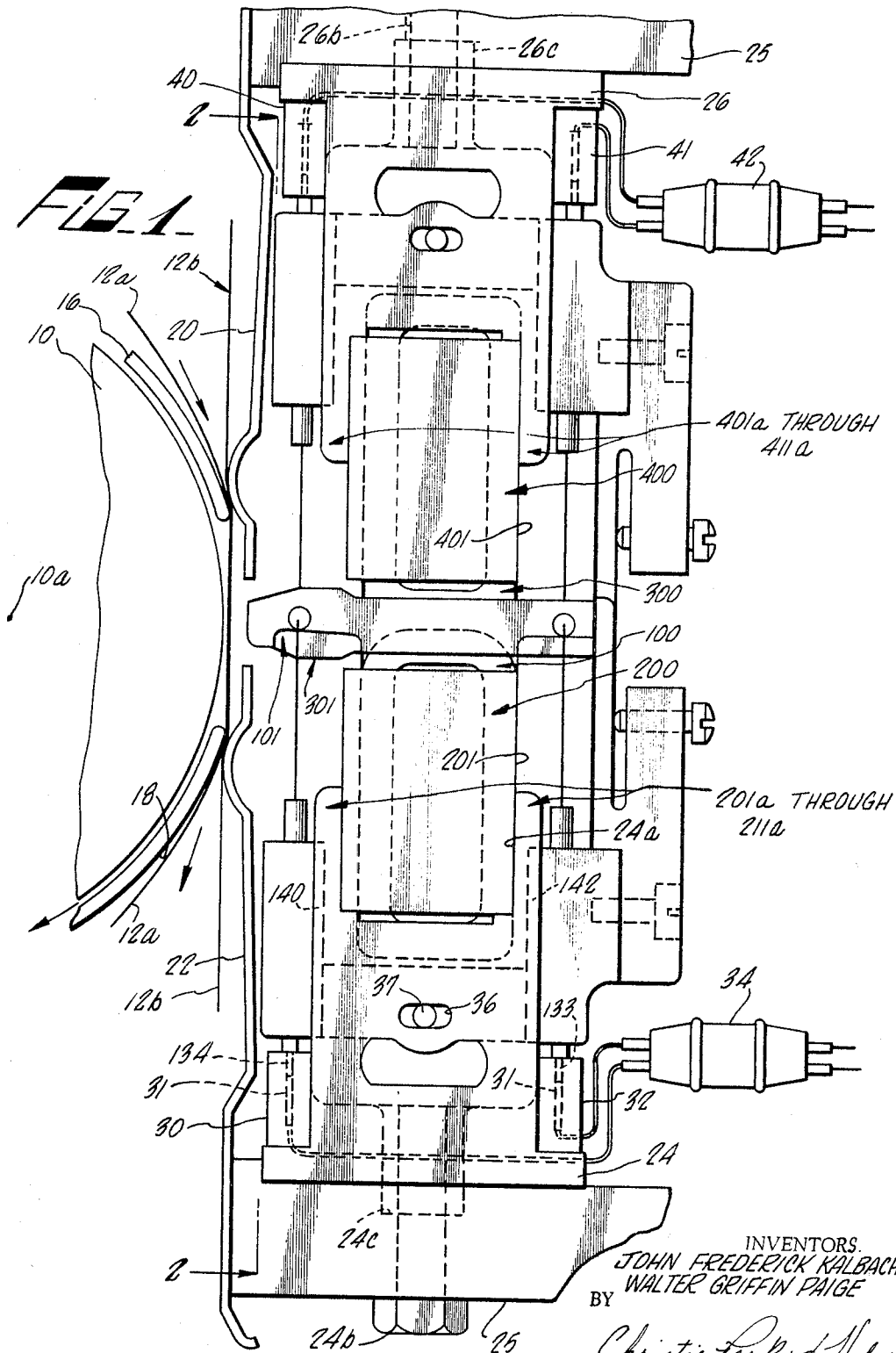


Filed April 16, 1964

3,282,203

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Nov. 1, 1966

J. F. KALBACH ET AL
MAGNETICALLY OPERATED PRINT HAMMERS
IN HIGH SPEED PRINTERS

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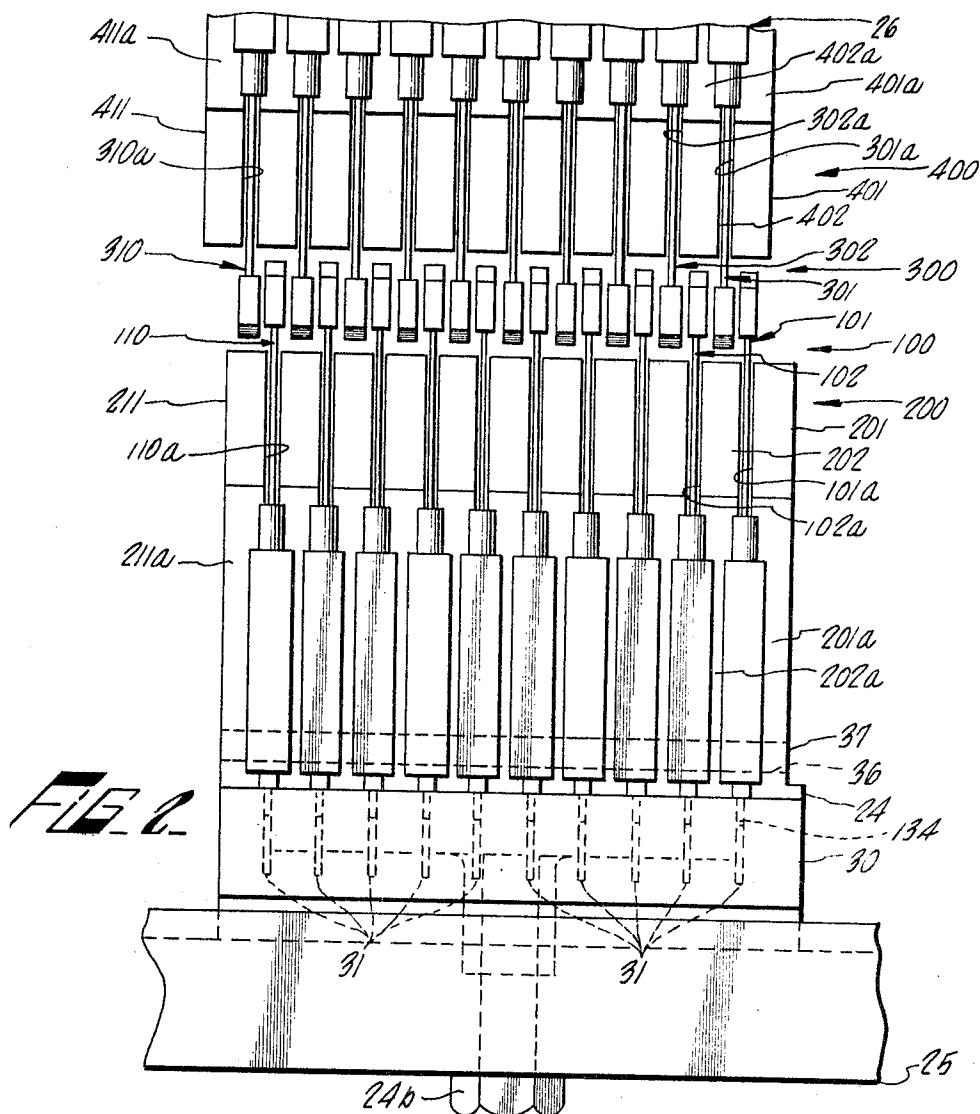


