A matrix print head including a housing (20) accommodating a plurality of longitudinally displaceable print wires (26) and a plurality of armatures (28) driveable by electromagnets (34, 36) to displace the print wires (26) forwardly from a non-print to a print position. The armatures (28) are pivotally supported on a pivot support (240) and are positioned between the associated electromagnets and a retaining flange. The armature members (28) are fixedly connected to the print wire members (26) to provide individual combination print wire and armature subassemblies operable in a non-ballistic mode to reduce the number of parts and facilitate repair or replacement. The wire (26) impacts the paper before the armature fully engages on the pole end surface (78) to create a rebound force.
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DOT MATRIX PRINT HEAD ASSEMBLY

Background of the Invention

This invention relates to a non-ballistic type dot matrix wire print head apparatus. Dot matrix wire print head apparatus may be generally classified as being of the ballistic type wherein the print wire members are not connected to the drive armatures and are driven by impact with the drive armatures, or the non-ballistic type wherein the print wire members are fixedly connected to the drive armatures so that the print wire members and armatures have unitary movement. While the features of the present invention are disclosed in conjunction with a non-ballistic type print head assembly, certain features may also be utilized with a ballistic-type print head assembly.

In prior art ballistic-type apparatus, such as that disclosed in United States patents, Nos. 4,230,038, 4,230,412, 4,185,929 and 4,478,528, the disclosures of which are incorporated herein by reference, wire type printing members (stylus or styli) are arranged in spaced relationship about a central longitudinal axis in a generally circular or elliptical matrix for reciprocable movement between a non-print position and a print position with the movement from the non-print position to the print position being of ballistic nature, i.e. by impact and/or driving engagement with another moving member. Each printing member is operatively associated with a radially innermost portion...
of a radially outwardly extending armature member and ballistically driven thereby by impact therewith during pivotal movement of the armature from a non-print position to a print position. A radially outermost portion of each armature is operatively associated with a radially outwardly located and circumferentially spaced electromagnetic means having radially spaced pole portions including a radially innermost pole portion and a radially outermost pole portion, the pole portions including flat coplanar radially spaced and radially extending end surfaces which face away from the direction of movement from the non-print position to the print position and engaging a side surface of the armature at various times.

In some types of the prior art ballistic-type apparatus, the construction and arrangement is such that the armature is pivotally supported at all times on a radially outermost edge of the end surface of the radially outermost pole portion and impacts the end surface of the radially innermost pole portion which is constructed and arranged to cause pivotal movement of the armature from the non-print position to the print position by magnetic attraction. In addition, the construction and arrangement is such that the armature impacts on the end surface of the innermost pole portion at approximately the same time that the printing member is being driven toward the paper. The result is that the kinetic energy of the armature is lost and only the kinetic energy of the printing member is thereafter effective to cause completion of the printing operation. The lost kinetic energy is simply dissipated upon impact with the surface of the pole portion with resultant high levels of noise and heat. In addition, the speed of the printing process is reduced and the number of sheets of paper which can be printed at one time is also limited. Furthermore, in order to obtain sufficiently high levels of kinetic energy to produce satisfactory printing
results, relatively high levels of energy must be used to operate the electromagnetic means.

In the invention disclosed in United States patent No. 4,230,038, the armature members and the electromagnetic means are constructed and arranged so that the armature members are normally pivotally supported by a first pivot means on a radially innermost edge of a radially innermost pole portion while being magnetically attracted by a radially outermost pole portion. In addition, the pole portions are constructed and arranged so that the end surfaces thereof face toward the direction of movement of the armature and the printing members from the non-print position to the print position. As a result, the driving movement of the armature continues after impact with the end surface of the outermost pole portion without loss of a substantial portion of the kinetic energy thereof as in prior art apparatus. Furthermore, the construction and arrangement is such that after impact of the armature with the end surface of the outermost pole portion, the first pivot means is disengaged and a second pivotal means is provided between a radially outermost portion of the armature and the radially outermost edge of the radially outermost pole portion whereby the driving movement of the armature may continue substantially unimpeded until completion of the printing operation.

For many years, there has been a trend toward the use of smaller size, dot matrix print head assemblies operating at relatively high speeds with maximum efficiency. There has also been a trend toward use of more print wire members in each dot matrix print head assembly and dot matrix print assemblies having at least 18 or more print wire members has become commonplace. It is often desirable to reduce the size of the print head assemblies which results in difficulty of assembly, repair and maintenance and increased costs of manufacture. At the present time, there is a need
for a relatively low cost and relatively small size, yet
highly efficient, dot matrix print head assembly which
is easy to assemble and be mounted on a printer
mechanism.

Objects of the present invention are to
provide a high speed, reliable, efficient, compact,
lightweight, low cost and easily manufacturable dot
matrix print head assembly. The invention provides a
dot matrix print head assembly which (1) reduces the
mass of moving parts; (2) reduces print wire resonances;
(3) employs a laminated electromagnet construction with
improved flux concentration and low inductance and low
current; and (4) employs an armature and pole
construction.

