United States Patent [19]

Matschke

[11] 3,904,011

[45] Sept. 9, 1975

[54] PRINTING HEAD FOR MATRIX PRINTER

[75] Inventor: **Arthur L. Matschke**, Westport, Conn.; **Jack K. Horowitz**, Laurelton, N.Y.

[73] Assignees: **Tele Speed Communications, Inc.**, Syosett, N.Y.

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[21] Appl. No.: **407,236**

[52] **U.S. Cl.** ..... **197/1 R**; 101/93.05

[51] **Int. Cl.²** **B41J 3/05**

[58] **Field of Search** ..... 197/1 R; 101/93.05

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Primary Examiner—J. Reed Fisher
Assistant Examiner—R. T. Rader
Attorney, Agent, or Firm—James J. Burke, II

[57] **ABSTRACT**

A printing head for a dot-matrix printer having one or more annular arrays of radially mounted electromagnets driving print wires located closely adjacent to the center-line axis of the printed character, which axis also corresponds to the center of the annular arrays. The printing head also includes a collector plate having a single aperture for the print wires near the printing face, and means for supporting and driving the printing head. With this printing head mass is kept to a minimum, printing wires are radially disposed to the axis of the printed character and are geometrically closer thereto. This reduces energy losses associated with flexure and friction, and increases printing speed.