FIG. 2

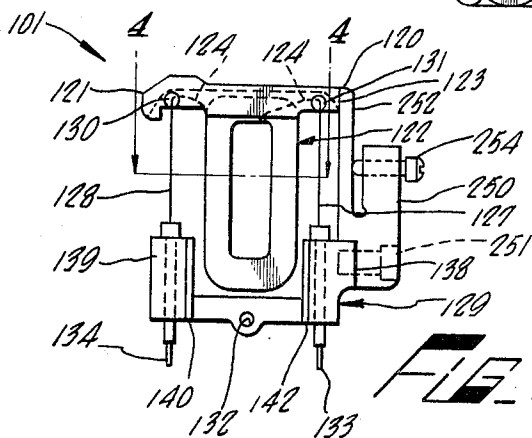


FIG. 3

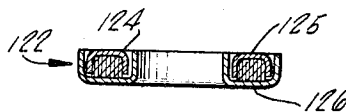


FIG. 4

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PRIOR ART

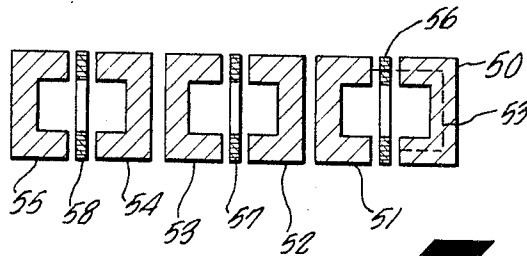


FIG. 8.

FIG. 10.

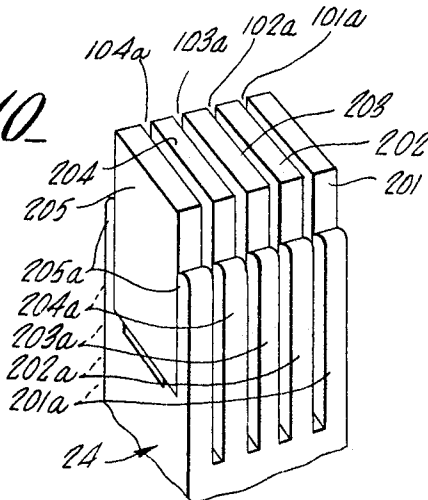


FIG. 9.

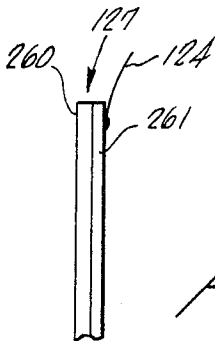


FIG. 6.

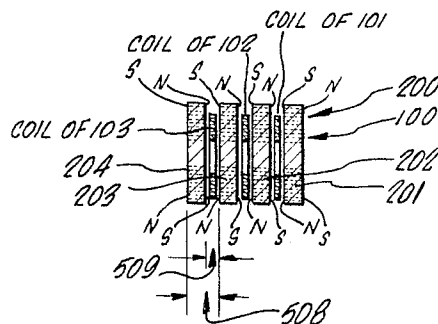


FIG. 1.

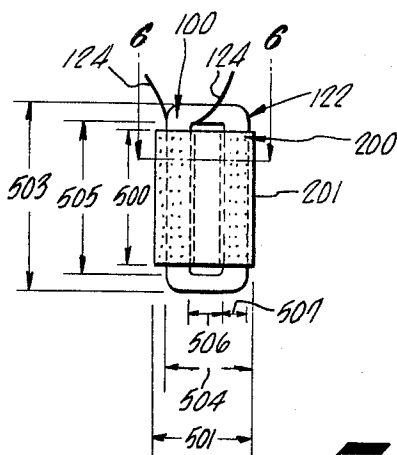
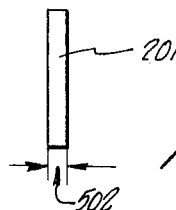


FIG. 5.

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MAGNETICALLY OPERATED PRINT HAMMERS IN HIGH SPEED PRINTERS

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15 Claims. (Cl. 101-93)

This invention relates to printing machines and more particularly to an improvement in magnetically operated printing devices for use in high speed printing machines.

High speed printers are well known which use back printing to impart a type character or mark on paper. A printer which back prints is one wherein a moving hammer strikes the paper being printed and forces it against a type character carried on a revolving drum or the like. The type character may have ink thereon or carbon paper may be placed, for example, between the paper and the drum for making the actual mark on paper.

There are a number of different devices for actually forcing the hammer against the type character. For example, in a first prior art printer, a solenoid is used to actuate print hammers, through a series of mechanical linkages, against a rotating drum. Such an arrangement suffers from the serious disadvantage that it is slow due to the mass of linkages which must be moved and due to the inherent play in connections between linkages. Additionally, this first prior art printer is quite large due to the fact that the solenoids must be staggered in a plane normal to the line of print at different positions in the machine in order to allow enough clearance to mount the solenoids and to allow clearance for operation of the solenoids and the connected linkages. Further, the printer is quite heavy due to the fact that relatively large and heavy solenoids are required to move the linkages and the hammers and due to the weight of the many linkages required.