Another object of the present invention is to
provide a relatively small size, e.g. approximately 2
inch diameter by 1-1/2 inch length, print head assembly
with a relatively large number of print wires, e.g. 24
print wire members. It is also an object of this
invention to provide a construction and arrangement
which enables the parts to be manually assembled with a
minimum of time and effort while also providing maximum
accuracy of critical relationships between the
operational components.

Summary of Invention

The present invention provides a print head
assembly comprising only two basic unitary sub-
assemblies for receiving and retaining the armature
members and the print wire members. One unitary sub-
assembly comprises a print wire housing with an integral
armature retaining flange made of one piece of molded
plastic material. The other unitary sub-assembly
comprises the electromagnetic pole means and a printed
circuit board means which are permanently fixedly
embedded (e.g. potted) within a drive housing means made
of one piece of molded plastic material. The
construction and arrangement is such that the wire
housing means and the drive housing means are directly connected to one another by suitable fastening means with the armature members and print wire members mounted therewithin and therebetween. In the presently preferred embodiment, the armature members are fixedly connected to the print wire members to provide individual combination print wire and armature sub-assemblies operable in a non-ballistic mode of operation and to reduce the number of parts and facilitate assembly and repair or replacement.

In addition, the present invention provides a new and improved armature construction and arrangement wherein pivotal edge means are provided on each armature rather than on a pole portion of the electromagnet means and a flat pole end surface provides a pivotal edge support means for each armature member. The present invention also provides a new and improved construction and arrangement of the armature members and associated armature guide and retaining means wherein each armature is retained by a pin means extending through a centrally located opening means in the armature. The pivotal edge means of each armature is held in continuous abutting engagement with the associated flat pole end surface by a biasing means in the form of a resilient compressible O-ring member.

The present invention relates to a non-ballistic type dot matrix print head wherein the print wire is attached to the armature tip. When the electromagnet is energized, the magnetic end of the armature is attracted to a pole end surface and the print wire is driven outward to the print position. The wire impacts the paper before the armature fully engages ("bottoms out") on the pole end surface to create a rebound force which reverses the motion of the wire and the armature to return the armature and print wire to the original non-print position. An armature stop means damps the return motion and re-locates the armature and
wire in the non-print position. A return-spring means acts as a static biasing force on the armature to keep it in place in the non-print position.

The present invention also provides a new and improved construction of the electromagnet means to maximize concentration of flux and speed of response. One of the features of the present invention is the shape of the magnetic yoke. The "space" in between the two pole portions is relatively large to reduce magnetic flux leakage. In addition, the inner pole curves in toward the outer pole adjacent the pole end surfaces to provide a "C" shape gap resulting in greater efficiency and speed of magnetic response for a relatively small armature which operates at high speed. The pole end portions have a "chamfer" which concentrates the magnetic flux. In the presently preferred embodiment, the yoke has a laminated stack design which improves efficiency and speed of magnetic response. Since the pivot edge means is on the armature rather than on the pole as has been the conventional approach, the magnetic yoke assembly is easier to manufacture with improvement in the functional tolerances of the assembly.

The contour of the armature is designed to be optimum magnetically, and to have minimum inertia. The armature is provided with a central transverse retaining means in the form of a hole for receiving a pin, rather than the use of peripheral slots or tabs to retain the armature in place. This design enables use of a single round hole which locates on a loose fitting plastic "peg" in the wire housing. This design is easier to manufacture and allows a more compact design.

The return spring means are provided by two elastomeric O-rings which are located in the wire housing and are compressed against the armature side surfaces opposite the pole portions. One of the O-rings is directly over the pivot point to continuously maintain the armature pivot edge in engagement with the
pole end surface. The other O-ring is radially inwardly offset from the pivot, and acts as the return spring. In prior art non-ballistic designs, separate individual coil springs or leaf springs have been used for each armature in the print head. The O-ring design allows the use of one single inexpensive part for the return spring of all actuators in the print head; provides better damping characteristics than metal springs, and is more compact than most other prior art designs.

The present invention also provides an improved "magnetic yoke assembly". In other designs, the magnetic yokes (metal) are one sub-assembly, and the coils/PC board are another. In the present design, all parts "snap" together and then the whole assembly is molded in thermoset plastic for rigidity. In the assembly procedure, the coils are wound on their bobbins, and the leads are terminated on pins in the bobbin in a conventional manner. Then the magnetic yokes are snapped into the coils, and the coils then snapped into a PC board, along with the connector. Then, the coils and connector are soldered to the PC board. Lastly, this assembly is all "potted" with a thermoset plastic to create a rigid assembly. Subsequently, the pole end portions of the magnetic assembly are ground flat (lapped) as a unit to create planar end surfaces and smooth flat abutment surfaces for pivotally supporting the armatures. Thus, the parts are "self-fixture"ing", whereas most other designs require assembly fixtures to build the assembly.

Spring-loaded armature stop means are provided to set the length of the stroke of the armatures solely based on the thickness of a shim. In other designs, the stroke (a highly critical item) is either adjusted in production, or is determined by the combination of several dimensions. By spring-loading the armature stop against a reference plane, the stroke is determined by the shim only, eliminating any adjustment in production,
and improving the tolerance of the stroke dimension.

In general, this invention provides a wire matrix print head assembly and apparatus which is less costly to manufacture and more reliable in operation while also being more efficient, less noisy, and having higher energy and speed potential than prior art apparatus.

The present invention provides a print head wherein the moving masses are extremely low. The magnetic system has a very quick response time, with a high accelerating force for its relatively small size and is extremely efficient. The low mass and high force produce high accelerations (therefore high speeds), and the high efficiency reduces overheating, and allows smaller (low power) drive electronics. Another unique feature is that all of this performance is achieved using conventional materials and in a simple, manufacturable design.

**Brief Description of the Drawing**

An illustrative and presently preferred embodiment of the invention is shown in the accompanying drawing wherein:

- Fig. 1 is a cross-sectional view of a dot matrix print head assembly constructed and arranged in accordance with the present invention;
- Fig. 2 is a reduced size plan view of the armature and drive assembly of the dot matrix print head of Fig. 1;
- Fig. 5 is an enlarged side elevational view of the armature of Fig. 2;
- Fig. 6 is a plan view of the armature of Fig. 5;
- Fig. 3 is a reduced plan view of the drive assembly of Fig. 2 without the armature;
- Fig. 4 is an enlarged partial side elevational view of an armature and electromagnet of Fig. 1;
- Fig. 7 is an enlarged side elevational view of
the magnetic yoke of the apparatus of Fig. 1;

Fig. 8 is an end view of the magnetic yoke of

Fig. 7;

Fig. 9 is a side elevational view of a bobbin;

Fig. 10 is another side elevational view of

the bobbin of Fig. 9;

Fig. 11 is an end view of the bobbin of Fig.

9; and

Fig. 12 is another end view of the bobbin of

Fig. 9.

General Assembly

In general, Figs. 1-4 show a non-ballistic-
type dot matrix print head which comprises a wire

housing means member 20 having an elongated print wire

guide and support portion 22 and an annular armature

retaining flange portion 24 for supporting a plurality

of elongated wire stylus print members 26, eg. 24, and

an equal number of armature members 28 in radially and

circumferentially spaced relationship about a central

longitudinal axis 30. The print head apparatus further

comprises electromagnetic drive housing means 31 for

supporting an equal number of armature actuating

magnetic pole means 34 and electrical wire coil means 36

located in radially and circumferentially spaced

relationship about central axis 30 in juxtaposition to

and operative relationship with the armature members 28.

Each of the pole means 34 have a radially innermost pole

portion 40, a radially outermost pole portion 42 and a

connecting portion 44 which is mounted on a printed

circuit board means 46. Coil means 36 are electrically

connected to the printed circuit board means 46 by

connector pin means 48 mounted on bobbin means 50, Figs.

9-12, which may have snap-in holding means 52 for

engagement with the printed circuit board means 46. The

print wire housing means 20 is fastened to the drive

housing means 31 by suitable fastener means 54, 56.

Each of the wire print members 26 has a paper
- 10 -

impacting print end portion 58 and a drive end portion 60 fixedly attached to an associated armature member. The wire members 26 are slidably reciprocably supported by guide and bearing plate members 62, 64, 66 for movement between a retracted non-print position and an extended print position. Each of the armature members 28 has a radially innermost wire drive end portion 68, a central intermediate pivot portion 70 located opposite inner pole portion 40, and a radially outermost magnetic drive end portion 72 located opposite outer pole portion 42. The armature members 28 are pivotally movable between a non-print position (schematically illustrated on the right side of Fig. 1) and a print position (schematically illustrated on the left side of Fig. 1) by selective energization of the associated electromagnetic means 34. Each of the armature members has a pivotal edge means 76 held in continuous abutting engagement (see Fig. 4) with a flat inner pole end surface 78 by a resilient compressible pivot spring means in the form of an O-ring member 80. A resilient compressible armature return spring means in the form of an O-ring member 82 continuously engages each armature member to provide an armature return force. A resilient compressible armature stop means 84 engages and locates the armature wire drive end portions 68 in the non-print position and dampens armature rebound during return movement from the print position to the non-print position.

Wire Housing Means

The wire housing means 20 is preferably made of one piece of rigid molded plastic material. Guide and support portion 22 comprises an elongated portion 100 of generally U-shaped peripheral configuration defined by a pair of spaced side wall portions 102, 104 and a connecting wall portion providing an elongated slot 106 therebetween. Axially spaced wire guide plate members 62, 64, 66, are preferably made of suitable
molded plastic material and have suitably shaped wire
guide and bearing holes 108 provided therein in variable
radially outwardly spaced relationship to central axis
30. As shown in Figs. 2 & 3, one half of the wire
members are located on one side of central axis 110 and
the other half of the wire members are located on the
other side of axis 110. The print end portions of each
group of wire members are arranged in a column pattern
and provide two spaced rows of wire members. In the
presently preferred embodiment, there are 12 wires in
each row.

The flange portion 24, Figs. 1 & 4, comprises
inner and outer radially extending surfaces 112, 114 and
an axially extending outer rim portion 116 having an
abutment surface 118 for supporting engagement with
drive housing means 31. An inner rim portion 120 is
provided with radially innermost armature mounting and
guide slot means 122 circumferentially spaced
thereabout. Each slot means 122 comprises
circumferentially spaced parallel side surfaces and a
radially extending flat bottom surface 124. The
armature mounting and guide and slot means loosely
receive the radially innermost armature end portions and
enable free pivotal movement between the non-print and
the print position.

A radially intermediate axially inwardly
extending second inner rim portion 126 is radially
outwardly spaced from rim portion 120 and located in
juxtaposition to inner pole portions 40. Rim portion
30 126 provides a first radially innermost annular O-ring
groove 128 in which is mounted a resilient compressible
relatively large diameter O-ring member 82 for
continuously engaging an intermediate portion of
armatures 28.

Rim portion 126 also provides a second
radially outermost annular O-ring groove 130 in which is
mounted a resilient compressible relatively small
diameter 0-ring 80 for continuously engaging a portion of the armatures 28 opposite pivotal edge means 76. Rim portion 126 also provides armature guide and retaining means 132, Fig. 4, in the form of a plurality of circumferentially spaced cylindrical axially extending stub shaft portions which are loosely received in centrally located bores in the armature members as hereinafter described. Stub shaft portions have coplanar end surfaces 134 which are abuttingly engaged with inner pole end surface 78.

The Armature Members

As shown in Figs. 5 and 6, each of the armature members 28 have flat parallel side surfaces 200, 202. Actuating end portion 72 has an intermediate maximum width portion 204 located between flat parallel intermediate surfaces 206, 208 which are connected to radially outermost flat end surface 210 by inclined surfaces 212, 214. Inclined surfaces 216, 218 extend radially inwardly from intermediate portion 204 to inwardly curved side surfaces 220, 222 which tangentially intersect inclined side surfaces 224, 226 of relatively narrow width elongated wire drive end portion 68. Drive end surface 228 is inclined at an angle of approximately 4.2 degrees for abutting fixed engagement with the end portion 230 of the associated wire member by brazing. The width of surface 228 is approximately equal to the diameter of the wire end portion 230 (e.g., approximately .008 inch).

Each of the armature members has an intermediate transverse slot 232 defined by an offset flat surface 234 and side wall surfaces 236, 238. Slot side surface 238 intersects side wall surface 202 at a substantially right angle to provide a sharp transverse edge 240 providing transverse line-type armature pivot means. Armature retaining means in the form of a centrally located circular hole 242 extends through the armature opposite slot 232 adjacent pivot means 76. The
circular shaft means 132, Fig. 4, on retainer flange portion extends through circular hole 242 opposite the end surface 78 of the inner pole portion 40 for abutting engagement with inner pole end surface 134. The diameter of hole 242 (e.g., .040 inch) is sufficiently larger than the diameter of shaft 132 so as to enable free pivotal movement of the armature. The depth of slot 232 (e.g., .015 inch) is such as to enable free pivotal movement of the armature without contact with the inner pole portion 40 or adjacent portions of drive housing 31. The width of the wire drive end portion tapers from .030 inch at the intersection with curved surfaces 220, 222 to .008 inch at drive end surface 228. The armature members have a length of approximately 0.70 inch and a thickness of approximately .050 inch and a maximum width of approximately .150 inch. The width of slot 232 is approximately .148 inch and the center line 244 of hole 242 is located approximately .040 inch from pivot edge 240. Drive end surface 228 is located approximately .389 inch from hole center line 244. Actuating end surface 210 is located approximately .316 inch from hole center line 244 and has a length of approximately .084 inch.

Electromagnet Means

As shown in Figs. 7 & 8, each of the pole means 34 preferably have a laminated construction made of a plurality of relatively thin metallic plate members 250, 251, 252, 253, 254 separated by very thin insulating coating or spacer members 25, 257, 258, 259.

Each pole unit has flat parallel side surfaces 262, 264 and a flat end surface 266 which abuts a flat side surface 268 of printed circuit board means 46 as shown in Fig. 1. Outer pole portion 42 has straight parallel inner and outer side surfaces 270, 272, a flat pole end surface 274, and an inclined chamfer surface 276. Inner pole portion 40 has a flat straight outer side surface 280 and an inclined surface 282 connected to inner pole
end surface 78. The inner side surface of inner pole portion 40 comprises an inclined flat straight surface 284, an intermediate straight flat surface 286, and a curved upper surface 288 having a relatively large radius of curvature (e.g., 4.50 MM) with a center of curvature located at 290 in the plane of inner pole end surface 78 which is coplanar with outer pole end surface 274. Inner pole end surface 78 has a longer length (e.g., approximately 3.75 MM) than the length of outer pole end surface 274 (e.g., approximately 2.75 MM).

Inner pole curved surface 288 provides a minimum air gap between the pole portions 40, 42 of approximately 1.5 MM at 292 between pole end surfaces 78, 274. A maximum air gap of approximately 3.5 MM is provided between opposite parallel straight pole side surfaces 270, 286.

Connecting side surface 294 has a length (approximately 2.0 MM) greater than the pole end surface gap 292.

As shown in Figs. 9 - 12, the bobbin means 50 is made of one piece of plastic material and comprises a core portion 300 with a pole mounting slot 302 and coil wire retaining end flanges 304, 306. A connecting portion 308 extends outwardly axially from flange portion 304. Connecting portion 308 has laterally spaced hub portions 310, 312 connected by an intermediate portion 314. Connector pin members 316, 318 are mounted in hub portions 310, 312 and connected to the end portions of the coil wire. Retaining tab means 52 comprises a flexible flange portion 320 having a flexible lip portion 322.

**Drive Housing Means Assembly**

As shown in Fig. 1, drive housing means 31 comprises a one piece body of plastic material having a flat end surface 330 which is coplanar with pole end surfaces 78 and provides an abutment surface 332 for engaging retaining flange rim portion 116. Fastener holes 334 receive fastening members 56. A central portion 336 has a recessed central cavity 338 with a
flat bottom wall 340 and an annular side wall 342
connected to end surface 330 by a tapered side wall 344.

Armature stop means 84 is mounted in central
cavity 338. Stop means 84 comprises a rigid support
disk member 341 which supports a resilient cushion
member 343 having a flat upper surface 345 for engaging
the wire drive end portions of the armatures in the non-
print position. A spring means in the form of a
resilient compressible O-ring member 346 supports disk
member 341.

The drive housing means 31 is molded around
the electromagnet means 34, the coil means 36, and the
printed circuit board means 46 by a potting operation.
The coil means 36 are first mounted on the pole means 34
by a sliding frictional fit to provide individual
electromagnetic unit sub-assemblies. Then, the
electromagnetic unit sub-assemblies are fixedly mounted
on the printed circuit board means 46 with pole end
surfaces 266 located in coplanar abutting relationship
on printed circuit board surface 268, coil wire
connector pin means 48 located in PC circuit connector
holes 350, and bobbin retaining flange means 52 located
in PC slots 352. Thus, the electromagnetic means and PC
board means form another unitary sub-assembly which is
then embedded in a body of plastic material 31 providing
a drive housing assembly. A portion 360 of the PC board
extends beyond the drive housing and has a control
circuit connector means 362 for connection to control
circuitry of an associated printer mechanism. Then, the
drive housing side surface 330 and the pole end surfaces
78, 274 are precision ground to provide coplanar end
surfaces. Fastener bores 334 and cavity surface 340 are
created by the molded plastic material 31.

The dot matrix print head assembly is
completed by placing the stop means 84 in central cavity
338. The O-ring members 80, 82 are mounted on pre-
assembled retaining flange portion 24. Then, the pre-
assembled armature and print wire units are mounted in the wire housing means 20 with the armature members associated with the guide slots 122 and guide shaft portions 132 of the retainer flange portion 24. A conventional thin annular anti-residual shim ring member 364 may be located between the armature members 28 and the outer pole portions 42. The wire housing means 20 is then fastened to the drive housing means 31 by fastening members 56. Suitable printer mounting means (not shown) are provided on each print head assembly for mounting on a printer mechanism.

Print Head Operation, Characteristics & Parameters

In the illustrative embodiment, there are 24 print wires made of tungsten carbide material of .008 inch diameter which are arranged to provide an output pattern comprising two staggered columns of 12 print wires. The print head assembly has a weight of approximately 150 grams and a diameter of approximately 2 inches. The print head is operable at 40 volts (minimum), 2 to 2.5 amps with a chopper or bi-level driver. The coils have a resistance of approximately 1.8 ohms and an inductance of approximately 1.2 mH. The print wire frequency is approximately 3KHz with a stroke of approximately .016 inch and heat generation per dot of approximately 1 mJ.

The contour of the yoke gap with minimum spacing between the pole end surfaces and maximum spacing between the intermediate pole portions reduces magnetic flux leakage and provides higher efficiency and speed with lower heat generation, while enabling the use of a small and extremely low inertia armature for high speed operation. The chamfer at the top of the outer pole operates in conjunction with the "low flux leakage" gap design to further concentrate the magnetic flux.

The slot in the armature provides a pivotal edge means on the armature rather than on a pole end surface whereby the end surface of the "potted magnetic
assembly is ground or lap-finished to provide coplanar pole end surfaces with reduction in mechanical tolerance requirements in the assembly.

The armature retaining hole and sub shaft means greatly simplifies the construction and arrangement of the armature members and the retaining flange means by elimination of additional slot and tab structure while simplifying manufacturing problems.

The construction and arrangement of the two armature biasing and location O-rings for pivot retention and for return spring action is simpler, less expensive and more compact that conventional designs while providing improved damping properties.

The self-fixture "snap together" design of the magnetic yoke and PC board sub-assembly greatly reduces costs while also enabling precision alignment of the parts. The PC board provides a support base for the electromagnet means with the bobbin connector means inserted into opening therein. Then the pin connections are soldered to the PC board and the potting compound is molded around all the parts for rigidity with minimal fixturing being required. This concept eliminates all conventional "structural" members in the assembly operation, such as metal support plates.

The "spring-loaded" armature stop means eliminates the use of either an adjustment in manufacturing, or high tolerance grinding or machining to set the depth of the armature stop assembly, which determines the armature stroke (a highly critical parameter). Some other designs use shims, individually selected for proper fit. The present concept uses a biasing spring in the form of an elastomeric O-ring which holds the armature stop assembly against a reference surface means in the form of the end surfaces of guide slots 122 on the molded plastic wire housing flange portion so that the wire stroke is not affected by variations in the thickness of the assembly parts.
Another advantage is that other stroke settings may be made by simply assembling with an appropriate shim (not shown) in between the armature stop means assembly and the reference surfaces.

In operation, the armature members are located in the non-print position by stop means 84 and O-ring members 80, 82. Upon selective energization of one of the coil means 36, the associated one of the armature members 28 is pivotally actuated from the non-print position to the print position about pivotal means 76. O-ring member 80 exerts a force-keeping pivotal means 76 in continuous engagement with inner pole end surface 78 and preventing armature contact with the retaining flange portion 24. After the print wire impacts the print medium in the print position and begins to rebound toward the non-print position, O-ring member 82 is effective to provide a return spring force on the armature. When the armature returns to the print position, it engages the resilient stop and damping means 84.

While illustrative and presently preferred embodiments of the invention have been disclosed herein, it is contemplated that the inventive concepts may be otherwise variously employed in alternative constructions and arrangements of dot matrix print head devices. For example, various concepts may be employed with either a ballistic-type or a non-ballistic-type print head. Thus, it is intended that the appended claims be construed to include various alternative construction and arrangements except insofar as limited by the prior art.
A matrix print head assembly comprising:

a number of print wire members spaced about a central longitudinal axis and being longitudinally movable between a non-print position and a print position;
wire guide housing means for movably supporting said wire members;

a number of rigid armature members equal to the number of wire members movable between a non-print position and a print position and extending radially outwardly of and being circumferentially spaced about the central longitudinal axis with a radially inner portion being driveably associated with said wire members during movement from the non-print position to the print position to drive the wire members from the non-print position to the print position;

a number of electromagnet means equal to the number of armature members mounted in juxtaposition to a radially outer portion of said armature members for pivotally supporting said armature members during movement from the non-print position to the print position and being selectively energizable for causing pivotal movement of the radially outer portion of said armature members toward said electromagnet means and opposite pivotal movement of the radially inner portion of said armature members from the non-print position to the print position by magnetic force applied to the radially outer portion;

electromagnetic drive housing means for supporting said electromagnet means in operative relationship with said armature means;

armature retainer flange means on said wire guide housing means for retaining said armature members in operative association with said electromagnet means;
said armature members being positioned between said electromagnet means and armature retainer flange means and said radially innermost portion being movable away from
said electromagnetic means toward said wire members during movement from the non-print position to the print position;
pivotal support means for continuously pivotally supporting said armature members during the movement of said armature members from the non-print position to the print position; and
said pivotal support means comprising a transverse pivot edge means on each of said said armature members and a flat pivot edge support surface means on said electromagnetic means.

2. The invention as defined in claim 1, and wherein:
said pivotal support means being spaced radially outwardly from said wire members and located in juxtaposition to a portion of said electromagnetic means next adjacent said wire members.

3. The invention as defined in claim 2, and wherein:
each of said armature members having first and second spaced radially extending parallel side surfaces;
the first side surface being located axially next adjacent said electromagnetic means and being intersected by a transverse surface to provide said pivot edge means on said armature members; and
the second side surface being located axially next adjacent said armature retaining flange means.

4. The invention as defined in claim 3, and wherein:
each of said electromagnetic means comprising a first radially innermost pole portion and second radially outermost pole portion being radially spaced from one another, the first pole portion being next adjacent said wire members, the second pole portion being spaced outwardly of said first pole portion a distance further away from said wire members than the distance between said first pole portion and said wire members, and the second pole portion being effective to actuate said armature members from the non-print position to the print position; and
said pivotal edge support means comprising a flat
pole end surface of said first pole portion next adjacent said wire members.

5. The invention as defined in claim 4, wherein:
   the distance between pivotal support means and
   said wire members being greater than the distance between
   said pivotal support means and said second pole portion.

6. The invention as defined in claim 5, and wherein:
   the distance between said pivotal support means
   and said wire members being greater than approximately 60%
   of the distance between said second pole portion and said
   wire members.

7. The invention as defined in claim 4, and further comprising:
   first guide means in said flange means located
   radially next adjacent said wire members and located between
   said wire members and said pivotal support means for
   guidably supporting said armature members during movement
   between said non-print position and said print position.

8. The invention as defined in claim 7, and further comprising:
   second guide means in said flange means located
   radially outwardly of said first guide means and radially
   inwardly of said pivotal edge means for guidably supporting
   said armature members during movement between said non-print
   position and said print position.

9. The invention as defined in claim 8, and further comprising:
   a first resilient compressible support means for
   continuously engaging said armature members and being
   located radially inwardly of said pivotal edge means and
   between said first guide slot and said second guide means.

10. The invention as defined in claim 9, and wherein:
    said first resilient compressible support means
    comprising an O-ring member having circumferentially spaced
    portions engageable with said armature members.

11. The invention as defined in claim 10, and further
comprising:
  a second resilient compressible support means for engaging said armature members radially outwardly of said first resilient compressible support means and said pivotal edge means and for applying a force to said armature members opposite to the direction of movement of said armature members from the non-print position to the print position.
12. The invention as defined in claim 11, and wherein:
  said second resilient compressible support means comprising: an O-ring member having circumferentially spaced portions in constant engagement with said armature members.
13. The invention as defined in claim 9, and wherein:
  said wire guide housing means and said flange means being made of one piece of molded plastic material; and
  said first guide means and said second guide means being integrally formed on said flange portion.
14. The invention as defined in claim 13, and further comprising:
  a first O-ring groove being integrally formed in said flange portion for receiving said first resilient compressible support means; and
  a second O-ring groove being integrally formed in said flange portion for receiving said second resilient compressible support means.
15. The invention as defined in claim 14, and wherein each of said second armature retaining guide means comprising:
  a hole means in said armature member located on the central longitudinal axis of the armature; and
  a pin means on said flange portion extending axially toward said armature member and being located in said hole means.
16. The invention as defined in claim 15, and wherein:
  said pin means and said hole means having a circular cross-sectional configuration; and
the diameter of said pin means being substantially less than the diameter of said hole means to enable pivotal movement of said armature member without engagement with said pin means.

17. The invention as defined in claim 15, wherein each of said first armature retaining guide means further comprising:

a rib portion on said flange portion extending axially toward said radially innermost end portion of said armature member;

slot means in said rib portion or receiving said radially innermost end portion of said armature member; and

said slot means having a larger size cross-sectional shape than the cross-sectional shape of said armature member for enabling pivotal movement of said armature member without engagement with said rib portion.

18. The invention as defined in claim 1, wherein each of said armature members comprising:

a radially outermost end portion located opposite said outer pole portion;

an intermediate portion located opposite said inner pole portion; and

a radially innermost end portion extending between said intermediate portion of said print wire member.

19. The invention as defined in claim 18, wherein:

a pivotal edge means on and extending transversely across said intermediate portion opposite said inner pole portion for continuous pivotal abutting engagement with the flat end surface of said inner pole portion.

20. The invention as defined in claim 19, wherein:

a first flat side surface on said armature member located opposite said pole means and extending radially outwardly from said pivotal edge means to said radially outermost end portion and being engageable with said end surface of said inner pole portion and said end surface of said outer pole portion in the print position.
21. The invention as defined in claim 20, wherein:
a second flat side surface on said armature member
located opposite said flange portion and extending the
length of said armature member and being parallel to said
first flat side surface.
22. The invention as defined in claim 21, wherein:
said radially innermost end portion of said
armature member having a width approximately equal to the
diameter of said wire member and being connected to said
intermediate portion by radially inwardly inclined side
surfaces.
23. The invention as defined in claim 22, wherein:
said inclined side surfaces intersecting said
intermediate portion adjacent said inner pole means.
24. The invention as defined in claim 1 and having
armature stop means located opposite said radially innermost
armature end portion and comprising:
a central cavity in said electromagnetic drive
housing means;
an armature abutment plate means mounted in said
central cavity for abutting engagement with each of said
armature members in the non-print position; and
a compressible resilient spring means in said
cavity between said housing means and said abutment plate
means for supporting and locating said radially innermost
end portions of said armature members in the non-print
position and damping rebound movement upon return to the
non-print position from the print position.
25. The invention as defined in claim 24, wherein said
armature retaining and locating means comprising:
a resilient compressible O-ring member located
between and mounted in continuous abutting engagement with
said flange portion and said armature members opposite said
pivotal support means.
26. The invention as defined in claim 25, and wherein:
an armature clamping means mounting on said flange
portion and located radially outwardly of said pivotal support means for supporting and locating said armature members in the non-print position and damping rebound movement upon return to the non-print position from the print position.

27. The invention as defined in claim 4, and wherein said electromagnetic housing means comprising:
   a solid one-piece block of plastic material with said electromagnetic pole means encapsulated therewithin and having a side surface located opposite said armature members; and said pole end surfaces being substantially coplanar with and surrounded by said side surface.

28. The invention as defined in claim 27, wherein: connection portions of said electromagnetic means being abuttingly engaged with and supported by said printed circuit board means; and said electromagnetic means and said printed circuit board means being surrounded by and fixedly located within said plastic drive housing means.

29. The invention as defined in claim 1, wherein said electromagnetic means comprising:
   an axially extending inner pole portion and an axially extending outer pole portion and a transverse connecting end portion;
   said inner pole portion and said outer pole portion being radially spaced from one another by a central axially extending slot means.

30. The invention as defined in claim 29, wherein:
   axially extending pole slot means located between and defined by opposite side wall portions of said inner pole portion and said outer pole portion for separating said inner pole end surface from said outer pole end surface and for separating said inner pole portion from said outer pole portion beyond said connecting portion; and said slot means having a variable width with a
minimum width between said inner pole end surface and said outer pole end surface and a maximum width between opposite intermediate portions of said inner pole portion and said outer pole portion.

31. The invention as defined in claim 30, wherein:
said outer pole side wall portion being flat and extending parallel to said central longitudinal axis of said wire housing means;
said inner pole side wall portion having an inclined side surface adjacent to and intersecting said inner pole end surface and extending toward said outer pole portion; and
an intermediate surface extending parallel to said outer pole side wall portion.

32. The invention as defined in claim 31, wherein:
plug-in electrical connector means on each of said bobbin means for connecting said wire coil means to said printed circuit board means.

33. The invention as defined in claim 32, wherein:
said plug-in electrical connector means and said printed circuit board means being fixedly embedded in and surrounded by said plastic drive housing means.

34. The invention as defined in claim 33, wherein:
a control circuit connector means mounted on said printed circuit board means and being accessible from outside said plastic drive housing means for connecting said printed circuit board means to control circuitry for said pivot head assembly.

35. The invention as defined in claim 34, wherein:
said coil means and said bobbin means being embedded and fixedly mounted within said plastic drive housing means and a portion of said drive housing means filling said slot means between said inner pole portion and said outer pole portion.

36. A method of manufacture and assembly of a dot matrix print head assembly comprising:
forming a wire housing member of one piece of molded plastic material having an elongated wire support portion and an armature retaining flange portion;

forming a drive housing assembly by maintaining electromagnetic units on a printed circuit board and then forming a body of plastic material around the electromagnet units and the printed circuit board;

grinding a flat surface across one end of the body of plastic material and end surface pole portions of the electromagnetic units;

mounting armature members and wire members between the wire housing member and the drive housing assembly; and

fastening the wire housing member to the drive housing assembly.
YOKE STACK
### INTERNATIONAL SEARCH REPORT

**I. CLASSIFICATION OF SUBJECT MATTER**

According to International Patent Classification (IPC) or to both National Classification and IPC

- **IPC (4)**: B8 J 3/12
- **U.S. Cl.**: 400/124

**II. FIELDS SEARCHED**

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Documentation searched other than Minimum Documentation to the extent that such Documents are included in the Fields searched

**III. DOCUMENTS CONSIDERED TO BE RELEVANT**

<table>
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<tr>
<th>Category</th>
<th>Citation of Document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to Claim No.</th>
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<tbody>
<tr>
<td>Y</td>
<td>US A, 4,626,115 (NORIGGE) 02 December 1986. (See the entire document).</td>
<td>1-35</td>
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<tr>
<td>Y</td>
<td>JP A, 60-48371 (INOUÉ) 16 March 1985. (See Figure 4).</td>
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  - "Z" document member of the same patent family

**IV. CERTIFICATION**

- **Date of the Actual Completion of the International Search**: 05 July 1989
- **Date of Mailing of this International Search Report**: 27 JUL 1989

**International Searching Authority**: TSA/US

**Signature of Authorized Officer**: [Signature]

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