

[54] **SOLENOID FOR WIRE PRINTER**

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[52] U.S. Cl. .... **335/274, 197/1 R**

[51] Int. Cl. .... **H01f 7/08**

[58] Field of Search ..... **197/1; 335/258, 260, 274**

[56] **References Cited**

**UNITED STATES PATENTS**

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**FOREIGN PATENTS OR APPLICATIONS**

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Primary Examiner—George Harris

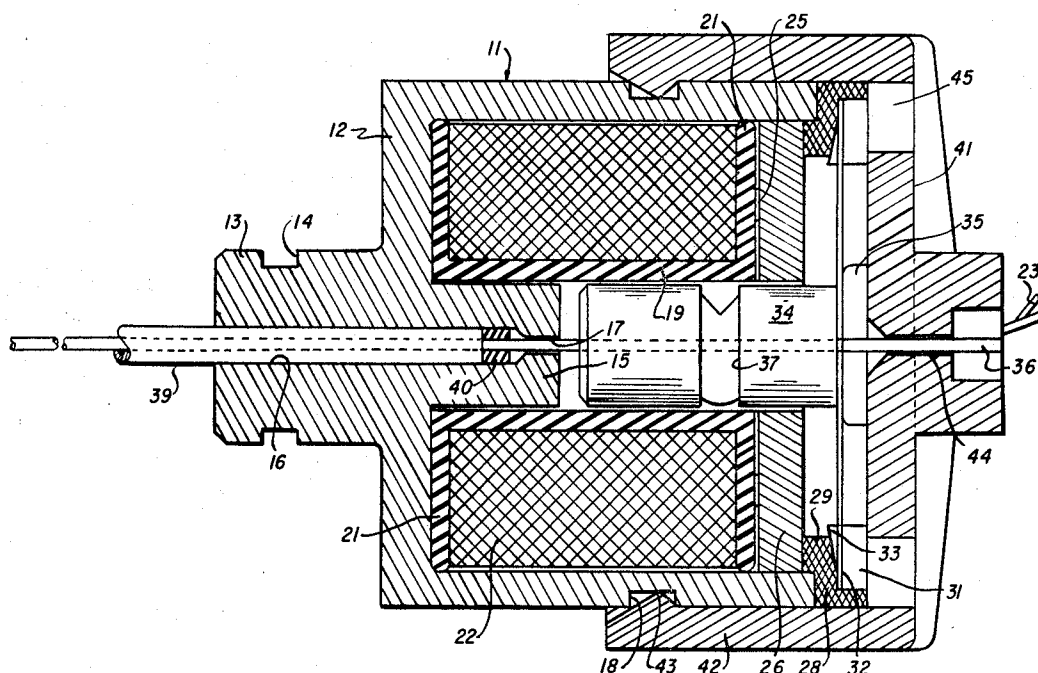
Attorney, Agent, or Firm—Davis, McCaleb & Lucas

[57]

**ABSTRACT**

Solenoid for longitudinally actuating printing wire in high speed wire printer comprising metal housing open at one end, a coil in the housing, an annular pole piece substantially closing open end of housing to eliminate air gap in flux path, a plunger secured to print wire by swaging to avoid degrading its magnetic characteristics and movable within and axially of coil and pole piece, a flat tempered steel spring engaging plunger to retain same in inactive position and to return it thereto following energization of the coil, a plastic spring seat formed as a ring mounted in open end of housing with recesses receiving ends of spring, and a plastic cap mounted over open end of housing in snap-fit engagement therewith, the cap and housing having axial bores to accommodate printing wire, with an enlarged outer portion of housing bore receiving a plastic bearing and the end of a plastic tube slidably encasing a major portion of the wire.

