Nov. 17, 1964 YOSHIYASU KIKUCHI 3,157,456

PRINTER

Filed Jan. 31, 1963 2 Sheets-Sheet 1

Fig. 1.

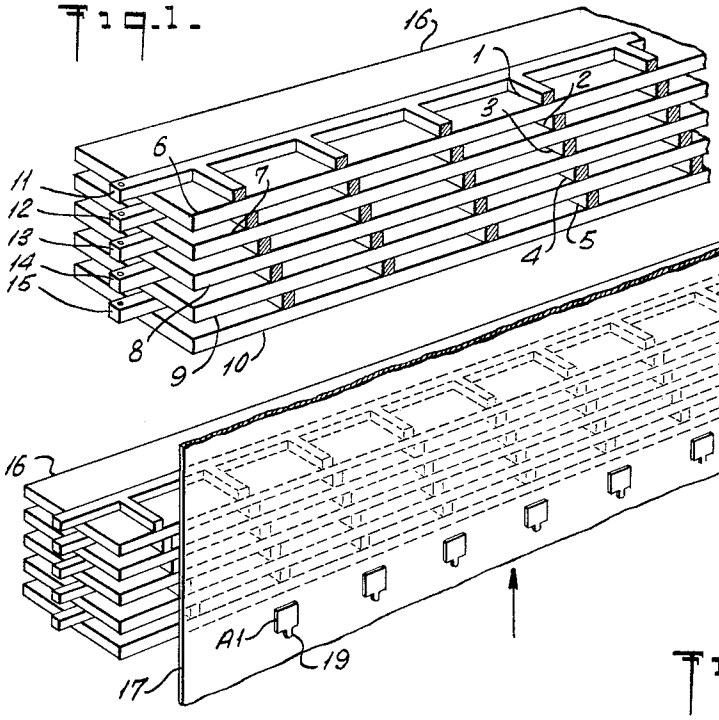


Fig. 2.

Fig. 3.

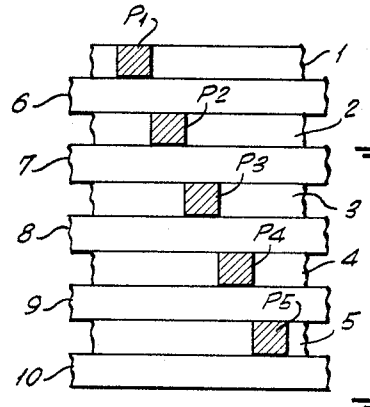


Fig. 4.

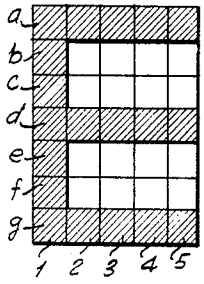


Fig. 5.

a	a1	a2	a3	a4	a5
b	b1	b2	b3	b4	b5
c	c1	c2	c3	c4	c5
d	d1	d2	d3	d4	d5
e	e1	e2	e3	e4	e5
f	f1	f2	f3	f4	f5
g	g1	g2	g3	g4	g5

Fig. 6.

	P1	P2	P3	P4	P5
0t					a5
1t					b5
2t				a4	c5
3t				b4	d5
4t			a3	c4	e5
5t			b3	d4	f5
6t		a2	c3	e4	g5
7t		b2	d3	f4	
8t	a1	c2	e3	g4	
9t	b1	d2	f3		
10t	c1	e2	g3		
11t	d1	f2			
12t	e1	g2			
13t	f1				
14t	g1				