20 Claims, 4 Drawing Figures

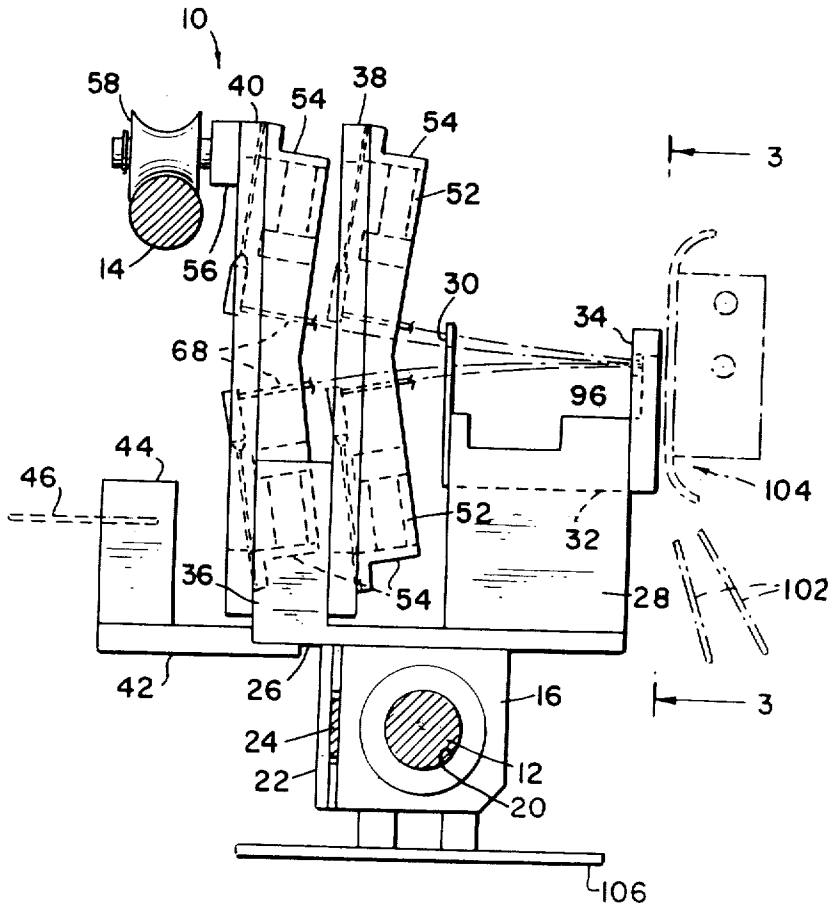


FIG. 1

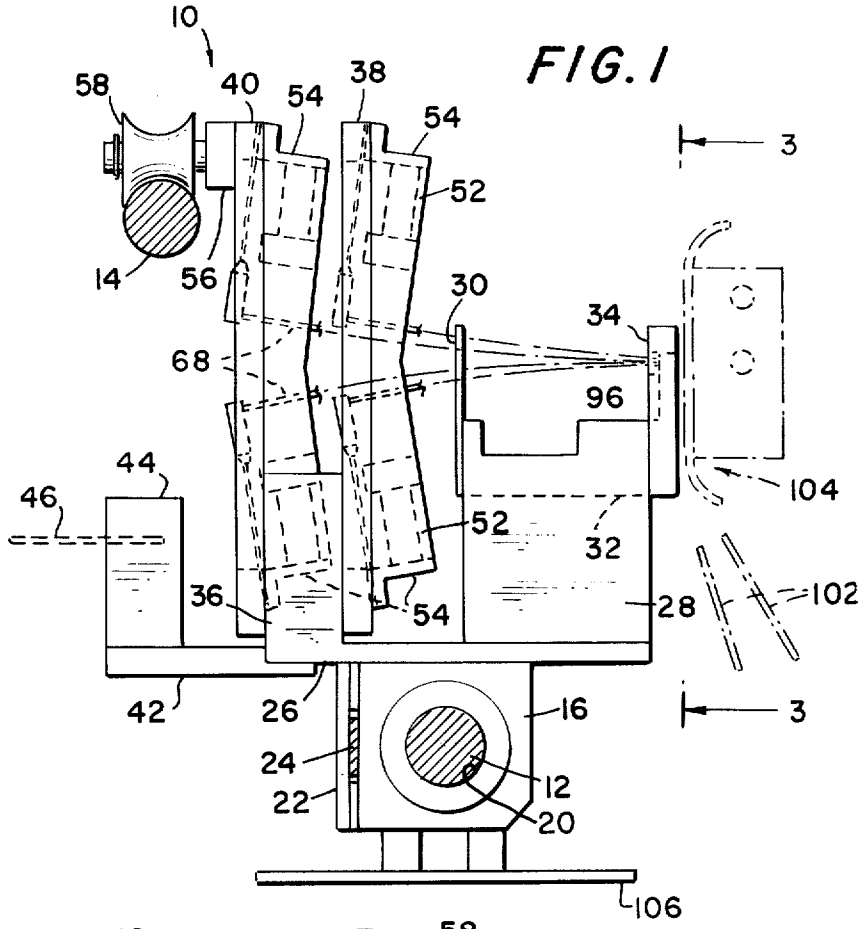

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FIG. 2

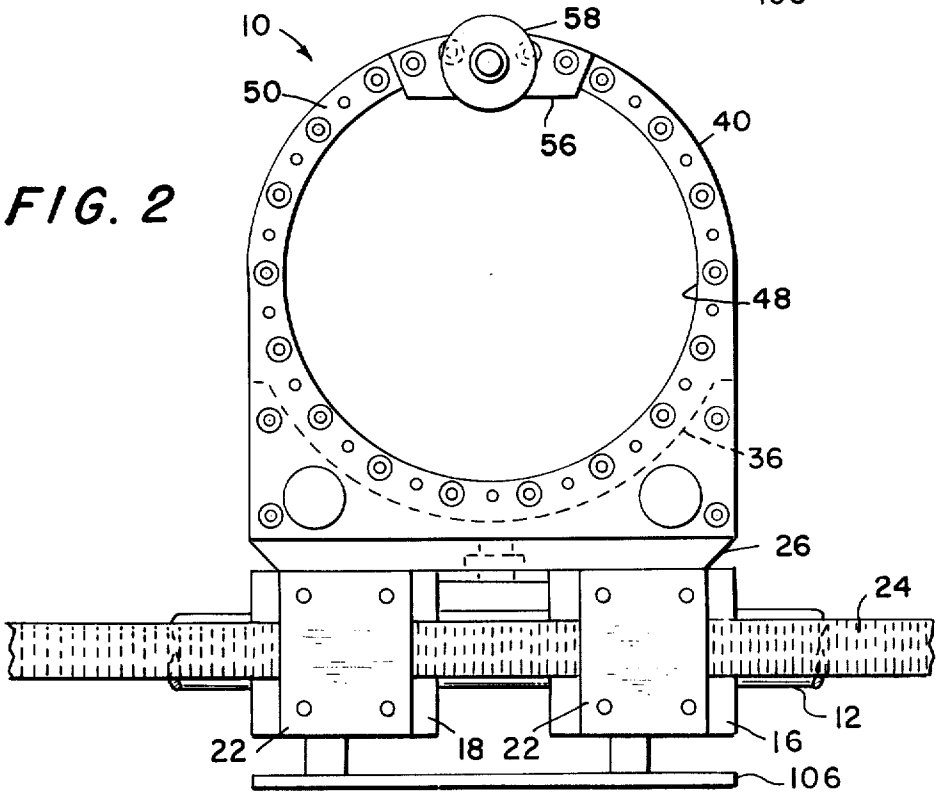
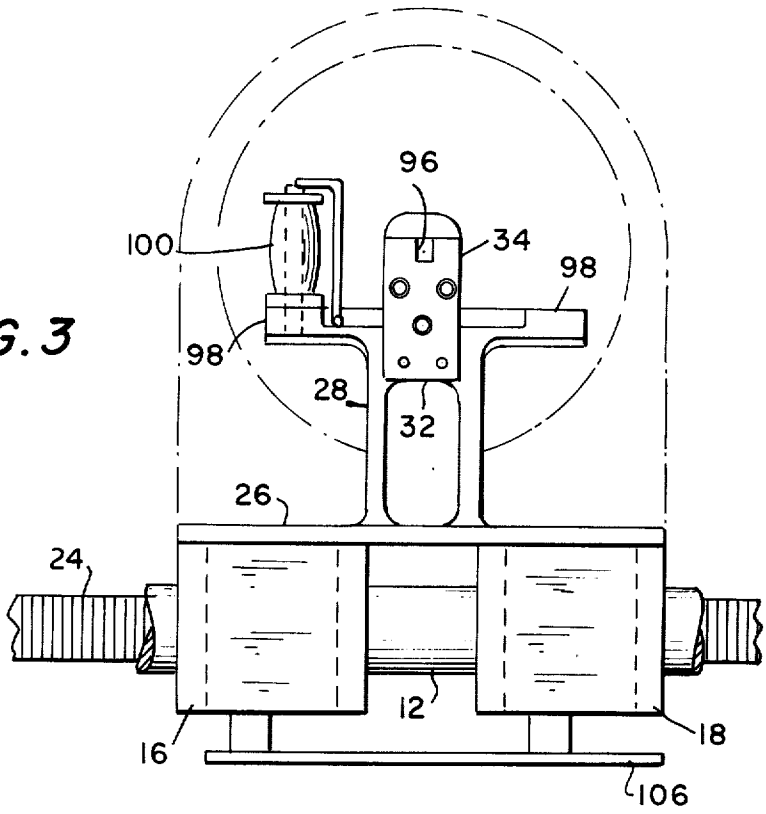

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FIG. 3


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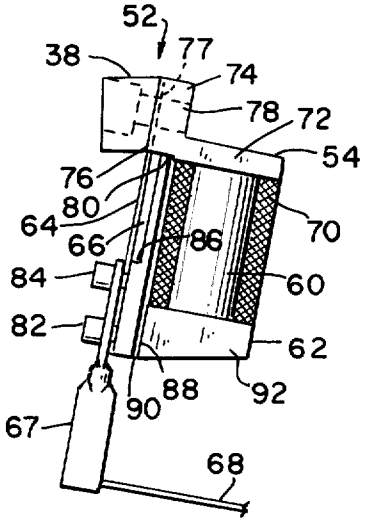

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FIG. 4

PRINTING HEAD FOR MATRIX PRINTER

BACKGROUND OF THE INVENTION

The present invention relates generally to dot-matrix printing and, more particularly, it relates to printing heads for dot-matrix printers.

A dot-matrix printer is one which forms an alphanumeric character from a plurality of dots by forcing the ends of selected printing wires from an array of such wires into contact with a printing medium, i.e. an inked ribbon, and the recording medium or copy. In one arrangement, the array comprises seven wires in a vertical row which produces a character in a five pulse sequence, with horizontal movement of the array or recording medium between each pulse. Alternatively, the array may comprise 35 wires arranged in five rows of seven wires each, which will produce a character with a single pulse, horizontal movement occurring only between characters. As the character printed is of the usual size of typewritten alphanumeric characters, about 0.1 inch × 0.1 inch, it is appreciated that the individual wires in a 7 × 5 array must be of small diameter. The present invention is principally adapted for a 7 × 5 array of printing wires and will be described in connection with such an array, but it could be adapted for other arrays as well.

The printing head of a dot-matrix printer will comprise (1) an array of electromagnets for converting electrical impulses into mechanical force, (2) printing wires driven by individual electromagnets, (3) means guiding the printing wires into close proximity at the printing face, (4) suitable supporting structure, and, except in printers where the printing head is stationary and the medium moves horizontally, (5) horizontal drive and return means. To facilitate quick printing head horizontal movement, including starting, stopping, accurate positioning and quick return, it is desirable that the printing head have the least mass possible.

