinciding with the reading of a card column. The card signals are amplified and gated with the toothed-wheel pulse signal, assuring exact synchronism. The card signal pulses go to four rows of sockets, one for each reading station, located on the plug panel. An electronic ring circuit is stepped along by the toothed-wheel pulse, in synchronism with the card reading, and suggestive pulses are sent to the four rows of sockets. A series of plugs on the panel are wired to a group of memory units, one unit for each possible letter in an address label, or 96 in all. Each memory unit consists of seven magnetic memories, each capable of storing a single signal. Each memory unit plug can be inserted into a socket corresponding to the card column desired printed in that position, so that when a group of pulses is received from a card column, the memory unit whose plug is connected to the socket pulsed by the ring circuit at that moment is activated. Six of the memory unit's magnetic memories are used for this. The seventh is activated by an auxiliary device which gives out a pulse only if the card signal has an even number of pulses. The result of this is that the signal content of each memory always consists of an odd number of pulses. This fact is used later to determine whether any signals have been lost.

Another toothed wheel run by the printer unit generates a series of pulses at the rate of seven for each character to be printed. An electronic ring of seven tubes is driven by these pulses and each seventh pulse advances another electronic chain, whose pulses are applied to read out the memory units in groups of four, one for each line. As each memory unit is read out, its signals go to one of the four printing-line units where they are applied to a group of six trigger tubes or flip-flops, setting a corresponding trigger for each signal present. These are connected into a germanium crystal diode decoding matrix in such manner that for each combination of signals, one and only one of the output lines corresponding to an alphabetic or numerical character is energized. Each output line is buffered by a cathode follower and is connected by crystal diodes into a 5-by-7 matrix of 35 gates or switches in the pattern of its character, as shown in Figure 8. When an output is energized, switches are open in this pattern. Five of the seven pulses which occur between reading of memory units are used to send a pulse into each column of seven switches in turn. A vibrator amplifier is connected to each row of five switches. Thus, as each column is pulsed, a signal is sent to an amplifier only if its switch in that column has been energized by the character signal. Each amplifier is connected to a vibrator, pulling it down when there is a signal, pulling it up when there is no signal. The paper tape is
moved one dot space as each column is pulsed, and the character is built up in 5 pulses. The fifth pulse resets the trigger tubes in preparation for the next character. All four line units operate simultaneously and each prints one line of the address.

At the decoding matrix, comparison is made to see if the total number of signals for a character is odd or even. If it is even, a signal must have been lost and an incorrect character could have been printed. The comparison circuit detects this and causes a black mark to be printed in place of the wrong character, at the same time lighting a warning light and shutting down the machine.

An additional feature is provided, consisting of three memory units into which can be read any three columns of the card. These are plugged into three letters of a city name or three numbers of a city code. As long as all cards have the same city name or code, nothing happens, but when the end of a city group is reached and the name or code changes, a signal is sent to the printer which prints a black mark at the end of the label. This enables labels from one city to be easily located.

It is frequently desirable to use a fixed card which has information common to a large group of cards, such as city and state names, dates, and so forth. A fixed-card station is provided which can be plugged in to print at any place in the address in the same manner as signals from the card feed. The card can carry up to 24 characters, extending the capacity of address cards, while eliminating repetitious punching.

The main power supply for the printing is housed in the machine cabinet and furnishes 365 volts d-c at 6 amperes. Others mounted in the electronic cabinet furnish regulated supplies of 265 volts at 2 amperes, 150 volts at 1.8 amperes, 50 volts at 500 milliamperes, and −150 volts at 500 milliamperes. A separate floating supply for trigger circuits delivers +150 volts, −100, −175, −250 volts. Also, 6.3 volts a-c at 300 amperes is furnished to filaments, and 110 volts a-c to control relays. Power input is 30 amperes at 230 volts, 60 cycles, single phase. If a defective coil or other unit causes the main d-c supply to draw more than 6 amperes, the main circuit breaker will open, shutting down the machine. An overload of more than 30 amperes on the a-c line will also open the circuit breaker. Fuses are provided for other power supplies.

Operation

The main circuit breaker switch, the start button for the electronic unit, and the two indicator lights for the electronic unit are mounted on one end of the electronic unit cabinet. The main circuit breaker switch controls all the power for both the electronic unit and the printer. When this switch is on, power is connected to all control circuits but nothing is energized until the control buttons are pushed.

The electronic unit is activated by pushing its start button. This turns on the filament power and lights one indicator light. After a few seconds' delay, the main power is turned on, lighting the other indicator light. The electronic unit and the printer are now ready to operate.

Operation of the printer is controlled by a start button which is duplicated on both sides of the printer. With cards in the hopper, pressing this button first starts the motor. As the motor comes up to speed, the card lifter drops, allowing the cards to feed. When a card is part way through the reading station, a signal is received from the electronic unit that engages the magnetic clutch, which starts the printer. The starting of the printer starts the read-out of the memory and printing begins.