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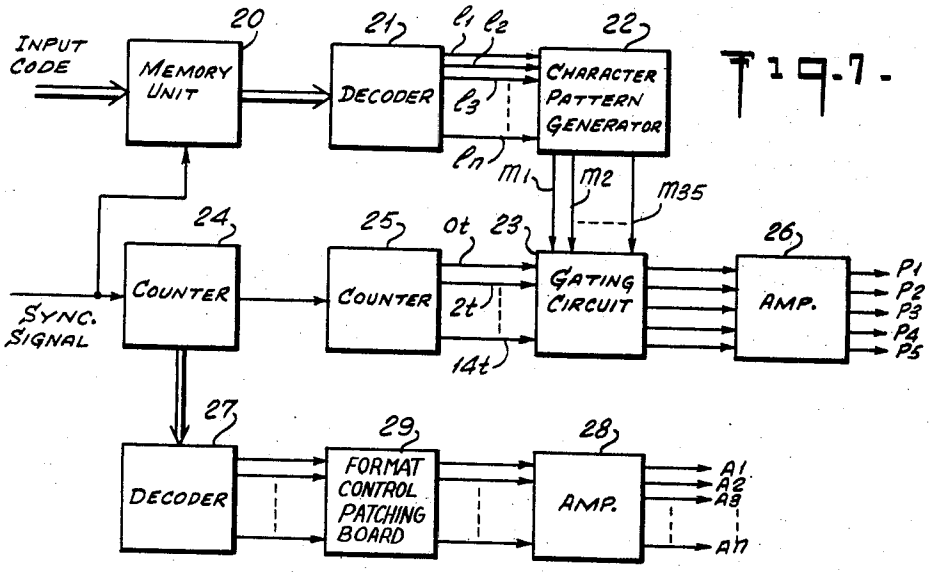


Fig. 7.

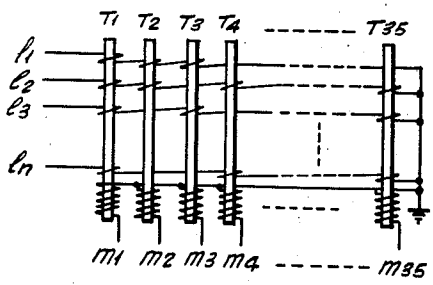


Fig. 8.

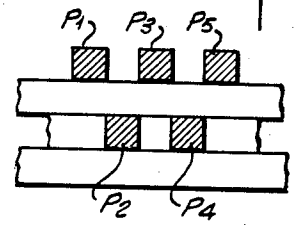


Fig. 9.

	P_1	P_2	P_3	P_4	P_5
0t		a2		a4	
1t		b2		b4	
2t	a-1	c2	a3	c4	a5
3t	b1	d2	b3	d4	b5
4t	c1	e2	c3	e4	c5
5t	d1	f2	d3	f4	d5
6t	e1	g2	e3	g4	e5
7t	f1		f3		f5
8t	g1		g3		g5

Fig. 10.

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3,157,456

PRINTER

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4 Claims. (Cl. 346—78)

This invention relates in general to printers and in particular to printers in which printed characters are formed by a printing head containing a plurality of independent dot-printing elements. The invention is applicable to any printer of the above noted type, but it is particularly useful in electronic printers, i.e. printers that utilize electrical discharges or electrical fields to make visible marks on a recording medium.

In prior art electronic printers, it has been known to use a printing head containing a line or several lines of independent dot-printing elements, and to print any desired letter, number, or abstract pattern by energizing the appropriate combination of dot-printing elements. It was necessary, however, to insulate each of the dot-printing elements from the adjacent dot-printing elements so that each element could be energized independently of the others. This meant that the individual elements had to be separated from each other by enough space to accommodate electrical insulation, which in turn meant that the printed characters were discontinuous, i.e., that they contained breaks corresponding to the boundary between adjacent pairs of dots. The width of these discontinuities can be reduced by using high quality insulation, but the discontinuities can never be eliminated in this prior art printing head. In addition, the conflicting requirements of close spacing and good insulation complicates the manufacture and assembly of the dot-printing elements and increases the cost of the finished article.

Accordingly, one object of this invention is to provide a printing head assembly of the above described type which is capable of printing solid characters without any discontinuities.

Another object of this invention is to provide a printing head assembly of the above described type which is easier to manufacture and to assemble than those heretofore known in the art.

