HIGH SPEED PRINT HAMMER AND BAR MAGNET MEANS

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Fig. 1

Fig. 2

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Fig. 4

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This invention relates generally to electrically controlled high-speed printing apparatus and more particularly to an improved electromagnetically operated hammer assembly for use in such apparatus.

High-speed printing devices utilizing rotating printing drums are well known in the prior art. Typically, such drums have alphabetic and/or numeric printing characters on the surface thereof arranged in columnar fashion. More particularly, the drum is provided with a plurality of circumferential tracks equal to the maximum number of characters to be printed on any one line and each such track includes one full set of characters which the particular printing device is adapted to print.

In such printing devices, a hammer assembly is associated with each circumferential track and includes a hammer or impact device which can be caused to strike a selected character during the rotation of the drum in response to appropriate control signals. An inked ribbon and a paper strip upon which data is to be printed are usually positioned between the drum and the hammers. Each hammer, when actuated, thus strikes the back of the printing paper strip thereby forcing the paper strip against the ribbon, and the ribbon in turn against the character on the drum to consequently print the selected character on the front of the paper strip.

Typical prior art hammer assemblies consist of a movable impact device which is associated with a solenoid such that upon energization of the solenoid coil, a solenoid armature is driven against the impact device to therewith propel it against the paper. In attempting to significantly increase the speed of printing devices, problems arise involving the coupling between the solenoid armature and the impact device and in efforts to solve these problems, improved hammer assemblies have been introduced, as for example disclosed in U.S. Patent Number 3,087,421. The hammer assembly disclosed in the cited patent avoids coupling problems by mounting a magnetic coil directly on the impact device and associating the coil with a permanent magnetic field such that energization of the coil develops a magnetic field which interacts with the permanent magnetic field to propel the impact device against the paper strip.

A still further improvement in hammer assemblies is disclosed in U.S. Patent No. 3,172,352 for a "Solemn Hammer Assembly" by Clifford J. Helms, which also utilizes the concept of mounting a coil on an impact device but which, in addition, introduces improved means for supporting the impact device. Inasmuch as it is desired that the printed characters be spaced by a certain small distance, it is of course essential that the impact devices be correspondingly spaced. Because of the physical size of each hammer assembly including the impact device, its supporting means, and the permanent magnets associated therewith, it has been impossible to space the impact devices sufficiently close to a single tier. Consequently, it has been the practice to stagger the tiers with all of the impact devices projecting forward to the same fine relative to the printing drum. As a result, it has been exceedingly difficult to reduce the physical size of the impact devices and since the contact time of each impact device against the printing surface is related to its size (mass), this has represented a limiting factor on the overall operating speed of the printing apparatus.

The improved support means disclosed in the aforementioned patent application permits the impact devices in each tier to be more closely packed than in prior arrangements thus permitting a reduction in the number of tiers required and a consequent reduction in the size of each impact device.

Although the improvements introduced by U.S. Patent No. 3,172,352 represent a significant advance over the state of the art, a continuing effort has been made to still further reduce the size of the impact devices to enable the printing apparatus to be operated even more rapidly. It is thus an object of the present invention to provide an exceedingly fast printing apparatus.

It is a more particular object of the present invention to provide an improved electromagnetically operated hammer assembly in which the impact devices thereof can be operated more rapidly than in prior art hammer assemblies.

Briefly, in accordance with the present invention, an improved permanent magnet arrangement is disclosed for providing a magnetic field for interacting with the magnetic field generated by the impact device coils. More particularly, in lieu of providing a pair of opposed permanent magnets for each impact device as disclosed in the aforesaid patent No. 3,172,352, a plurality of serially arranged permanent magnets are provided which form a single closed magnetic loop around all of the impact device coils. Aligned pairs of slots are defined in opposed sides of the single loop, each slot pair adapted to accommodate a single impact device coil. By developing a permanent magnetic field in this manner, slots for accommodating the impact device coils can be defined much more closely than has heretofore been possible thus reducing the number of impact device tiers required. Consequently, the impact devices need not be as long or massive and thus they can be operated more rapidly. By reducing the size of the impact device, the efficiency of the apparatus is of course also increased inasmuch as less power is required to print each character.

It is a still further object of the present invention to provide a method of efficiently and inexpensively fabricating the permanent magnet arrangement of the present invention.