**11 Claims, 7 Drawing Figures**



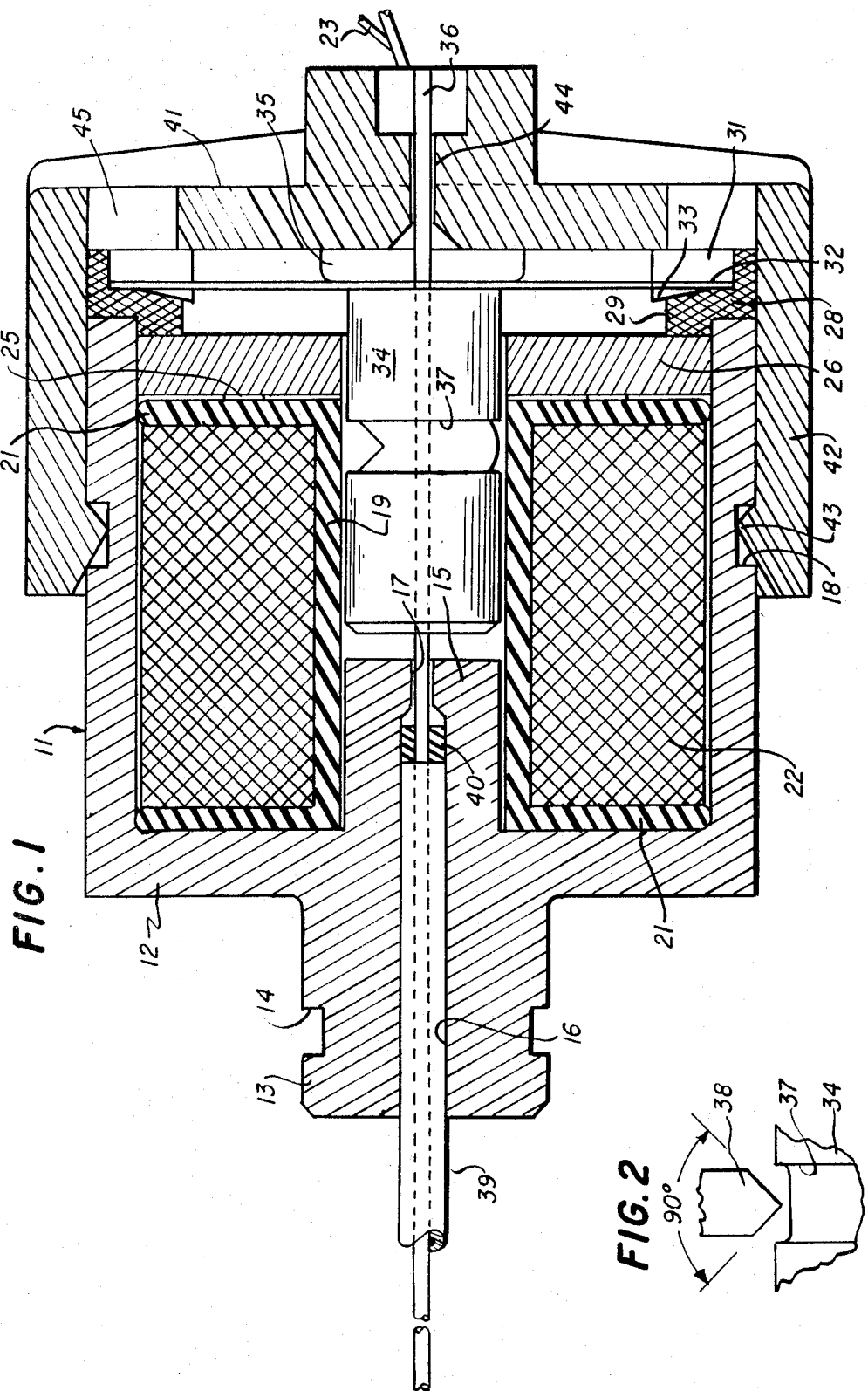


FIG. 6

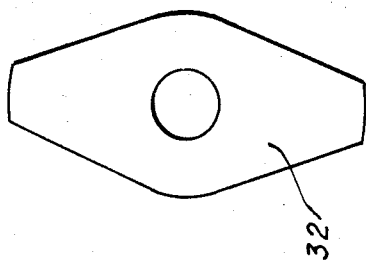


FIG. 5

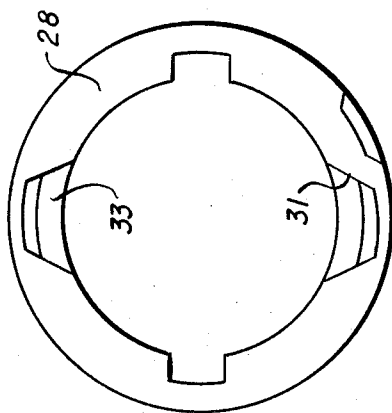


FIG. 3

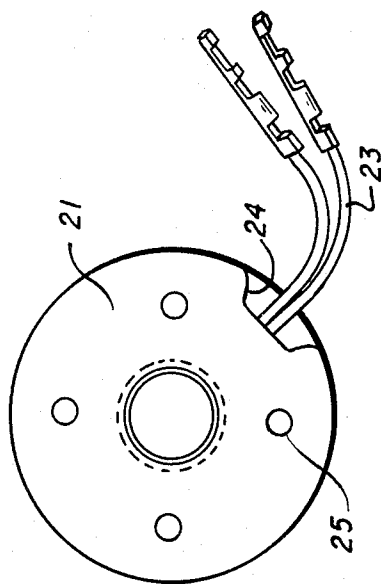


FIG. 7

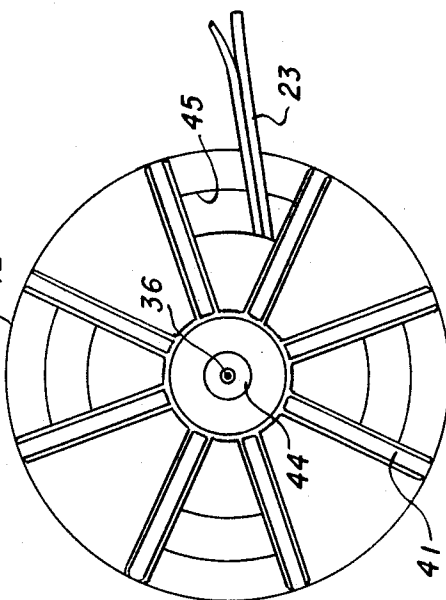
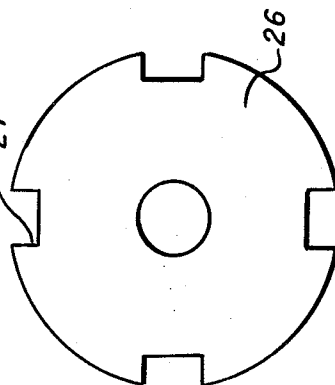


FIG. 4



## SOLENOID FOR WIRE PRINTER

## BACKGROUND OF THE INVENTION

## 1. Field of the Invention

This invention relates in general to wire printers, and more particularly to a solenoid for actuating a printing wire in a very high speed wire printer.

## 2. Description of the Prior Art

Prior wire printers have used electromagnets for longitudinally actuating the printing wires and have secured the wires to the armatures employed, such as by soldering, brazing, various types of adhesive bonding, and force and spring fits, but all of these have proven to be unsatisfactory, both as to cost and unreliability in the field, as well as introducing non-magnetics that degrade the magnetic characteristics of the assembly. These disadvantages of the prior structures are tremendously magnified with increased speed of operation, and a large number of parts and adjustments during manufacture, assembly and because of excessive wear are required by such devices.