Other objects and advantages of the invention will be apparent to those skilled in the art from the following description of one specific embodiment of the invention, as illustrated in the attached drawings, in which:

FIG. 1 is a perspective view showing an array of dot-printing elements according to this invention;

FIG. 2 is a schematic perspective view of the dot-printing elements of FIG. 1 and an array of electrodes with a recording medium passing between the dot printing elements and the electrodes;

FIG. 3 is an enlarged elevation view of a portion of the array of dot-printing elements shown in FIG. 1;

FIG. 4 is a first chart illustrating the operation of this invention;

FIG. 5 is a second chart illustrating the operation of this invention;

FIG. 6 is a third chart illustrating the operation of this invention;

FIG. 7 is a block diagram of a character generating circuit which can be used in connection with the dot-printing elements of this invention;

FIG. 8 is a schematic diagram of one suitable circuit for the character pattern generator shown in FIG. 7; and

FIGS. 9 and 10 illustrate another example of the dot-printing elements and the operation of this invention.

Referring to FIG. 1, instead of placing the dot-forming elements in a straight line, this invention places the dot-printing elements, i.e., dot-forming elements in a staggered line such as illustrated in FIG. 1, where elements **1** through **5** are metallic dot-forming elements and elements **6** through **10** are insulating plates which separate the dot-forming elements. This particular embodiment of the invention is adapted to print a line of characters, and each of the first, second . . . , and *n*th projections of comb-like elements **1** through **5** are dot-printing elements for one character. The dot-printing elements for each character are staggered vertically to form a step-like series P1 . . . P5, as indicated more clearly in FIG. 3, which shows all of the dot-forming elements necessary to produce one character. The characters are produced by energizing the dot-printing elements in time sequence as the recording medium is moved past the dot forming elements. This process is illustrated schematically in FIG. 2, which shows a recording medium **17** being moved past printing head **16** in the direction indicated by the arrow. The recording medium is responsive to electrical fields or electrical discharges, and an electrode is mounted with a narrow gap opposite each dot-printing element on the other side of the recording medium **17**, as indicated schematically by electrodes A1 . . . A*n*.

An electrical potential field can be generated at any desired dot-printing element by applying a voltage between the terminal **19** of the appropriate electrode and the dot-printing element. The voltage is applied to the dot-printing element via terminals **11** . . . **15**, which are attached to a corresponding one of the comb-like members which form a row of dot-printing elements. Thus a voltage applied between terminal **11** and electrode A1 produces a potential field at the first dot-printing element of member **1**, a voltage applied between terminal **11** and electrode A2 produces a potential field at the second dot-printing element of member **1**, a voltage applied between terminal **12** and electrode A2 produces a potential field at the second dot-printing element of member **2**, and so on. It will be apparent to those skilled in the art that respective electrodes A1, . . . A*n* must be provided for each of the first, second . . . , and *n*th dot-printing elements of the comb-like members. No particular means are shown in the drawings for mounting the electrodes, but it will be apparent to those skilled in the art that any suitable mounting means can be employed.

The operation of the above described embodiment can be best described in connection with the formation of a single character rather than a line of characters. FIG. 3 shows one character-forming portion of the printing head assembly **16** shown in FIGS. 1 and 2. This portion contains a staggered line of dot-printing elements P1 . . . P5 which are sufficient to print any character that can be formed from a 5 by 7 array of squares such as illustrated in FIG. 4. As a concrete example, we will illustrate how to form the letter E, which is indicated by the shaded areas in FIG. 4. Dot-forming elements P1 . . . P5 correspond to the columns **1** . . . **5** in the rectangular array of FIG. 4. If the array is considered to be moving past dot-forming elements P1 . . . P5, with the dot-forming elements always in line with the corresponding column **1** . . . **5**, the dot-forming elements will occupy each row *a* . . . *g* of their columns at successive instants of time. Now let *t* be the time required for the recording medium to travel a distance equal to the vertical distance between the centers of staggeredly arranged dot-forming elements in the 5 by 7 array of FIG. 4, and the vertical dimension of the center to center dimension of dot-printing elements P1 to P2, P2 to P3, P3 to P4, and P4 to P5 be equal to twice the dimension of the said adjacent rows of dots. Although in this example, the distance between adjacent dot printing elements is twice the dimension of said adjacent rows of dots, one can also select the distance to be the same as, or an integral multiple of such dimension. The exact time sequence

in this example will be as illustrated in FIGS. 5 and 6. FIG. 5 identifies each square in the 5 by 7 array of FIG. 4, and FIG. 6 shows where each dot-printing element P1 . . . P5 will be located through a sequence of 14 time intervals *t*. It will be apparent from this chart that all of the dots constituting a 5 by 7 array such as shown in FIG. 4 can be printed out in a time interval equal to 14*t*.

Suppose now that the character pattern E is composed of dots as illustrated in FIG. 4. It will be evident by reference to the time chart of FIG. 6 that if electric signals are applied through terminals to element P1 at times 8*t*, 9*t*, 10*t*, 11*t*, 12*t*, 13*t*, and 14*t*, to element P2 at 6*t*, 9*t*, 12*t*, to element P3 at 4*t*, 7*t*, and 10*t*, to element P4 at 2*t*, 5*t*, and 8*t*, to element P5 at 0*t*, 3*t*, and 6*t*, the shaded dots will be printed after a time elapse of 15*t*, thereby producing the letter E. It will also be evident that any other letter can be produced in the same manner.

It should be noted that the individual dot printing elements P1 . . . P5 are preferably slightly overlapped in the horizontal dimension, so that the characters formed therefrom are solid in the horizontal dimension. Solidarity of characters in the vertical dimension is achieved by timing the energization of the dot printing elements so that the individual dots overlap in the vertical dimension. This can be done quite simply by energizing the individual dots long enough to allow the recording medium to move slightly during the energized period. It should also be noted that the dot printing elements could be separated vertically by any integral multiple of the vertical dimension of the dot printing elements.

FIG. 7 shows a schematic block diagram of the control equipment for energizing the dot-printing elements of this invention. The memory unit 20 may be any suitable unit which provides information for characters to be printed on a recording medium in the form of codes. For example, the memory unit might be a magnetic core unit, magnetic drum equipment, or an assembly of transistorized logic circuits. The codes indicating the types of characters (0, 1 . . . 9; A, B . . . Z; +−, @ . . . etc.) to be printed per line are read out of memory unit 20 in succession in a prescribed sequence and in synchronism with the feed speed of the recording medium. These codes are sent out to a decoder 21 to be decoded according to character types, with the result that the signals indicating the character types are sent out to a character pattern generator 22 from wire l_1, l_2 . . . which correspond to the character types.

The character pattern generator transmits signals to a gating circuit 23 via conductors m_1, m_2, m_3 . . . m_{25}, which correspond respectively to dots *a*–1, *a*–2, *a*–3 . . . *g*–5 in FIG. 5.

A counter 24 performs an "add one count" operation in synchronism with the feed speed of the recording medium, the numerical value of the other add one counter 25 being increased by one every time the number of characters per line is counted by the counter 24. Simultaneously the numerical value of the counter 24 is reset to zero state. Therefore, by selecting the feed speed of the recording medium so that said medium moves by an amount corresponding to one dot during the time when the numerical value of the counter 25 increases by one, the time corresponds exactly to *t*. It is possible, therefore, to select the five signals to print the dots of corresponding columns 1, 2, 3, 4 and 5, in FIG. 5 in the gating circuit 23 from signals delivered over wires m_1, m_2 . . . m_{35} so as to meet the relation indicated in FIG. 6 by use of the signals from wires 0*t*, 1*t* . . . 14*t* corresponding to the counted value of the counter 25. The selected signals are suitably amplified by amplifier 26 and applied to terminals 11, 12, . . . 15, in FIG. 1, respectively. At the same time, the information indicating the numerical value of the counter 24 is sent out to a decoder 27 to be decoded into signals indicating printing positions of characters per line and these signals are applied respectively

to the rear electrodes A1 . . . A*n*, in FIG. 2 through an amplifier 28.