Other staggering arrangements of the solenoids have been devised. For example, solenoids have also been staggered above, below and radially from the line of print.

An improved prior art printer over the first prior art printer is one wherein a plurality of printing hammers are positioned adjacent a rotating drum, each of the printing hammers comprising an elongated shank having an electrically energizable current carrying coil connected intermediate the ends of the shank. An array of U shaped magnets are provided to cause printing hammers, having excited coils, to be moved towards the type drum for printing. The magnets are made of a magnetic material commonly referred to as ALNICO V. A separate pair of U shaped magnets is required for each current carrying coil and the array of magnets are staggered in depth, normal to the surface of the drum. For example, there may be as many as six rows of staggered magnets.

The improved prior art printer has many desirable features over the first prior art printer. For example, the weight and size of the printing machine is reduced due to the elimination of the heavy solenoids and linkages. However, the improved prior art printers suffers from the disadvantage that the magnets must be staggered in depth in order to allow the printing hammers to be positioned close enough together for printing a complete line of print. The reason that staggering is required is that normally it is desired to print ten characters per inch in a line of print. Thus, a printing hammer spacing of .1 inch spacing on center is required. A printing hammer spacing of .1 inch on center cannot be achieved with U shaped magnets without staggering the magnetic elements. One disadvantage of having a staggered array is that the printing hammers must be long enough to ac-

commodate a coil for each row of magnets in the staggered array, thereby greatly increasing the lengths of the hammers and thereby increasing the dwell time of the hammer during an impact with the drum. The speed of operation of the printer is dependent in large upon the dwell time of the hammers, and the speed decreases as dwell time increases.

The present invention greatly improves the operation of the improved prior art high speed printing apparatus. For example, one embodiment of the present invention is capable of operating at a speed of 3000 lines per minute, whereas the improved prior art printer is only capable of printing at a speed of 300 lines per minute. Accordingly, this embodiment of the present invention affords an increase in speed by a factor of approximately 10. In addition, the weight and overall size of the aforementioned embodiment of the present invention is markedly reduced as compared with the improved prior art printer. Further, both the cost and complexity of the aforementioned embodiment of the present invention are reduced in comparison with the improved prior art printer. Also, the present invention eliminates the need for a separate pair of magnets per coil.

A very significant improvement in an embodiment of the present invention is that the need for staggering of the solenoids or actuating devices is eliminated. The actuating devices or means are arranged in a straight line parallel with the axis of the print drum.

Briefly, a specific embodiment of the present invention comprises, a rotatable type drum and a plurality of hammer assemblies. Each hammer assembly comprises an elongated member having a hammer tip at one end thereof and a substantially flat coil mechanically connected intermediate the ends of the elongated member with the axis of the coil perpendicular to the member, also provided are means for supporting the elongated members and the connected coils with the coils spaced a short prefixed distance apart and in a substantially straight row parallel with the axis of the drum, the mounting means is adapted to allow the hammer assemblies to move the hammers thereof into a printing position with respect to the drum. A parallelepiped shaped ceramic magnet having a thin dimension positioned in between each adjacent pair of coils is also provided. The magnets are magnetized through the thin dimension in a direction parallel with the axes of said coils such that a magnetic interaction is caused which forces a coil to move, in the corresponding gap, so that the connected hammer tip is forced into a printing position with respect to the drum, in response to current applied in the particular coil.

Stated another way, an embodiment of the present invention comprises, a plurality of permanent magnets positioned in a substantially straight row. Each of the magnets has a pair of parallel surfaces separated by a thin dimension which face the adjacent magnet, at both sides, to define slot-shaped gaps therebetween. A hammer assembly is provided for each gap comprising a hammer tool and a substantially flat coil mechanically connected to the hammer tool. Means is provided which is adapted for supporting the hammer assemblies with the axes of the coils thereof in a substantially straight line perpendicular to the surfaces of the magnets such that the coils are free to move in the corresponding gaps toward and away from a predetermined point of impact. The magnets are magnetized through the thin dimension thereof parallel with the axes of the coils such that a north pole magnetic field is formed in one gap and a south pole magnetic field is formed in the adjacent gap. All of the magnets are magnetically poled in one direction along one side of the row of magnets and in the opposite direction along the opposite side of the row of magnets. The coils are

positioned in relation to the poles of the magnets such that a force is caused between a coil and the corresponding magnets, responsive to current applied in the coil, for forcing the connected hammer tool into such point of impact.

These and other aspects of the present invention may be more fully understood with reference to the following description of the figures of which:

FIG. 1 is an enlarged side elevation view of a printer, with a portion of the housing and drum broken away, and embodying the present invention;

FIG. 2 is an enlarged cross-sectional view of the printer shown in FIG. 1 and is taken along the lines 2—2 of FIG. 1;

FIG. 3 is a side elevation view of the printing hammer assembly shown in the printer of FIGS. 1 and 2;

FIG. 4 is a cross-sectional view of the coil of the hammer assembly shown in FIG. 3 and taken along the lines 4—4 of FIG. 3;

FIG. 5 is a side elevation view of the lower row of coils and lower row of magnets in FIG. 1, with the rest of the printer broken away in order to illustrate the relationship between the coils of the hammer assemblies and the magnets which are used in printer of FIGS. 1 and 2. FIG. 5 also illustrates the active magnetic area of the magnets by dots;

FIG. 6 is a cross-sectional view of the first four magnets in the lower row and the corresponding three coils taken along the lines 6—6 of FIGS. 5. FIG. 6 also illustrates the active magnetic area of the magnets, by dashed lines, and shows the north and south poles of the magnets using the abbreviations N and S;

FIG. 7 is a side view of one of the magnets shown in FIG. 5;

FIG. 8 is a sketch of a portion of the improved prior art printing device showing a top elevational view of three coils positioned in between the poles of three pairs of "U" shaped magnets, and shown with the elongated hammer shank removed. FIG. 8 is a cross sectional view of the coils and magnets of the improved prior art printing device taken similar to the view of the present invention in FIG. 6; and

FIG. 9 is a side elevational view showing the edge of a portion of one of the flat spring supports for the hammer assemblies, shown in FIG. 1.

FIG. 10 is a pictorial view of five of the magnets shown in FIG. 1 along with a portion of the module base 24 illustrating the manner in which each is securely fastened in between a pair of rigid and parallel members and thereby held parallel to each other.

Refer now to the enlarged view of the printer shown in FIGS. 1 and 2 and embodying the present invention. FIG. 1 shows a rotatable type drum 10 having a plurality of rings of type (not shown) around the periphery thereof. The type in the rings are aligned in rows so that like characters (i.e. all A's), for a single line of print, may be typed out at the same time in parallel. The drum has an axis, illustrated by a dot 10a in FIG. 1, extending perpendicular to the surface of the paper in FIG. 1. The dot 10a is not shown at the true center of the drum 10 but is shown as positioned in FIG. 1 for illustration purposes. The type drum 10 is rotated by a suitable driving motor (not shown) in a manner well known in the printer art. The drum 10 is typically rotated at a speed of from 300 to 1500 r.p.m.

Although a type drum is shown as the type bearing means, by way of example, it should be understood that the present invention is equally applicable to other type bearing means, such as a type bearing chain, a moving type box, or other devices having type thereon. It should also be understood that the type bearing means could be moved on demand, rather than continuously.

A lower row of print hammer assemblies 100 and an upper row of print hammer assemblies 300 are shown for striking a sheet of paper 12b which is positioned in

between hammer tips of the rows of hammer assemblies 100 and 300 and the type drum 10. A web of carbon paper 12a is placed next to the paper 12b so that when a hammer strikes the paper 12b a type character, on the type drum 10, is back typed on the paper 12b. The web could also be composed of an ink ribbon within the scope of the present invention.

Two arcuately shaped ribbon shields 16 and 18 are used in conjunction with a second set of ribbon shields 20 and 22 for guiding the paper in between the row of hammer assemblies 100 and 300 and the type drum 10. Ribbon shields 16, 18, 20 and 22 are connected by means (not shown) to the printer frame 25 and are used in a conventional manner well known in the printer art for guiding the paper and carbon paper.

The paper 12b and carbon paper 12a may be moved continuously or intermittently, by means (not shown) which is well known in the printer art.

Magnetic means is provided for cooperating with the hammer assemblies in rows 100 and 300 for causing printing operations to take place. The magnetic means for row 100 include a plurality of solid parallelepiped shaped magnets positioned in a substantially straight row 200 parallel with the axis 10a of the type drum 10. An upper row of solid parallelepiped shaped magnets are similarly positioned in a straight row 400 parallel with the axis of the drum 10 for actuating the row of hammers 300.

Eleven magnets are shown in the lower row 200. Moving from right to left in FIG. 2 the magnets are referenced by the symbols 201 through 211 (only the first two magnets 201 and 202 and the last magnet 211 in the row are shown with reference numbers in FIG. 2). Each of the magnets has a pair of parallel and substantially flat surfaces arranged with respect to the adjacent magnet, at both sides, to define slot-shaped gaps therebetween. Moving from right to left in FIG. 2, the slot-shaped gaps are referenced by the symbols 101a through 110a, which bear numbers corresponding to numbers of corresponding hammer assemblies positioned thereat with the letter a following the numbers to designate the reference to the gap as opposed to the hammer assembly (only the first two and the last magnet in the row are shown with reference numbers in FIG. 2).

The row of magnets 200 is anchored in the printer by means of a module base 24 and the frame 25. The module base 24 is attached to the frame 25 by means of a bolt 24b which is threaded into a riser member 24c, a part of the module base 24. The riser 24c fits into a recess formed in the frame 25.

With reference to FIG. 10, which shows a pictorial view of the magnets fastened into the module base 24, it will be seen that there is a pair of parallel support arms 205a upstanding at either side of the magnet 205. The parallel support arms 205a are dimensioned and positioned so that the gaps at either side remain unobstructed. There is an identical pair of rigid and parallel support arms 201a through 204a and 206a through 211a for each of the magnets 201 through 204 and 206 through 211. Only one arm of the pair of arms 201a through 204a is shown in FIG. 10. Also, only magnets 201 through 205 are shown in FIG. 10. Each of the magnets 201 through 211 is securely cemented by means of an epoxy cement (not shown) in between the corresponding pair of support arms.

It is well known that magnets exert forces when positioned in close proximity to each other. A feature of the present invention is that the forces on each of the magnets in each row starting with the second magnet from each end and moving towards the center have equal and opposite forces acting thereon, due to the polarity of the adjacent magnets. However, the magnets at the ends of the rows have unequal magnetic forces acting thereon and the forces are quite significant. The magnetic forces pull and tend to move the end magnets toward the adjacent magnet. Therefore, it is necessary to provide a structure

which rigidly holds the end magnets in position. To this end the support arms are rigidly formed as a part of the base structure 24 so as to hold the magnets in place parallel to each other.

The row of hammer assemblies 100 include ten hammer assemblies which, moving from left to right in FIG. 2, are referenced by symbols 101 through 110 (only the first two hammer assemblies 101 and 102 and the last hammer assembly 110 bear reference symbols in FIG. 2). Thus, one hammer assembly is provided for each of the gaps 101a through 110a. Each hammer assembly comprises an elongated member having a hammer tip at one end, a substantially flat coil mechanically connected intermediate the ends of the member with the axis of the coil perpendicular to the elongation of the member and means for supporting each hammer assembly such that the coil is free to move in the corresponding gap toward and away from the surface of the drum.

Refer now to FIGS. 3 and 4 which show a side elevation view of the hammer assembly 101 and a cross-sectional view of the coil. The elongated member is shown generally at 120 with a hammer tip at the end 121. A coil 124 and protective shields 125 and 126 are shown generally at 122 and are mechanically connected intermediate the ends 121 and 123 of the elongated member 120.

The coil 124 is generally rectangular shaped, and is made out of a flattened ribbon-like wire which is coated with a nonconductive coating to prevent shorting between turns. All the windings lie in a single plane parallel with the elongation of the elongated member 120. Thus, the coil is flat and its axis is perpendicular to the elongation of the elongated member 120. The protective shields 126 and 125 surround the coil 124 and provide a rigid support for the coil 124 for the purpose described.

The elongated member 120 has a slit running down the length thereof into which the assembly 122 is inserted. The assembly 122 is secured in the slit of the elongated member 120 by means of an epoxy cement (not shown).