## SUMMARY OF THE INVENTION

This invention enables very high speed of operation of a wire printer with maximum reliability by using a solenoid for longitudinally actuating each printing wire, comprising a metal housing having an open end for receiving the coil and an annular pole piece substantially closing the open end of the housing to eliminate air gaps in the flux paths, and a plunger movable axially relative to the coil and pole piece and having a bore for slidably receiving the printing wire to which it is secured by swaging to avoid degrading its magnetic characteristics while preventing any separation of the wire from the plunger. The solenoid further employs a spring engaging the plunger to retain it in inactive position and to return it thereto, following energization of the coil to move the plunger to operated position and deenergization of the coil, which is a flat piece of tempered steel centrally apertured to receive the plunger and having its ends retained by a plastic spring seat, together with a plastic cap mounted over the open end of the housing. The unreliability, excessive wear, adjustments and manufacturing and assembly problems inherent in electromagnets used in prior wire printers thus are all eliminated and a much higher speed of operation is attained.

## IN THE DRAWINGS:

FIG. 1 is a longitudinal cross-sectional view through a solenoid embodying the features of the invention;

FIG. 2 is a detailed elevation of a portion of the plunger and a swaging tool;

FIG. 3 is an end elevational view of the coil assembly, as seen from the rear or right end of FIG. 1;

FIG. 4 is a similar elevation of the pole piece;

FIG. 5 is an end view like FIGS. 3 and 4 of the spring seat;

FIG. 6 is an end elevation of the spring; and

FIG. 7 is an end view of the cap, as seen from the right of FIG. 1.

## DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring more particularly to FIG. 1, reference numeral 11 indicates, in general, a solenoid for longitudinally actuating a printing wire in a high speed wire

printer embodying the features of this invention which includes a metal housing 12, preferably of cold rolled steel with a cadmium finish. The front end of the housing (the left end in FIG. 1) is reduced to form an outer mounting hub 13 having a circumferential groove 14 for receiving a split retaining ring (not shown). As illustrated in copending application for U. S. Letters Patent Ser. No. 313,248, this outer mounting hub 13 is inserted through a suitable aperture in a printing head casing and retained therein by means of a split ring being snapped into the groove 14. The housing 12 is provided with an extension of the outer mounting hub 13 comprising an inner hub 15 and a stepped bore through both hubs 13 and 15 having an outer portion 16 and a reduced inner portion 17 at its inner end. Housing 12 also is provided with a circumferential groove 18 in the outer surface of its cylindrical body for a purpose to be later described.

Mounted interiorly of the solenoid housing 12 is a coil comprising a bobbin 19 in the form of a spool with a hollow cylindrical drum and circumferential end flanges 21. This bobbin 19 is made of plastic, preferably that produced by E. I. du Pont de Nemours and Co., Inc. under their trademark "ZYTEL." Wound upon the bobbin 19 between the end flanges 21 are a plurality of turns of wire 22 to complete the coil. In the illustrated embodiment, No. 32 AWG wire is employed in 530 turns covered with thermosetting pressure-sensitive adhesive tape, with each end of the wire connected to a suitable lead 23. As best seen in FIG. 3, the rear flange 21 is provided with a peripheral slot 24 to accommodate the leads 23, and four protuberances 25 which extend longitudinally of the solenoid rearwardly therefrom (FIG. 1) and are spaced from each other circumferentially thereof adjacent the flange periphery.

Mounted interiorly of the housing 12 adjacent the rear end flange 21 of the coil is a metal pole piece 26 which, like the housing 12, is of cold rolled steel machined to extremely close tolerances with a cadmium finish. This pole piece 26 is centrally apertured and provided with four marginal slots 27 spaced from each other (FIG. 4), one of which will accommodate the leads 23. A plastic spring seat 28 (FIGS. 1 and 5) in the form of a ring marginally reduced on its front face to define a flange 29 (FIG. 1) fitting into the open rear end of the housing 12 engages against the latter and the pole piece 26. The spring seat 29 preferably is made from the plastic manufactured by E. I. du Pont de Nemours and Co., Inc. under its trademark "DELRIN" because of its excellent wear resistant and bearing characteristics. The rear face of this spring seat 28 has two diametrically opposed recesses 31 for receiving the ends of a flat tempered steel spring 32 (FIG. 6) with each of the recesses 31 including an inner surface 33 which slopes centrally inwardly to accommodate forward flexing of the spring 32.