The novel features that are considered characteristic of this invention are set forth with particularity in the appended claims. The invention itself both as to its organization and method of operation, as well as additional objects and advantages thereof, will best be understood from the following description when read in connection with the accompanying drawings, in which:

FIGURE 1 is a side sectional view, partially broken away, of a printing apparatus constructed in accordance with the present invention;

FIGURE 2 is a diagrammatic horizontal sectional view taken substantially along the plane 2-2 of FIGURE 1 illustrating the orientation of the impact devices and the arrangement of the permanent magnets;

FIGURE 3 is a vertical sectional view taken substantially along the plane 3-3 of FIGURE 1; and

FIGURES 4(a)–(f) comprise a series of illustrations showing a preferred method of fabricating a permanent magnet arrangement useful in the apparatus of FIGURE 1.

Attention is now called to FIGURE 1 which illustrates a printing apparatus in accordance with the present invention. The apparatus includes a printing surface preferably in the form of a rotatable drum 10 having a plurality of circumferential tracks thereon, each track including each of the characters to be printed by the apparatus. The drum 10 is positioned so as to rotate past an inked ribbon 12. A strip of paper 14 upon which char-
acters are to be printed is positioned on the other side of the ribbon 12 such that when the paper strip is urged into engagement with the ribbon and against a character on the surface of the printing drum 10, the character will be printed upon the side of the paper adjacent the rib-
bon 12. In short, hammer assembly 16 is provided for each of the tracks on the printing drum. As disclosed in the aforesaid patent application, each hammer assembly 16 includes an impact device 18 supported by a pair of flat electrically conductive spring members 20. Each impact device 18 has a coil assembly 22 secured thereto. Although it is not essential to the operation of the hammer assemblies, the coil assemblies preferably extend above and below the impact device for balancing the forces applied thereto. Each coil assembly 22 includes a coiled electrical conductor whose terminals are respectively connected to the support members 20. Each of the support members 20 has a sleeve 24 secured thereto in which sleeves are adapted to be received in a V-shaped positioning receptacle 26 defined on the edge of base plates 28 and 29. Since it is usually desired to print characters spaced by about 0.1 inch, the impact devices must be spaced by this same distance. In order to permit this, two groups of interleaved hammer assemblies are provided with the support members 20 of the first group depending from the base plate 29 and the support members of the second group projecting upwardly from the base plate 28.

In order to propel the impact device 18 against the paper strip 14, current can be applied to the conductive support members 20 to thus drive current through the conductor of the coil assembly 22 to thereby develop a magnetic field extending substantially perpendicularly to the plane of the impact device. The magnetic field provided by the coil assembly 22 interacts with the magnetic field provided by a permanent magnet assembly to thus propel the impact device 18 against the paper 14. Four magnet assemblies are provided. Two of the magnet assemblies 30, 32 are secured to base plate 29 and respectively provide magnetic fields interacting with the upper portions of the coil assemblies in the first and second groups of hammer assemblies. Magnet assemblies 36 and 38 are supported on base plate 28 and provide fields interacting with the lower portions of the coil assemblies. Essentially, the magnet assemblies provide a field extending in a first direction forward of each coil assembly and a field extending in a second direction to the rear of such coil assembly. When the impact device is to be propelled, its coil is energized to develop a field which tends to align itself with the field extending in the first direction.

Attention is now called to FIGURE 2 which illustrates two of the magnet assemblies each of which can be seen to be comprised of a series of small permanent bar magnets 40 laid end to end on a base 42. More particularly, each of the magnet assemblies is comprised of first and second rows 44 and 46 of small bar magnets 40. The magnets 40 of row 44 are all poled similarly and positioned so as to define slots 48 therebetween. The magnets 40 of row 46 are also poled similarly but opposite to the poled orientation of row 44. The magnets 40 of row 46 define slots 48 which are in alignment with the slots defined in row 44. A magnetic bridging bar 50 couples the last magnet 40 in row 44 to the first magnet 40 in row 46 and similarly a bridging bar (not shown) provides a magnetic path between the last magnet 40 of row 46 and the first magnet 40 of row 44. Thus, each of the magnet assemblies defines a single closed magnetic loop including a plurality of aligned slots.

The coil assembly 22 of a different hammer assembly is adapted to be received in each pair of aligned slots defined in each of the magnet assemblies. Thus, starting from the leftmost hammer assembly 16 in FIGURE 3, it can be noted that the coil of the first hammer assembly projects into the first slots defined in magnet assemblies 30 and 36. The coil of the second hammer assembly projects into slots defined in magnet assemblies 32 and 38. The coil of the third hammer assembly projects into slots defined in the magnet assemblies 30 and 36 and so forth. This interleaving of hammer assemblies from each of the two groups is continued for the full stack of hammer assemblies. Thus, if the slots defined in each of the magnet assemblies are spaced by 0.2 inch, the impact devices are actually spaced by 0.1 inch. Of course, the spacing of the characters to be printed corresponds to the spacing of the impact devices. The magnet assemblies illustrated in FIGURES 1 through 3 can be formed by merely providing a base plate 42 and adhering a series of permanent bar magnets 40 thereto with some adhesive such as epoxy. Although a structure so formed could adequately function as contemplated, the positioning of so many small bar magnets as precisely as necessary would be very costly. Consequently, a method of efficiently and inexpensively fabricating a hammer assembly of the type illustrated in FIGURES 1 through 3 such that the desired precision can be gained by machining rather than by positioning small parts, is illustrated in FIGURE 4.

The magnet assemblies of FIGURES 1 through 3 can be fabricated by initially providing a T-shaped bar 60 having a length equal to that of the entire hammer assembly stack. The bar 60 is preferably formed of a nonmagnetic material such as aluminum. A pair of long bars 62 and 64 formed of permanent magnetic material can then be bonded to the shoulders 66 and 68 respectively of the bar 60. In addition, a pair of bridging bars 70 and 72 of magnetic material are adhered between the ends of the bars 62 and 64. Subsequently, a vertical hole is formed, as by drilling, through the center of the T-shaped bar at each position where a slot is desired. As previously noted, the spacing between magnet assemblies will be on the order of 0.2 inch. If the slot width is about 0.04 inch, a total of 0.16 inch of permanent magnetic material will exist around the slot. Using Alnico VIII, these dimensions permit a field strength on the order of 4500 gauss to be established in the slot. After the holes 74 are formed, the slots can be formed by grinding, milling, or sawing through the center line of each hole 74 along a line extending perpendicular to the block 60.

After the structure of FIGURE 4(e) has been thus fabricated, a pair of windings can be threaded through each of the holes 74. By driving a current through the windings 80 in the direction indicated by the arrows in FIGURE 4(f), the segments of the bars 62 and 64 will be magnetized in the direction shown in FIGURE 4(e). Thus, by following the method steps suggested in FIG-
URE 4, a magnet assembly of the type useful in the printing apparatus of FIGURE 1 can be easily and inexpensively fabricated.

From the foregoing, it should be appreciated that an improved permanent magnet assembly has been disclosed herein for use in hammer assemblies in high speed printing apparatus. More particularly, by providing a magnet arrangement comprised of a series of bar magnets forming a single closed magnetic loop, a number of alternate slots can be defined more closely than in prior art assemblies where a closed magnetic loop was formed around each coil assembly; as shown, for example, in the aforesaid Patent No. 3,172,352. As previously pointed out, by enabling the slots in each magnet assembly to be positioned more closely, more complete coverage of the paper can be reduced enabling the length (and mass) of the impact devices to be reduced to thus permit a consequent reduction in travel and impact time of the impact device. A still further advantage is attained by reducing the required number of hammer assembly tiers to two and that is that only one type of impact device is re-
quired. More particularly, it should be appreciated that all of the impact devices of FIGURE 1 are identical with the slots suspended from base plate 29 having their coil as-
sembly toward the rear and those mounted on base plate 28 being reversed and having their coil assembly toward the front. Where more than two tiers are used, as shown in the aforesaid Patent No. 3,172,352, different types of impact devices, i.e. impact devices having their coil assemblies at different positions must be provided.

In addition to the fabrication advantages mentioned, the assembly of FIGURE 4 has excellent heat dissipation characteristics inasmuch as the thermal resistance from the coil to the magnets and vertical portion of bar 60 is lower than in prior arrangements because a greater area of material exists immediately adjacent the slots. Since the magnets are fit flush on two surfaces against the bar 60, the thermal resistance therebetween is low thereby providing a large metal block exposed to the 15 ambient air. The holes 74 further enhance heat dissipation.

What is claimed is:
1. In a high speed printing apparatus including a plurality of impact devices, each device having means thereon for selectively generating a magnetic field, an assembly for providing a permanent magnetic field adapted to interact with said selectively generated magnetic field, said assembly comprising a base formed of a nonmagnetic material and having an inverted T-shaped cross-section defining an upwardly extending central bar and first and second shoulders extending substantially perpendicularly therefrom;

a plurality of equally spaced slots defined in said central bar extending substantially perpendicularly thereto;

a plurality of permanent bar magnets each having first and second substantially perpendicular surfaces;

means securing said bar magnets to said base in physical alignment and in series magnetically to define a magnetic field extending in a second direction to the rear of said coils; and first and second bridging bars respectively magnetically coupling the end magnet of said first group to the adjacent end magnet of said second group and the end magnet of said second group to the adjacent end magnet of said first group.

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