Electromagnets of the type generally employed heretofore in this service have an axially moveable armature within a core carrying a winding, and the print wire is secured to one end of the armature. Energizing the electromagnets forces the wire against the printing medium and, at the same time, the armature compresses or tensions a spring. The spring provides the force necessary to return the armature and wire to their retracted positions when the coil is de-energized. One problem that has arisen with such devices is the tendency of the print wire to work loose from the armature.

Perhaps the most serious problem in the design of a 7 × 5 dot-matrix printing head results from the necessarily large space between adjacent wires at the electromagnet end thereof (due to the size of the electromagnets) and the very close spacing therebetween at the printing face. This results in the printing wires (1) being of differing lengths, (2) traveling differing tortuous paths at differing angles to the printing face, or (3) a combination of these two. While the mass of the printing wire may be small compared to the mass of the armature, differing wire lengths can cause non-uniformity in printing unless this is compensated for in some way. Flexing of wires during the printing stroke will require tubular guides or the like, and frictional losses caused thereby reduce the force available for printing and also cause non-uniformity of printing and high rates of wear. A 35 electromagnet printing head

will necessarily have many electromagnets and associated print wires far removed from the centerline axis of the printed character. This can be as much as 30°, and means that substantial energy must be expended overcoming friction of the wire against a guiding tube. Compensation for this results in increasing the mass of the printing head (through provision of more powerful electromagnets).

An array of electromagnets in close proximity to each other creates additional problems. In a high speed printer producing 200 characters per second, the electromagnets will generate a substantial amount of heat. Special provision for cooling must be made since the electromagnets are too closely spaced for natural convection to take care of the load. The close spacing can also cause cross-talk problems, due to overlapping magnetic fields, which also impairs the quality of printing.

It would be desirable for dot-matrix printers to produce a solid or near-solid appearing character, but this has not been possible heretofore. The print wires, approaching the printing face from various angles, are still slightly spaced at the printing face; the printed character is thus a collection of discrete dots.

OBJECTS OF THE INVENTION

It is a general object of the present invention to provide an improved printing head for a dot-matrix printer.

Another object of the present invention is to provide a printing head of low mass for dot-matrix printers.

A further object of the present invention is to provide a printing head for dot-matrix printers which is capable of producing solid-appearing characters.

A still further object of the present invention is to provide a printing head for dot-matrix printers wherein all print wires bend through an arc of large radius, and wire flexure is minimized.

Yet another object of the present invention is to provide a printing head for a dot-matrix printer wherein cooling and cross-talk problems are substantially avoided.

A still further object of the present invention is to provide a printing head for a dot-matrix printer wherein all print wires are closely adjacent the centerline axis of the printed character throughout their entire length.

Another object of the present invention is to provide a printing head for a dot-matrix printer that is simple, economical and reliable.

Various other objects and advantages of the present invention will become clear from the following detailed description of an embodiment thereof, and the novel features will be particularly pointed out in connection with the appended claims.

THE DRAWINGS

Reference will hereinafter be made to the accompanying drawings, wherein:

FIG. 1 is a side elevation view of a printing head in accordance with the present invention, with all but four electromagnet units deleted for clarity of illustration;

FIG. 2 is a left end elevation view of the FIG. 1 embodiment;

FIG. 3 is a right end elevation view of the FIG. 1 embodiment, taken along line 3—3 of FIG. 1; and

FIG. 4 is a detailed side elevation view of an electromagnet particularly designed and adapted for use in the FIG. 1 embodiment.

DESCRIPTION OF EMBODIMENTS

In essence, the present invention comprises an array of specially designed electromagnets radially mounted on a pair of annular array plates around the centerline axis of the printed character. Energizing of an electromagnet moves its spring-mounted armature into contact with a pole piece thereof, and a print wire, connected to the armature by a right-angle shoe very close to said centerline axis, is moved into contact with the printing medium. The printing head also includes a transition bearing plate and a collector bearing assembly at the printing face, but other wire-guiding means are not required, because the print wires are very close to the centerline axis along their entire length, are all of substantially the same length and all bend through substantially the same large-radius arc. Support means, electrical connection, drive means and ribbon guide means are also provided.