A stop button is located on each side of the printer. When either stop button is pressed, the card lifter lifts the cards, preventing any more cards from feeding. When the last card in process has been printed, the clutch is de-energized, and the brake is applied, stopping the printer at the end of the label. After a few seconds, the motor will stop.

The printer will stop automatically, as if one of the stop buttons had been pressed, under any of the following conditions:

1. Hopper runs out of cards.
2. Receiving hopper is full of cards.
3. Paper, or carbon paper, breaks.
4. Cards jam.
5. Signal missing in memory.

Thompson, Hunt, Jr.—Eastman Kodak Multiple-Stylus Electronic Printer

From the collection of the Computer History Museum (www.computerhistory.org)
6. Second card reads into memory when first has not been read out.

The Eastman Kodak Company has built a similar printer with the card feed and reading station reading four groups of holes in the card simultaneously, and printing the corresponding characters continuously as read. The signals from the card go directly to the flip-flops, then are decoded and energize the matrix in the same manner as in the foregoing description, but without the use of any memory. The entire 4-line address can be carried in a single card with the card punched for this purpose. The 4-line deck strip printer at this conference is so built, except that instead of reading holes in cards, we read holes in program disks by means of photoelectric tubes to obtain our signals. This is a demonstration set-up to be replaced later by a card feed.

Discussion

A. Hyman (Anderson Nichols Company): What advantages are there to the electronic printer as compared to the strip printer which is being used by Life and Time magazines?

Mr. Thompson: I hope nothing we have said has left the impression that our matrix, or multiple-stylus printer, supersedes the photoelectric printer that we developed and made for printing address labels. The machine, which scans addresses photoelectrically and prints them, has been very successful. We built 26 of them for Time, and the machines have printed the labels for all the mailed copies of Time and Life for the past 4 years. They operate a minimum of 5,000,000 labels a week, and run 16 hours a day, which gives them an equivalent life of 8 years. They are good machines and they have a definite field.

The multiple-stylus printer described covers a somewhat different field. Instead of printing from the photoelectric impulses, it prints from a signal that is received from the hole in the card. It is not necessary to print the address on the card; you simply punch the address in the card and print from that.

The multiple-stylus printer is a more expensive and much faster machine. The ratio of speed is about 6 to 1. The photoelectric machine, installed for Time and Life magazines and licensed to Addressograph, will print 120 labels per minute; our multiple-stylus printer will print six times that number.

Garment Tag Equipment

ORVILLE G. HESSLER

In any operation where there is sufficient volume, and where transactions are recorded manually for purposes of controlling inventory and for providing management with reports, there is likely to be a clerical problem. This clerical problem manifests itself in several ways. First, the time taken to compile the information needed for controlling inventory becomes excessive, with the result that actual control is less effective as the volume of transactions increases. Secondly, management reports are delayed, so that situations in need of management action can become critical. Third, errors tend to occur more frequently with the increased volume of work, the increased pressure, and the greater number of new people.

As a way out of such bottlenecks, business, industry, and government agencies have turned to the punched card systems of International Business Machines Corporation and Remington Rand. Proper application of the punched card solves the problem by economies in time and personnel, and by being more accurate.

Large retailers run into this operating problem over and over again. The volume of units is extreme, and the need for proper control of inventory is vital. Reports to management are numerous. There are many fields within an organization in which a remedy may be needed and, of course, many factors must be considered before choosing an operation that is particularly troublesome from a clerical standpoint.

In looking for a solution to these problems, it was decided to apply mechanized inventory control to a line of merchandise that is particularly troublesome from a clerical standpoint. One reason for this is a fundamental of the punched card system: to start as far back in the operation as possible.

Inventory control by punched cards has not been readily adaptable to many lines of merchandise, and their use is especially difficult in the retail end of the business. Here, merchandise is on the display floor or on counters or racks. Since the punched card system starts to function at the time of a sale, it becomes obvious that the regular-sized card (about 3 by 7 inches) cannot be attached to many items, especially small ones, because of the relative importance thus assumed by the card. For some merchandise it would be a matter of attaching the item to the card, rather than the card to the item.

For a merchandising reason, then, it is not desirable to attach a standard punched card to an item. One alternative is to use one card for each group of identical items on display. But there is the obvious objection of not being able to serve several customers 'in parallel' if the customers each decide to pick up identical items and carry them to the salesperson. The punched card remains with the merchandise on display, and would have to be obtained by the clerk, who would also have to replace it. This procedure is not realistic, besides requiring that the card be 'read' at the time of the transaction.

Many kinds of merchandise are in need of better inventory control, so the problem is a broad one. On the other hand, it is wiser to make changes on a limited basis, prove them out, and then extend...