Consequently it is possible to print all the dots *a*–5 of each character per line at time 0*t* by use of the codes which are read out in succession from the memory unit 20. Upon completion of printing of the dots *a*–5, the content of the counter 25 is converted from 0*t* to 1*t*. Then by use of the same codes read out from the memory unit 20, dots *b*–5 can be printed. In the same manner, all of the dots *a*–4 and *c*–5 can be printed simultaneously when the numerical value of the counter 25 becomes 3*t*, and so on. Thus the printing of a complete character for one line can be accomplished. Causing the memory unit 20 to memorize the content of the next line and the counter 25 to reset to 0*t* enables the characters in the next line to be printed. If the printing of the next line is performed immediately in this case, the line advance spacing corresponds to an interval of 8 dots. The line advance spacing can be freely adjusted as long as the printing of the next line starts at a position in which the recording medium has progressed an integral number of dots.

It is possible to perform formatting if a format control patching board 29 is inserted between the decoder 27 and the amplifier 28, for example. FIG. 8 shows an example of the character pattern generator 22, in which the pulse transformers T_1, T_2 . . . T_{35} correspond to dots *a*–1, *a*–2 . . . *g*–5 in FIG. 5. By coupling signal wires l_1, l_2, l_3, . . . as primary windings, selected ones of pulse transformer T_1, and energizing one of the wires l_1, l_2 . . . , and l_n, T_2 . . . T_{35}, respectively, signals indicating the character pattern corresponding to the energized wire emerge from secondary windings m_1 m_2 . . . m_{35} of this character pattern generator.

Although a description has been made above in connection with a specific embodiment of this invention, it will be understood that the description is made simply by way of example and not as a limitation to the scope of the invention. For example, the character pattern could be split into a number of dots other than 35, the dot printing elements could be mounted differently than illustrated herein (for example, in the manner shown in FIG. 9, for which the exact time sequence will become as illustrated in FIG. 10, as will be understood from the former embodiment), and several characters could be printed in parallel or all characters per line at a time by using a plurality of rear electrodes or a single rear electrode instead of using the rear electrodes provided for individual characters as illustrated in the disclosure. Although electrostatic, discharge recording, and electrolytic methods have been proposed for the recording, it would be possible to adopt any other recording method such as, for example, a mechanical, optical, electromagnetic, or radioactive emission method. These and many other modifications will be apparent to those skilled in the art, and this invention includes all modifications falling with the scope of the following claims.

I claim:

1. An arrangement for electrically printing characters comprising

a printing head,

said printing head including a plurality of conductive comb-like members disposed generally parallel to one another and separated from one another by means of layers of insulation whereby a sandwich-like structure is formed,

the projections of said comb-like members each comprising a conductive dot printing element,

adjacent dot printing elements on each comb-like member being distantly spaced from one another compared with the dimensions of transverse cross sections of said elements,

corresponding dot printing elements on adjacent comb-like members being offset with respect to one another

so that the corresponding elements form a step-like series,

and a recording medium positioned closely adjacent the ends of said dot printing elements and adapted for movement in a direction transverse to said elements.

2. The combination defined in claim 1 which further includes electrode means positioned on the opposite side of said recording medium from each of said series of dot printing elements to produce characters on said medium when an electric potential is applied between any of said electrode means and a cooperating dot printing element.

3. The combination defined in claim 2, wherein the center to center distance of said dot-printing elements is equal to an integral multiple of the distance between adjacent rows of dots to be printed in the direction of movement of said recording medium.

4. The combination defined in claim 3 and also including means for selectively energizing said dot-printing elements in time sequence to print predetermined characters on said recording medium.

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LEO SMILOW, *Primary Examiner.*