The present invention differs from prior art dot-matrix printing heads primarily in avoiding the moveable central armature type of solenoid which has the print wire attached at one end. Rather, there is provided a simple leaf spring armature having a shoe terminating in a right angle print wire, which extends back across the axis of the magnet. This allows the electromagnets to be mounted in a circle around the centerline axis of the printed character, with all said shoes very close thereto. While all of the electromagnets for a 7 × 5 array could be mounted in a single circle, it would have to be of impractically large diameter, and it is preferred to mount them in two planes in circles having diameters which are not unduly large. Print wires attached to shoes in one plane are not precisely as long as print wires from the other, but this is not a serious problem.

At the printing face, all of the print wires are on or parallel to the centerline axis of the printed character, and they pass through a single aperture in sliding contact with each other and with the walls of the aperture. This contrasts with prior art printers, where printing wires approach the printing face at a slight angle through discrete apertures, and there is friction and wear between wire and aperture with each stroke. By using a single aperture, substantially solid appearing characters are produced, and friction and wear are actually reduced. This is because wear occurs only along the line of contact between an energized printing wire and one that is at rest and/or the wall of the aperture. On a given stroke there is no friction or wear between adjoining energized printing wires. Since there is only a few degrees of curvature in any print wire, it has a higher column strength and is subject to less flexure than wires in prior art printers. This increases printing efficiency and reduces wire wear.

By virtue of the radial mounting of the electromagnets in a pair of planes, there exists considerable spacing therebetween which substantially eliminates cooling and cross-talk problems.

A preferred embodiment of the printing head of the present invention is illustrated in FIGS. **1–3**, and attention is directed thereto.

The printing head **10** is mounted within the printer (not shown) on a lower carriage bearing shaft **12** and an upper carriage bearing shaft **14**. The printing head **10** is supported on a base including a pair of bearing support legs **16, 18** each having a horizontal bore **20** which accommodates shaft **10**. Legs **16, 18** are also provided with timing belt clamps **22** to which the timing belt **24** is secured. Suitable means (not shown) are utilized to drive timing belt **24** and thus move printing head **10** along shaft **12**.

A print head base plate **26** is integral with the top surfaces of bearing support legs **16, 18,** securing them in spaced relation on shaft **12**. Base plate **26** supports the printing mechanism. Specifically, at the forward side (nearest the printing surface) of the printing head, base plate **26** includes an upwardly extending carriage bearing bridge **28,** to which are secured a wire bearing transition plate **30,** a bridge element **32** and an adjustable-aperture wire collector bearing plate **34,** the structure and function of which are set forth in more detail hereinbelow. On the side of the print head away from the printing surface, base plate **26** has an upwardly extending boss **36,** which serves as a mounting block for the inner and outer electromagnet array plates **38, 40,** also described below. It is preferred that legs **16, 18,** plate **26** bearing bridge **28** and boss **36** be formed as a single machined casting of a non-magnetic and heat-dissipating material. Lastly, plate **26** also includes a bracket **42** for mounting a photoswitch encoder **44.** The later element co-acts with a sequence encoder strip **46** mounted on the main chassis of the printer for use in electromagnet pulse control. Bracket **42** is shown as a discrete part but could also be integral with plate **26.**

Array plate **38, 40** can be merely flat and rectangular and have a large, round bore **48** therein, but minimum mass requirements make it preferable to have the upper portion **50** rounded. Functionally plates **38, 40** could be considered as a circular frame having a mounting leg on the lower portion. It will be appreciated that other arrangements for mounting array plates **38, 40** could be employed. Rigidity of plates **38, 40** will be improved if a plurality of spacer bars (not shown) are employed therebetween.

A plurality of electromagnets **52** are radially deployed at spaced intervals around the periphery of bore **48,** on each of array plates **38, 40,** by a bracket **54** formed on one pole piece of the electromagnet. Electromagnets **52** can be considered as having a generally I-shaped core with bracket **54** extending outwardly from the left side of the top, where it is secured to the front surface of the array plate. Further, the inward surfaces of array plates **38, 40** are angularly milled, so that the mounting surfaces of brackets **54** slope inwardly to form an acute angle with the printing axis, rather than being normal thereto. The angle at which the brackets **54** (and electromagnets) are mounted determines the arc of the print wires, as hereafter discussed.