The spring 32 has a central recess slidably receiving the main body of a plunger 34 (FIG. 1) which terminates at its outer end in an enlarged integral head 35 for flexing the spring and being moved by it in a manner later to be described. As seen from FIG. 6, this flat spring 32 preferably has a substantially diamond shape with the corners thereof cut off or rounded and the upper and lower ends approximately one-third as wide as its central recessed midportion. The main body of the plunger 34, which preferably is made of cold rolled steel, heat treated and subsequently nickel

plated, is cylindrical and only slightly smaller in diameter than the inner hub 15 of the housing 12 and extends freely through the central aperture of the coil retainer or pole piece 26 and into the hollow drum portion of the coil bobbin 19. The plunger 34 has a central bore for receiving a printing wire 36 to which it is secured in unique fashion.

Intermediate its ends, the plunger 34 has a peripheral groove 37 which originally is shaped with a flat bottom surface having a slight curvature at its ends into its side walls, as shown in FIG. 2. After insertion of the printing wire 36 through the bore of the plunger 34, this groove portion 37 is compacted or compressed in well-known manner by a suitable swaging tool 38 (FIG. 2) to permanently secure the plunger to the wire 36. Following such swaging operation, the groove 37 will have been reshaped as shown in FIG. 1. After such attachment of the printing wire 36 and plunger 34 and subsequent assembly thereof in the solenoid, an extruded plastic guide tube 39 is slid onto the wire to encase a major portion thereof, with the rear end of the tube being disposed in the outer portion 16 of the bore of the housing 12 as a bearing for the wire during longitudinal operational movements thereof. It is preferred that this tube 39 be made from the plastic manufactured by E. I. du Pont de Nemours and Co., Inc. under the trademark "ZYTEL." An auxiliary bearing for the wire 36 is provided in the form of a plastic ring 40 mounted in the inner end of the enlarged outer portion 16 of the bore of the housing 12. This bearing 40 preferably is made from a plastic manufactured by E. I. du Pont de Nemours and Co., Inc. under the trademark "DELRIN."

To complete the solenoid 11, a plastic cap 41 is mounted over the open rear end of the housing 12 (FIGS. 1 and 7). This cap 41 preferably also is made from "DELRIN" and comprises a ribbed end portion joined at its periphery with forwardly extending fingers 42 (FIG. 1) circumferentially spaced from each other as axially extending arms with inturned noses 43 seating in the annular circumferential groove 18 of the housing 12 to effect a snap-fit engagement of the cap on the housing. The end wall of the cap 41 is provided with a stepped bore 44 for guidingly accommodating the rear end of the printing wire 36 and a plurality of apertures 45 spaced between the fingers or arms 42, through one of which the leads 23 extend, as shown in FIG. 7.

It is necessary to maintain the coil 22 against longitudinal or axial movement relative to the housing 12. This is assured by the close tolerances required for the latter and the pole piece 26, which substantially eliminate air gaps and provide for a press fit of the pole piece into the open end of the housing, and the protuberances 25 on the rear flange 21 of the bobbin 19 previously described. As the pole piece 26 is pressed into the housing 12 during assembly of the solenoid, it crushes or compresses these plastic protuberances 25 which firmly seats the bobbin in the housing while obviating the holding of the outer length of this plastic bobbin 19 to extremely close tolerances. Thus, the pole piece 26 also functions as a coil retainer.

Referring to FIG. 1, it will be understood that the operative parts of the solenoid 11 comprising the spring 32, plunger 34 and printing wire 36 are illustrated in normal or inactive position. When the winding 22 of the coil is energized, the plunger 34 is driven forwardly or to the left in FIG. 1 by completion of the flux path

created by the coil through housing 12, pole piece 26, plunger 34 to the housing 12. This imparts longitudinal printing movement forwardly or to the left in FIG. 1 to the wire 36. Deenergization of the coil permits the plunger and wire assembly 34, 36 to be restored immediately by the spring 32 from operated position to inactive position. The reason for providing the inwardly sloping surfaces 33 in the spring receiving recesses 31 of the spring seat 28 now will be apparent as being to accommodate the flexing of the spring 32 by the head portion 35 of the plunger as the latter is moved forwardly to operated position. Wear, which might be caused by the high frequency movements of the spring 32, has been eliminated by the use of a plastic material for the spring seat 28 having outstanding bearing characteristics.