The supporting means for the hammer assembly 101 includes a pair of flat springs 127 and 128. The springs 127 and 128 are mechanically connected, parallel to each other, between a point adjacent to the ends 121 and 123 of the elongated member 120 and a hammer assembly base structure 129. The springs 127 and 128 extend into circular perforations 130 and 131 which are formed in the elongated member 120. Epoxy is molded into the circular perforations 130 and 131 so as to securely attach the springs to the elongated member 120. The opposite ends of the springs 127 and 128 are embedded in the base structure 129 which is molded out of a suitable rigid plastic or other nonconductive material.

The springs 127 and 128 not only support the elongated member 120 but in addition provide an electrical current path to and away from the coil 124. To this end, the springs are preferably made out of flat strips of fiber glass with a layer of copper coated thereon. An enlarged side elevation view of the upper end of the spring 127 is shown in FIG. 9, showing the fiber glass 260, and the copper conductor 261 deposited on the fiber glass 260. Also shown is the conductor 124 welded to the copper conductor 261. The layer of copper provides an electrical current carrying path between the ends of the spring. The fiber glass withstands compression and tension forces when the hammer assembly is actuated into and out of a printing position and, in addition, provides a spring return which normally tends to retract the hammer assembly to the position shown in FIG. 3. The ends of the coil 124 are shown connected to the ends of the springs 127 and 128 by the dashed lines in FIG. 3.

The springs 127 and 128 are electrically connected to pins 133 and 134 by means of electrical conductors shown in dashed lines. With reference to FIGS. 1 and 2 it will be seen that the pins 133 and 134 mate with receptacles 31 formed in connector blocks 30 and 32 which are po-

sitioned on either side of the row of hammer assemblies 100.

The receptacles 31 provide an electrical connection to the connector pins of each of the hammer assemblies from the electrical hammer driving circuits. The receptacles 31 in the connector blocks 30 and 32 are individually and electrically connected to a twenty-pin connector 34 to which the energizing current for the coils is applied. Although a separate connection is indicated from each of receptacles 31 to the connector 34, in one embodiment of the invention all receptacles are electrically connected together and connected to one pin of the connector 34.

Included in each of the hammer assemblies of rows 100 and 200 and attached to the shoulder of each hammer assembly is a hammer stop device. Referring to FIG. 3, the print hammer assembly 101 has a hammer stop device 250 which is attached to a shoulder 138 of the base structure 129 by means of a bolt 251. The bolt 251 is threaded into the shoulder 138. The hammer stop device 250 has an adjustable member 252 against which the backend 123 of the elongated member 120 strikes as the elongated member is returned to rest from a printing operation. The position of the adjustable member 252 with respect to the drum 10 is adjusted by setting the position of a bolt 254 which is threaded into the stop device 250.

Similar to the shoulder 138 the base structure 129 of the hammer assembly 101 has a shoulder 139. The shoulders 138 and 139 have keys 140 and 142 which slide a short distance into the groove in between the adjacent support members and thereby provide a rigid supporting structure for the hammer assembly. The keys 140 and 142 of the hammer assembly 101 are shown inserted in the gap 101a in FIG. 1 and are indicated by dashed lines.

The base structure 129 has a protrusion adjacent to which a locking hole 132 is formed. An elongated locking hole 36 (see FIGS. 1 and 2) is also provided along the length of the module base 24 and is aligned with the locking hole in hammer assembly 120 as well as a corresponding locking hole in each of the other hammer assemblies. A locking pin 37 is inserted through the elongated locking hole 36 in the module base 24 and through the locking holes of each of the hammer assemblies in row 100. In this manner each of the hammer assemblies is rigidly secured to the module base 24.

In the preferred embodiment of the present invention the elongated member and the coils of the hammer assemblies weigh about 1.2 g. The weight of the elongated member and coil is important in causing the hammer to strike the drum with an acceptable energy level. Although hammer assembly 120 has been described by way of example, each of the other hammer assemblies in the lower row 100 as well as those in the upper row 300 are identical to hammer assembly 120.

With the hammer assemblies in mind, consider specifically the novel magnetic means for operation of the hammer assemblies. The magnets in the preferred embodiment of the invention are of the type made by the Indiana Steel Company, a division of Indiana General Corporation, and identified by the name INDOX V. INDOX V is a permanent ceramic magnet made out of a highly orientated barium ferrite material. The more important characteristics of INDOX V, to the invention described herein, are a high peak energy product of approximately 3.5 million, an extremely high coercive force, low weight and a low incremental permeability. The high coercive force of INDOX V makes possible the use of a much shorter magnetic path length than is possible with previously used permanent magnets such as the type commonly referred to as ALNICO V, and yet on an equivalent weight basis INDOX V magnets have an energy product comparable with ALNICO V magnets.

Demagnetizing fields are applied to the magnets by the coils of the hammer assemblies, during energization of

the coils. The low incremental permeability characteristic of the INDOX V magnet causes it to provide a very constant magnetic field when subjected to external demagnetizing fields. One of the most outstanding characteristics of INDOX V magnets to the present invention is that the magnets are naturally most efficient with a very short magnetic path length and a large active magnetic gap area. This characteristic enables the magnets to be magnetized through the thin dimension of the magnet from one gap to the other and thereby allows one magnet, in conjunction with its two adjacent magnets, to provide a magnetic field for two adjacent coils. This feature allows the magnets to be spaced very close together. Although INDOX V magnets are described by way of example, it should be understood that other magnets having characteristics similar to those outlined hereinabove may be used within the scope of the present invention.

FIG. 5 is a side elevation view of the row of magnets 200 and the coils of the hammer assemblies in row 100 which are shown with the elongated member and supporting means removed. FIG. 6 is a cross-sectional view of the magnets and coils shown in FIG. 5 taken along the lines 6—6 but showing only the magnets 201 through 204 and the coils of the hammer assemblies 101, 102 and 103. FIG. 7 is a side elevation view of the magnet 201.

The magnets are magnetized over active areas and the fields of the magnets are parallel with the axes of the coils. This also makes the direction of magnetization normal to the parallel surfaces, in the gaps, at either side of the magnets as shown by dashed lines in FIG. 6. With reference to FIG. 6 it will be seen that a north pole magnetic field is formed in one gap and a south pole magnetic field is formed at the opposite side of a magnet in the adjacent gap. It should also be noted that all of the magnets are magnetically poled in one direction, namely, from south to north moving from right to left, along one side of the row of magnets while the magnets are poled in the opposite direction, namely, north to south moving from right to left, along the opposite side of the row of magnets. Thus, within each gap the magnetic field at one side of the row of magnets is poled in the opposite direction from the magnetic field in gap at the opposite side of the row of magnets. The active magnetic areas at each side of the magnets are slightly larger than the width of one side of a coil and are illustrated by dashed lines in FIG. 6 and the dotted areas in FIG. 5.