Outer array plate **40** has a bracket **56** secured along the top edge to provide a mounting for stabilizer bearing **58** which rides on upper carriage bearing shaft **14.** This stabilizes the head and prevents any rotation of the printing head around shaft **12.**

Electromagnets **52** are described and claimed in U.S. Pat. No. 3,836,880 issued Sept. 17, 1974 and assigned to the same assignee as the present application. They are also shown in FIG. **4** and attention is directed thereto.

The electromagnet **52** comprises a core **60** with two integral pole sections **62, 54,** a spring **64** mounted with and adjacent to one pole section, a field shunt **66** and a shoe **67** attached to spring **64.** A printing wire **68** is attached to the free or distal end of shoe **67.** Core **60** of course carries a winding **70,** shown in part. Array plate **38** is also shown in part.

Core **60** with pole sections **62, 54** must be made of a suitable magnetic material or magnetizable material, as must the field shunt **66.** It is preferred that core **60** and pole sections **62, 54** be formed as an integral unit, but this is not necessary. In the embodiment shown, core **60** has a rounded rectangular cross-section. This is not a necessary feature, but provides sufficient flux with minimum mass.

Pole section **54** is located at the outer end of core **60** and comprises a flat plate portion **72** of dimensions suitable to retain the cross-section of winding **70,** and a leg **74** at one side, to provide a mounting structure. Leg **74** has a machined surface **76** including a slot **77.** Spring **64** is secured between slot **77** and the angularly milled surface of array plate **38,** a threaded hole **78** for receiving a screw (not shown) being provided for this purpose.

As shown in FIG. **4,** surface **76** is generally but not necessarily parallel to the axis of core **60.** The precise angle of surface **76** determined the gap and the printing stroke. The inner surface of plate portion **72** is provided with a step-shaped recess **80** adjacent surface **76** to receive the free end of field shunt **66.** This improves magnetic field continuity and provides a mechanical dampener for the moving spring, shunt and shoe assembly on the return stroke, when the free end of shunt **66** will abut recess **80.**

Spring **64** is a leaf spring made out of a suitable material such as spring steel or beryllium-copper, and extends down past inner pole section **62.** The field shunt **66** and shoe **67** are secured to spring **64** at its free end by a pair of screws **82, 84.** Shunt **66** is essentially a bar of magnetic material extending from a point opposite inner pole section **62** into recess **80** on the plate portion **72** of outer pole section **54.** So as not to impede the motion of spring **64,** and to optimize mass distribution and inertial loads, field shunt **66** is undercut at **86,** near screws **82, 84,** a small distance. This permits free movement of spring **64.**

Inner pole section **62** includes a surface **88** forming a strike plate spaced from and opposed to the secured end of field shunt **66.** Surface **88** is not quite parallel with the axis of core **60,** but is rather angled slightly so as to be parallel with the opposing surface of field shunt **66** when the electromagnet is energized, spring **64** rotates in an arc from surface **77,** and the two surfaces are brought into contact. The gap **90** between surface **88** and field shunt **66** is roughly one-half the desired length of stroke of each printing wire. The lower surface **92** of pole section **62** is configured to provide required flux strength and minimum mass.

Shoe **67** is also secured to spring **64** by means of screws **82, 84,** but on the opposite side thereof to field shunt **66.** Shoe **67** extends beyond solenoid **52** to near the center of bore **48.** It is important that shoe **67** be rigid (i.e. not subject to flexure) and of sufficient mass for printing requirements. The print wire **68** is secured in the distal end of shoe **67** and extends back across the axis of core **60** to the printing face.

Thus, when coil **70** is energized, shunt piece **66** is drawn across gap **90** and toward strike plate **88,** tensioning spring **64** and moving print wire **68** the required distance into contact with the printing and recording medium (not shown).

In conventional solenoids, the armature moves away from the center of the flux field as the stroke proceeds. As a result, the greatest force is generated at the beginning of a stroke. With the present invention, the force increases as gap **90** is reduced, and is greatest at the moment of impact with the printing medium. Again with a conventional solenoid, the armature must move the desired length of the printing stroke plus the distance necessary to accomodate any flexure. With the present invention, the distance travelled by shunt **66** across gap **90** is only a fraction of the distance travelled by print wires **68,** because of the larger radius through which the distal end of shoe **67** travels. Not only does this allow a smaller gap **90** for a given length of printing stroke, but it also provides a higher angular velocity for print wires **68** than for shunt **66.** These are all advantageous in dot-matrix printing.