It will be appreciated that this solenoid 11 employs a minimum number of parts, substantially eliminates any air gaps in the flux paths and the necessity for any adjustment due to excessive wear or during manufacturing and assembly. The method heretofore described for securing the plunger 34 to the printing wire 36 is inexpensive and extremely efficient, and results in a reliable mechanical attachment with out introducing any non-magnetics that would degrade the magnetic characteristics of this assembly 34, 36. The construction of the solenoid 11 not only thus eliminates the several disadvantages of prior printing wire actuating mechanisms in reducing costs and insuring reliable operation, but also enables very high speed of operation of the order of 1.2 milliseconds to complete a reciprocation of the printing wire from inactive to actuated position and back to inactive position, with the wire having been moved longitudinally approximately .015 of an inch.

It is thought that the invention and many of its attendant advantages will be understood from the foregoing description, and it will be apparent that various changes may be made in the form, construction and arrangement of the parts without departing from the spirit and scope of the invention or sacrificing all of its material advantages, the form hereinbefore described being merely a preferred embodiment thereof.

We claim:

1. A solenoid for longitudinally actuating a printing wire in a high speed wire printer, comprising a metal housing open at one end, a coil mounted in said housing, an annular pole piece substantially closing said open end of said housing, a cylindrical plunger having a through axial bore for receiving and secured to the printing wire and movable within and axially of said coil and pole piece, a flat and substantially diamond-shaped spring engaging said plunger to retain the same in inactive position and to return it thereto following energization of said coil to move said plunger to operated position and deenergization of said coil, and a plastic cap removably mounted over the open end of said housing to limit movement of said plunger by said spring relative to said housing.

2. A solenoid according to claim 1, wherein said plunger is secured to said wire by peripheral swaging to avoid degrading its magnetic characteristics.

3. In a solenoid according to claim 2, wherein said housing has a hub with a stepped axial bore having an enlarged outer portion and a reduced inner portion receiving said printing wire, a plastic tube slidably encasing a major portion of said wire with one end thereof

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disposed in said enlarged outer portion of said housing bore as a bearing for said wire.

4. In a solenoid according to claim 3, a plastic ring in the inner end of said enlarged outer portion of said housing bore as an auxiliary bearing for said wire.

5. A solenoid according to claim 2, wherein said plastic cap has an axial bore for receiving an end portion of said wire and guiding longitudinal movements thereof.

6. In a solenoid according to claim 1, a plastic seat for the ends of said spring engaging said pole piece and said housing and held in the latter by said cap.

7. A solenoid according to claim 1, wherein said spring comprises a flat piece of tempered steel centrally apertured to receive said plunger, and said plunger has an enlarged end flange engaged by said spring.

8. In a solenoid according to claim 7, a spring seat for engaging the ends of said spring, comprising a plastic ring interposed between said housing and said cap.

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9. A solenoid according to claim 8, wherein said ring is formed with diametrically opposed recesses in its outer face receiving the ends of said spring and having inner surfaces sloping centrally inwardly to accommodate inward flexing of said spring by said plunger.

10. A solenoid according to claim 1, wherein said coil comprises a plastic bobbin having a rear flange with rearwardly extending protuberances adapted to be compressed by said pole piece during insertion of the latter into said metal housing, whereby said pole piece functions as a coil retainer to prevent axial movement of said coil relative to said housing.

11. A solenoid according to claim 1, wherein the outer surface of said housing has a peripheral groove, and the inner end of said cap comprises axially extending arms with inturned noses seating in said groove to effect a snap-fit engagement of said cap on said housing.

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