The coils are positioned in relation to the magnets such that one side of the coil is positioned in the active magnetic area of a gap towards one side of the row of magnets and the other side of the coil is positioned in the active magnetic area near the opposite side of the row of magnets. In this manner all the current which flows in the one direction (i.e. in an upward direction as shown in FIG. 5), is in a magnetically active area which is poled in one direction, whereas the other side of the coil in which current flows in the opposite direction (i.e. in a downward direction as shown in FIG. 5) is in the other active magnetic area of the cores in which the field is poled in the opposite direction. With this configuration, current applied in the coil of one of the hammer assemblies causes a flow of electrons through the coil which interacts with the magnetic field in the corresponding gap causing a force on the coil which moves it. The coil is forced to move in between the two adjacent magnets either toward or away from the surfaces of the drum, depending on the direction of the current in the coil. Since the elongated member is connected to the coil, the hammer tip is forced to strike the surface of the drum whenever the current in the coil is in such a direction that the magnet is forced to move in the direction of the drum.

Table I shows the dimensions of the coils and magnets of a preferred embodiment of the present invention. The dimensions shown in Table I are identified in FIGS. 5, 6 and 7.

Table I

	inch		inch
500	1.00	505	1.12
501	0.75	506	0.460
502	0.156	507	0.114
503	1.375	508	0.200
504	0.688	509	0.044

An important feature of the present invention is that the magnets and corresponding coils are all aligned in a straight row parallel with the surface of the drum. This is in contrast to the prior art wherein the magnets and coils are staggered in depth. In order to make the spacing between hammer assemblies short enough so that staggering can be eliminated with the standard center to center hammer spacing of .1 inch, it has been found that the ratio of the length of the air gap in between adjacent magnets, i.e. dimension 509 in FIG. 6, to the total magnetic path length, (including the magnetic path length of the magnet plus the air gap length,) i.e. dimension 508 in FIG. 6, should be $\frac{1}{2}$ or greater with a flux density over the active area of the magnets of 1,000 gauss or greater. This is in marked contrast to the prior art wherein the ratio of air gap length to total magnetic path length is in the order of $\frac{1}{4}$, with higher flux density but a correspondingly greater hammer mass due to increased length of the hammer.

FIG. 8 shows a sketch of a prior art hammer actuating mechanism showing three coils and the corresponding magnets. The view of the prior art device as shown in FIG. 8 is a cross sectioned view taken similar to the view of the present invention as shown in FIG. 6. The prior art magnets are referenced by the symbols 50 through 55 and are U shaped magnets. The magnets 50 through 55 are shown with coils 56, 57 and 58 of the hammer assemblies (the rest of which are not shown) in between the ends of the legs of the magnets. In one embodiment of the improved prior art printer the total magnetic path (including the magnetic path length of the magnet plus the air gap length), which is indicated by dashed line 53 in FIG. 8, is approximately $\frac{1}{16}$ inches long, whereas the dimensions of the gap is between the end of the legs of two adjacent magnets is approximately $\frac{1}{16}$ inches. Thus, the ratio of the air gap length to the magnetic path is $\frac{1}{4}$ which is in marked contrast to the ratio in the present invention of $\frac{1}{2}$ or greater.

In order to achieve high printing speeds, the weight and length of the elongated member in the hammer assemblies must be minimized. As the length of the elongated member increases the dwelling time of the elongated member upon striking the drum increases. The reason is that as the elongated member increases in length, the time for the shock wave to travel from the backend of the elongated member to the hammer, and back again, increases. To this end it has been found that greatly increased speed can be achieved by limiting the length of the elongated member, as shown in the drawings, so that it is at least as long as the width of the coil connected thereto but shorter in length than twice the width of the coil.

The upper row of hammer assemblies 300 and upper row of magnets 400 are constructed and assembled essentially the same as the lower rows 100 and 200. The individual hammer assemblies in row 300 are identical to the hammer assemblies in row 100 and moving from right to left in FIG. 2 are referenced by the symbols 301 through 310. (Only the first two hammer assemblies 301 and 302 and the last one in the row 300 have the reference numbers shown.) The individual magnets in row 400 are identical to the magnets in row 100 and moving from right to left are referenced by the symbols

401 through 411. (Only the first two magnets 401 and 402 and the last magnet 411 in the row have their reference numbers shown in FIG. 2.) The magnets 401 through 411 are identical to the magnets 201 through 211 and, moving from right to left in FIG. 2, are arranged to provide slot-shaped gaps 301a through 310a for the hammer assemblies 301 through 310. (Only gaps 301a, 302a, and 310a have their reference numbers shown in FIG. 2.) Similar to the lower row of magnets 200, the upper row of magnets 400 are rigidly cemented in between upstanding support arms. The upstanding support arms, moving from right to left in FIG. 2, are referenced by the symbols 401a through 411a. (Only the support arms 401a, 402a and 411a have their reference numbers shown in FIG. 2.) The support arms 401a through 411a are formed as an integral part of a module base 26 which is connected to the base structure 25 by means of a bolt 26b similar to module base 24.

The upper row of hammer assemblies 300, the upper row of magnets 400, and the module base 26 are identical to the lower rows 100 and 200 and the module base 24 but are upside down and displaced slightly with respect to the lower rows 100 and 200 and the lower module base 24 so that the elongated members of the hammer assemblies in the upper row 300 fall in between the elongated members of the hammer assemblies in the lower row 100. Thus, a gap between a pair of adjacent magnets in the upper row of magnets 400 coincides with the middle of a magnet in the lower row of magnets 200.

The module base 26 is rigidly secured to the frame 25 by means of a bolt 26b which is threaded into a riser 26c of the module base 26. Similar to the connector blocks and connector 34 connector blocks 40 and 41 and a connector 42 are provided for the same purpose for the upper row of hammer assemblies 200.

As a general rule, printers have 120 character positions in a line of print, with a center to center spacing of the hammers of .1 inch. The center to center spacing in the lower row is .2 inch. Therefore, the upper row of hammer assemblies 300 is added to provide the desired center to center spacing of .1 inch. It will be understood that additional modules may be added to the module of hammer assemblies and magnets shown in FIGS. 1 and 2 until the total complement of 120 hammer assemblies are obtained for a complete line of print 120 character positions. It should also be noted that the individual hammer assemblies are identical and are easily plugged and removed from the connector blocks. This feature greatly simplifies maintenance by allowing hammer assemblies to be replaced easily and rapidly as desired. Also, the entire module base 24, magnets 200 and hammer assemblies 100 can be removed from the printer frame 25 simply by removing the bolt 24b. This feature also facilitates easy maintenance and repair of the printer.

Consider the operation of the printer. Whenever it is desired to force one of the hammers into a printing position with the drum 10, current is applied through one of the connectors 34 and 42 to a pair of wires running to the corresponding hammer assembly. The current passes through to the receptacle of one of the connector blocks 30 and 32 up through the spring of the hammer assembly, through the coil, and back out through the coil to the other spring. The current passes through the other spring through the other connector block, back to the connector. The current in the coil is such that it causes an interaction with the magnets on either side of the coil causing the coil and the elongated member to be forced towards the rotating drum 10. The hammer tip of the elongated member strikes the paper causing the character in front of the hammer tip to be used to make an imprint on the paper.

The hammer assembly is returned to its normal deactivated position by applying a current through the coil in the opposite direction. This causes the coil and con-

nected elongated member to be forced back in the opposite direction until it is stopped by the corresponding hammer stop.

It will be understood that there is a separate hammer driver circuit (not shown) for each hammer assembly in the printer so that one or more hammer assemblies may be actuated simultaneously.

What is claimed is:

1. A printing device comprising: a rotatable type drum; a plurality of parallelepiped shaped ceramic magnets positioned in a substantially straight row parallel with the axis of said type drum, each of said magnets cooperating with the adjacent magnet, at both sides, to define slot-shaped gaps therebetween; and a hammer assembly for each gap comprising an elongated member having a hammer tip at one end, a substantially flat coil mechanically connected intermediate the ends of said member with the axis of the coil perpendicular to the elongation of said member and means including a pair of flatsprings connected to the hammer assembly and adapted for supporting each hammer assembly such that the coil is free to move in the corresponding gap toward and away from the surface of said drum, the springs comprising an electrically conductive material and connected to the ends of said coil for providing an electrical current path thereto, the magnets being magnetized parallel to the axes of the coils so that current applied through the springs to a particular coil causes a force between the coil and adjacent magnets forcing the hammer tip of the connected member into a printing position with the drum.

2. A printing device comprising: movable type bearing means; a plurality of permanent magnets positioned in a substantially straight row, each of said magnets having a pair of parallel and substantially flat surfaces arranged with respect to the adjacent magnet, at both sides, to define slot-shaped gaps therebetween; and a hammer assembly for each gap comprising an elongated member having a hammer tip at one end, a substantially flat coil mechanically connected intermediate the ends of said member with the axis of the coil perpendicular to the elongation of said member and means adapted for supporting each hammer assembly such that the coil is free to move in the corresponding gap toward and away from the type bearing means, the magnets being magnetized parallel to the axes of the coils so that current applied in a coil causes a force between the coil and adjacent magnets forcing the hammer tip of the connected member into a printing position with the type bearing means.

3. A printing device comprising: a rotatable type drum; a plurality of hammer assemblies each comprising an elongated member having a hammer tip at one end thereof and a substantially flat coil mechanically connected intermediate the ends of said elongated member with the axis of the coil perpendicular to the member; means for supporting the elongated members and the connected coils with the coils spaced a short prefixed distance apart and in a substantially straight row parallel with the axis of said drum, said mounting means being adapted to allow the hammer assemblies to move the hammers thereof into a printing position with respect to the drum; and a parallelepiped shaped ceramic magnet having a thin dimension positioned in between each adjacent pair of coils, said magnets being magnetized through the thin dimension in a direction parallel with the axes of said coils such that a magnetic interaction is caused which forces a coil to move, in the corresponding gap, so that the connected hammer tip is forced into a printing position with respect to said drum, in response to current applied in the particular coil.

4. A printing device as defined in claim 3 wherein each hammer assembly is characterized whereby the coil thereof has an overall width dimension, parallel with the elongated extension of said member, the dimension of said

elongated member parallel with the elongated extension thereof being greater than said outside width dimension but less than twice as long as said outside width dimension.

5. A printing device as defined in claim 4 wherein said supporting means comprises a support structure and a pair of substantially parallel flat springs connected between the base structure and the elongated member.

6. A printing device comprising: movable type bearing means; a plurality of hammer assemblies comprising a hammer tool and a substantially flat coil mechanically connected to said hammer tool; means for supporting the hammer tools and connected coils of said hammer assemblies with the coils spaced a short prefixed distance apart with the axis of each coil positioned in a substantially straight line, said mounting means being adapted to allow the hammer assemblies to move the hammer tool thereof into a printing position with respect to the type bearing means; and a thin ceramic magnet positioned in between each adjacent pair of coils, said magnets having a pair of substantially flat surfaces facing the adjacent magnets which are separated by the thin dimension thereof and being magnetized through the thin dimension in a direction parallel to the axis of said coils such that a magnetic interaction is caused which forces the coil to move in the corresponding gap so that the corresponding hammer tool is forced into a printing position with respect to said type bearing means, in response to current applied to the particular coil.

7. A printing device comprising: a rotatable type drum; a plurality of parallelepiped shaped ceramic magnets positioned in a substantially straight row parallel with the axis of said type drum, each of said magnets cooperating with the adjacent magnet, at both sides, to define slot-shaped gaps therebetween; and a hammer assembly for each gap comprising an elongated member having a hammer tip at one end, a substantially flat coil mechanically connected intermediate the ends of said member with the axis of the coil perpendicular to the elongation of said member and means adapted for supporting each hammer assembly such that the coil is free to move in the corresponding gap toward and away from the surface of said drum, the magnets being magnetized parallel with the axes of the coils such that a north pole magnetic field is formed in one gap and a south pole magnetic field is formed in the adjacent gap, all the magnets being magnetically poled in one direction along one side of the row of magnets and in the opposite direction along the opposite side of the row of magnets, the coils being positioned in relation to the poles of the magnets such that a force is caused between a coil and the corresponding magnets, responsive to current applied in the coil, for forcing the hammer tip of the connected member into a printing position with the drum.

8. A printing device as defined in claim 7 including a support structure and wherein said supporting means comprises a pair of flat suspension springs mechanically connected in parallel between the support structure and the elongated member at either side of the connected coil.

9. A printing device as defined in claim 8 wherein said suspension springs comprise an electrically conductive material and are connected to opposite ends of said coil for providing electrical current thereto.

10. A printing device comprising: type bearing means; a plurality of ceramic magnets positioned in a substantially straight row, each of said magnets having two substantially flat parallel surfaces separated by a thin dimension and facing the adjacent magnet, at both sides, to define slot-shaped gaps therebetween; a hammer assembly for each gap comprising an elongated member having a hammer tip at one end and a substantially flat coil mechanically connected intermediate the ends of said member with the axis of the coil perpendicular to the elongation of said member; and means adapted for supporting each hammer assembly such that the coil is free to move in the corresponding gap toward and away from said type bear-

ing means, the magnets being magnetized through the thin dimensions parallel with the axes of the coils such that a north pole magnetic field is formed in one gap and a south pole magnetic field is formed in the adjacent gap, all the magnets being magnetically poled in one direction along one side of the row of magnets and in the opposite direction along the opposite side of the row of magnets, the coils being positioned in relation to the poles of the magnets such that a force is caused between a coil and the corresponding magnets, responsive to current applied in the coil, for forcing the hammer tip of the connected member into a printing position with the type bearing means.

11. Assembly for a printing apparatus comprising: a plurality of permanent magnets positioned in a substantially straight row, each of said magnets having a pair of parallel surfaces separated by a thin dimension and facing the adjacent magnet, at both sides, to define slot-shaped gaps therebetween; a hammer assembly for each gap comprising a hammer tool and a substantially flat coil mechanically connected to said hammer tool; and means adapted for supporting the hammer assemblies with the axes of the coils thereof in a substantially straight line perpendicular to said surfaces of the magnets such that the coil is free to move in the corresponding gaps toward and away from a predetermined point of impact, the magnets being magnetized through the thin dimension thereof parallel with the axes of the coils such that a north pole magnetic field is formed in one gap and a south pole magnetic field is formed in the adjacent gap, all of the magnets being magnetically poled in one direction along one side of the row of magnets and in the opposite direction along the opposite side of the row of magnets, the coils being positioned in relation to the poles of the magnets such that a force is caused between a coil and the corresponding magnets, responsive to current applied in the coil, for forcing the connected hammer tool into such point of impact.

12. A printing device comprising: type bearing means; a plurality of permanent magnets positioned in a substantially straight row, each of said magnets having first and second substantially flat and parallel surfaces separated by a thin dimension and facing the adjacent magnet, at both sides, to define slot-shaped gaps therebetween, said row of magnets having first and second sides, the dimension therebetween being substantially larger than said thin dimension, the magnets being magnetized over an active area adjacent said first side normal to said first and second surfaces with a north pole at said first surface and a south pole at said second surface, the magnets being magnetized over an active area adjacent said second side normal to said first and second surfaces with a south pole at said first surface and a north pole at said second surface; a hammer assembly for each gap comprising a hammer tool and a substantially flat coil mechanically connected to said hammer tool; and means adapted for supporting each hammer assembly with the coil in the corresponding gap and the axis of the coil normal to said parallel surfaces such that the coil is free to move in the corresponding gap toward and away from said type bearing means, each coil being positioned in relation to active areas of the magnets such that a force is caused between the coil and the corresponding magnets, responsive to current applied in the coil, for forcing the connected hammer tool into a printing position with the type bearing means.

13. A printing device comprising: type bearing means; a plurality of permanent magnets positioned in a substantially straight row, each of said magnets having a pair of substantially flat surfaces facing the adjacent magnet, on both sides, which are parallel with the corresponding surfaces of the adjacent magnets to define slot-shaped gaps therebetween, each magnet being magnetized in a straight line normally to the surfaces thereof and characterized and positioned in relation to the adjacent magnet with a ratio of air gap length to air gap length plus magnetic path

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length of the magnet of at least $\frac{1}{8}$ and for providing a flux density over an active area of the magnet surfaces of at least 1000 gauss; a hammer assembly for each gap comprising a hammer tool, a substantially flat coil mechanically connected to said hammer tool; and means adapted for supporting the hammer assembly such that the coil is in the corresponding gap with the axis of the coil perpendicular to the magnet surfaces on either side, the support means being adapted to allow the coil to move in the corresponding gap toward and away from the type bearing means, the coils being positioned in relation to the active areas of the magnets such that a force is caused between the coil and the corresponding magnets, responsive to current applied in the coil, for forcing the connected hammer tool into a printing position with the type bearing means.

14. A printing device comprising: a rotatable type drum a plurality of parallelepiped shaped ceramic magnets having sides and positioned in a substantially straight row parallel with the axis of said type drum, each of said magnets cooperating with the adjacent magnet, at both sides, to define slot-shaped gaps therebetween; connector means including an electrical connector at each side of each of said gaps; and a pluggable hammer assembly for each gap comprising an elongated member having a hammer tip at one end, a substantially flat coil mechanically connected intermediate the ends of said member with the axis of the coil perpendicular to the elongation of said member, a hammer assembly base structure, a pair of flat springs connected between the hammer base structure and

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the elongated member and adapted for supporting each hammer assembly such that the coil is free to move in the corresponding gap toward and away from the surface of said drum, the springs comprising an electrically conductive material and electrically connected to the ends of said coil for providing an electrical current path thereto, and a pair of connector means mechanically connected to said bath structure and adapted for forming an electrical connection with the electrical connector at each side of the corresponding gap, each one of the pair of connector means being electrically connected to the conductive material of one of said springs, the magnets being magnetized parallel to the axes of the coils so that current applied through the springs to a particular coil causes a force between the coil and the adjacent magnets forcing the hammer tip of the connected member into a printing position with the drum.

15. A printing device as defined in claim 14 having means comprising a pair of support arms rigidly attached at the sides of each magnet for thereby securely holding each magnet in place with respect to the other magnets.

References Cited by the Examiner

UNITED STATES PATENTS

3,145,650	8/1964	Wright	101—93
3,164,084	1/1965	Paige	101—93
3,172,352	3/1965	Helms	101—93

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