It is preferred that print wires **68** be made of a wear-resistant, low-friction material, and in this service electropolished tungsten wire is preferred. It will be appreciated from geometrical considerations that the less curvature there is in wires **68,** the more printing energy will be delivered at the printing face and the less energy will be dissipated in flexure. It is preferred that such flexure as will inevitably occur take place near shoe **67** rather than where the wires are in close proximity to each other and to bearing plate **30.** The latter could cause momentary delays in wire movement and slow printing rate. To this end, the angle at which electromagnets **52** are mounted is such that wires **68** travel through an arc of shorter radius adjacent shoe **67,** which radius increases with distance therefrom. Overall, wires **68** describe an approximately parabolic arc with the short radius near shoe **67.**

Print wires **68** extend from shoes **67** into the aperture **96** in collector wire bearing plate **34** in the large radius arc as described above. As an additional aid in guiding print wires **68,** transition wire bearing plate **30** may be provided at an intermediate point. Transition plate **30** has **35** discrete holes (not shown) for print wires **68,** arranged in a pattern that is intermediate the double-circle pattern of the wires in the planes array plates **38,** 40 and the 7×5 rectangular pattern at the face. Adjacent the printing face, the wires **68** are confined in a single aperture **96** in collector wire bearing plate **34.** Aperture **96** is nominally 0.070 inch $\times$ 0.100 inch, but adjustable, so as to accomodate differing sizes of print wires **68,** as well as providing the ability to compensate for wire wear.

As noted hereinabove, the use of a single aperture **96** to contain all print wires **68** is a distinct advantage of the present invention. Not only is wire wear reduced, but by framing the wires **68** in this way, squareness of the characters is insured, the distance between the printing face and the recording medium is less critical, and clear, substantially solid-appearing characters are produced.

Bridge element **32** may also be provided with outwardly extending arms **98** (FIG. **3**) to act as supports for ribbon guides **100** (one shown).

In FIG. **1**, certain ancillary printer features which are not part of the present invention are shown in phantom. These are paper guides **102** and floating platen **104.**

It will be appreciated that print wires **68** connected to electromagnets **52** mounted on outer array plate **40** will necessarily be somewhat b nger than those mounted on inner array plate **38.** The difference in mass caused by these two wire lengths is not sufficient to affect printing quality, but it is preferred that the inner mounting surfaces of the two array plates be machined at slightly different angles so that print wires **68** from the planes of both array plates have essentially the same geometry and flexure characteristics.

If desired, logic circuity for driving the solenoids can be mounted on the printing head **10.** As shown in FIG. **1**, the circuit board **106** is secured on suitable brackets to the underside of legs **16, 18.** This may simplify electrical connection (not shown) from the signal input to electromagnets **52.**

It should be apparent from the foregoing that the printing head of the present invention accomplishes the stated objects by providing a pair of radial electromagnet arrays that enable all printing wires to be located near the centerline axis of printed characters. The radial electromagnet mounting also enables the electromagnets to be so spaced that cooling and cross-talk problems are essentially eliminated. The printing head of the invention is of low mass, but has a weight-to-power ratio sufficient for superior printing (in fact, it weighs no more than known seven-solenoid printing heads). The increased depth of printing field, due to all print wires being parallel at the printing face, makes the printer easier to use because platen adjustment is seldom required. Those skilled in the art will appreciate that in any successful printing head the flux paths, pulse widths, mass, intertia, resonances, decay rates and overall geometry must be considered and carefully coordinated in order to achieve optimum results of fast and trouble-free printing.

Various changes in the details, steps, materials and arrangement of parts, which have herein been described and illustrated to explain the nature of the invention, may be made by those skilled in the art within the principle and scope of the invention as defined in the appended claims and their equivalents.

What is claimed is:

1. Printing head for dot-matrix printing at a printing face comprising:

means for supporting said printing head within a printer;

electromagnet mounting means on said support means spaced from the printing face of said printer and including vertical plate means having a large diameter bore therein;

printing wire collector plate means mounted on said support means adjacent the printing face of said printer and having a single printing wire aperture therein; the axis of which defines the centerline axis of a character to be printed;

a plurality of electromagnets mounted around the periphery of said bore and having armature means terminating in shoe means extending at their distal ends to near said centerline axis at a small angle to a plane normal to said axis;

each said electromagnet including a core having an axis extending radially from said centerline axis;

energizing of said electromagnets functioning to move said distal end of said shoe means toward said aperture a distance equal to a desired printing wire stroke; and

printing wire means extending from each said shoe means into said aperture and terminating in a plane parallel and closely adjacent to said printing face, each said printing wire means describing an arc of large radius.

2. The printing head as claimed in claim **1**, wherein said support means includes drive means for moving said printing head parallel to said printing face.

3. The printing head as claimed in claim **1**, wherein said electromagnet mounting means includes a pair of said vertical plate means in spaced, parallel relation.

4. The printing head as claimed in claim **1**, and additionally comprising transition plate means intermediate said shoe means and said collector plate means including apertures guiding said printing wire means.

5. The printing head as claimed in claim **1**, wherein the axis of said bore is coincident with the centerline axis of characters to be printed.

6. The printing head as claimed in claim **1**, wherein said arc is an approximately parabolic arc having its shortest radius at said shoe means.

7. The printing head as claimed in claim **1**, wherein said electromagnet means include spring return means to retract said shoe means to a rest position when said electromagnet means is de-energized.

8. The printing head as claimed in claim **1**, wherein each said printing wire means extends from said shoe means back across the axis of the core to its associated electromagnet.

9. The printing head as claimed in claim **7**, wherein each said electromagnet comprises:

magnetic means including two opposed pole sections and a core extending therebetween;

a coil surrounding said core between said pole sections;

said armature means comprising:

leaf spring means secured to one said pole section and extending substantially parallel to the axis of said core to the other said pole section;

magnetic field shunt means secured to said spring means and extending between but spaced from said pole sections;

said shoe means secured to said spring means and extending therebeyond; and

said printing wire means extending back across the axis of said core.

10. The printing head as claimed in claim **1**, and additionally comprising circuit means for selectively energizing said electromagnet means in accordance with received signals.

11. The printing head as claimed in claim **1**, wherein said printing wire aperture is adjustable.

12. The printing head as claimed in claim **3**, including 35 of said electromagnets, said aperture retaining said printing wires in a seven-by-five array.

13. Printing head for dot-matrix printing at a printing face comprising:

means for supporting said printing head within a printer;

electromagnet mounting means on said support means spaced from the printing face of said printer and including vertical plate means parallel to said

printing face and having a large diameter bore therein;

printing wire collector plate means mounted on said support means adjacent said printing face and having a single, adjustable printing wire aperture therein, the axis of which defines the centerline axis of characters to be printed;

a plurality of electromagnets radially mounted around the periphery of said bore, each said electromagnet comprising:

magnetic means including two opposed pole sections and a core extending therebetween, the axis of said core extending radially from said centerline axis;

a coil surrounding said core between said pole sections;

leaf spring means secured to one said pole section and extending substantially parallel to the axis of said core to the other pole section;

magnetic field shunt means secured to said spring means and extending between but normally spaced from said pole sections;

shoe means secured to said spring means and extending at the distal end thereof to near said centerline axis at a small angle to a plane normal to said axis;

printing wire means extending from each said shoe means back across the axis of said core and into said aperture, and terminating in a plane parallel and closely adjacent to said printing face, each said printing wire means describing an arc of large radius;

energizing of said electromagnets functioning to move the distal end of said shoe means toward said aperture a distance equal to a desired printing wire stroke.

14. The printing head as claimed in claim **13,** wherein said support means includes drive means for moving said printing head parallel to said printing face.

15. The printing head as claimed in claim **13,** wherein said electromagnet mounting means includes a pair of said vertical plate means in spaced, parallel relation.

16. The printing head as claimed in claim **13,** and additionally comprising transition plate means intermediate said shoe means and said collector plate means including apertures guiding said printing wire means.

17. The printing head as claimed in claim **13,** wherein the axis of said bore is coincident with the centerline axis of characters to be printed.

18. The printing head as claimed in claim **13,** wherein said arc is an approximately parabolic arc having its shortest radius at said shoe means.

19. The printing head as claimed in claim **13,** and additionally comprising circuit means for selectively energizing said electromagnet means in accordance with received signals.

20. The printing head as claimed in claim **15,** including 35 of said electromagnets, said aperture retaining said printing wires in a seven-by-five array.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,904,011 Dated September 9, 1975

Inventor(s) Matschke, Arthur L.; Horowitz, Jack K.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 8, line 32: "to" should be --of--.

Signed and Sealed this

eighteenth Day of *November 1975*

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks