May 28, 1968 F. H. SHEPARD, JR 3,385,211

SOLENOID ARRANGEMENT FOR HIGH SPEED PRINTER

Filed Dec. 15, 1965 2 Sheets-Sheet 1

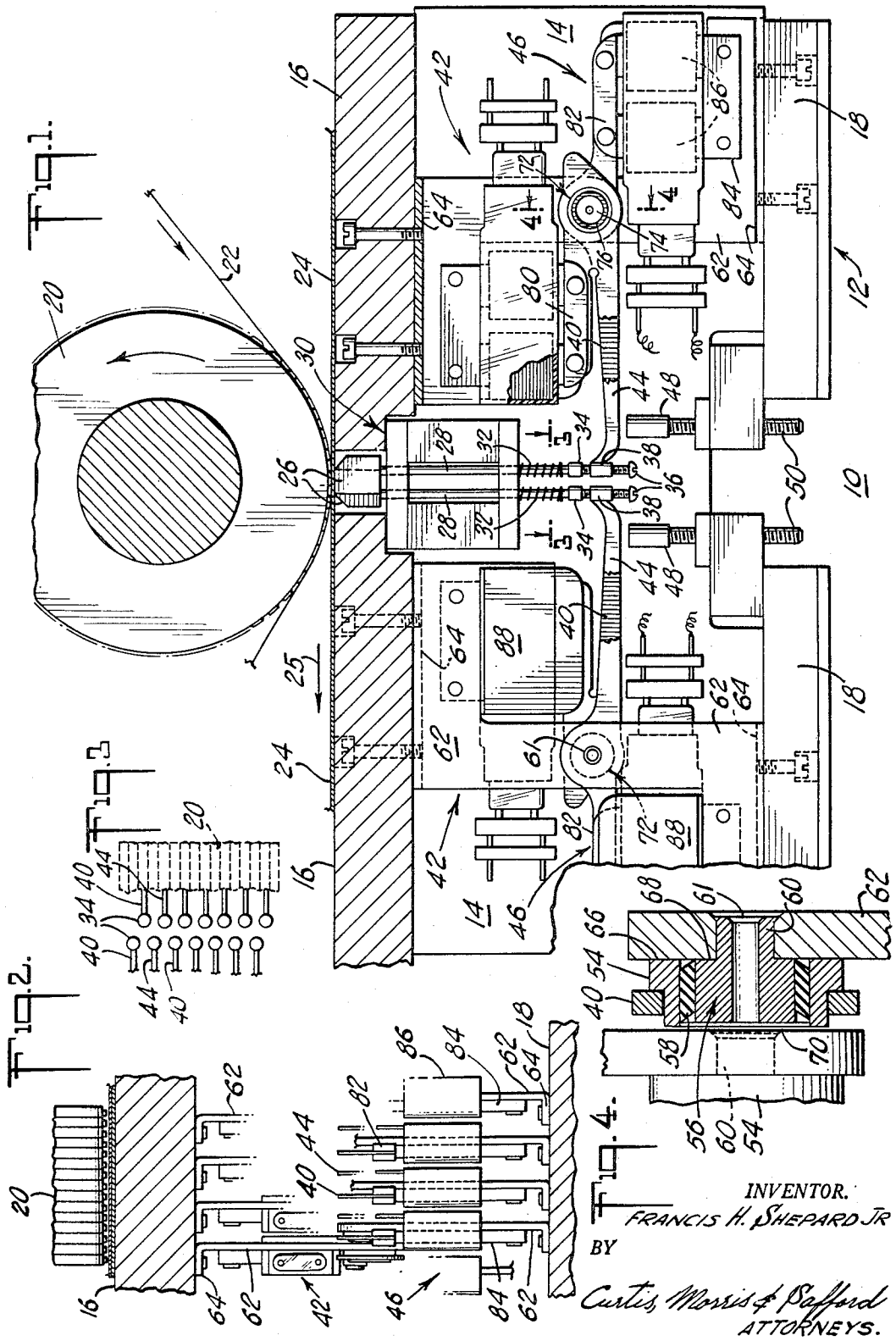

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

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Fig. 5.

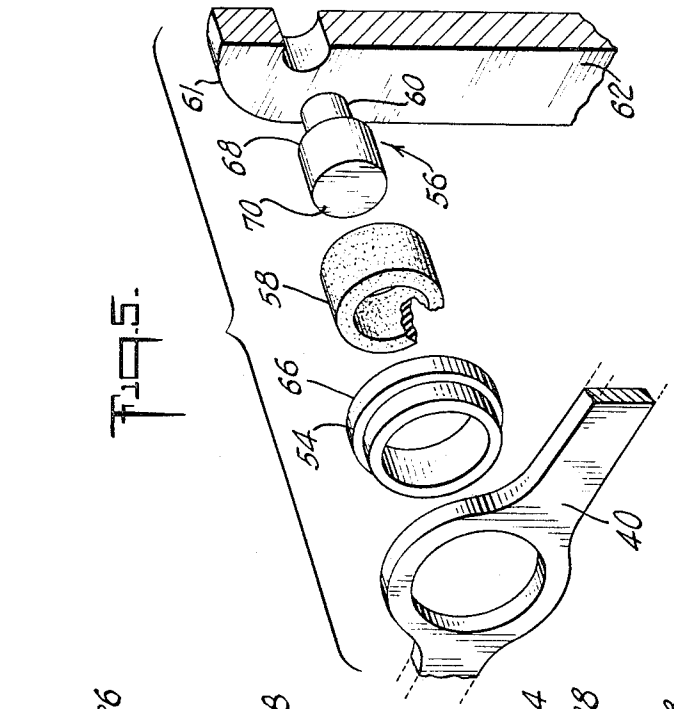
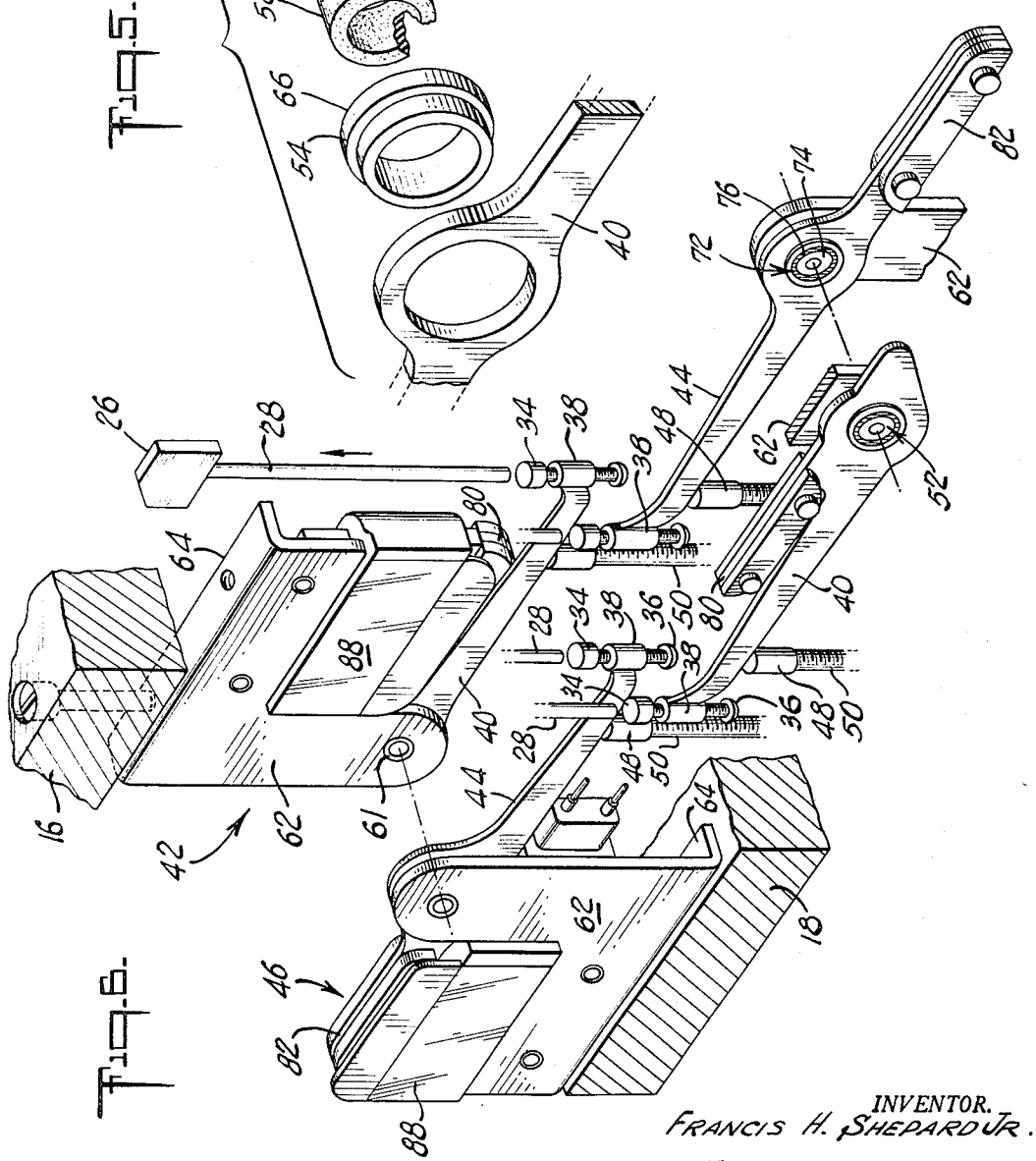


Fig. 6.



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SOLENOID ARRANGEMENT FOR HIGH SPEED PRINTER

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This invention relates to an improved electromagnetic solenoid for firing a hammer in a high speed printer.

An object of this invention is to provide a solenoid which has substantially improved efficiency and which can be closely spaced in a high speed printer.

A further object is to provide a solenoid which has extreme longevity and reliability.

Another object is to provide a closely spaced solenoid arrangement in which the individual solenoids have more closely matched operating characteristics and greater freedom from interaction than previous arrangements.

Still another object is to provide a solenoid which can be mass produced at low cost and with great precision.

These and other objects will in part be understood from and in part pointed out in the following description.

In the inventor's United States Patent 2,787,210, he describes a high speed printer in which characters are printed on a page or sheet of paper at kilocycle rates by blows of hammers against a continuously moving type font. For each character to be printed across the page there is a corresponding hammer and its associated drive or firing solenoid. Standard spacing for printed characters produced by this kind of machine is ten to the inch horizontally across the page. Thus the hammers, and their solenoids, must be spaced ten to the inch and this presents design and operating difficulties with the solenoids. The present invention in one of its aspects greatly alleviates these difficulties.

An important requirement in a high speed printer is that the hammers and their solenoids operate with extreme timing accuracy (e.g., be timed to strike within plus or minus a few microseconds) for billions of cycles of operation. If the timing deteriorates or becomes erratic, the quality of printing of the machine is seriously affected.

Among the factors which affect the timing of the hammers are the low efficiency of the solenoids which drive them, the relatively slow speed of response of the solenoids, the degree of interaction among them when tightly packed in a machine, and their long-term wear and aging characteristics. The present invention in another of its aspects provides an improved solenoid design which greatly reduces these difficulties.

The design of previous solenoids, such as shown in the above-mentioned patent, has been such that the individual solenoids were expensive to manufacture and moreover were not uniform in their operating characteristics. The present invention, in another of its aspects, makes possible low cost, mass manufacture of solenoids with extreme precision.

A better understanding of the invention together with a fuller appreciation of its many advantages will best be gained from the following description given in connection with the accompanying drawings wherein:

FIGURE 1 is a side view of the printing mechanism, including solenoids embodying the invention, of a high speed printer,

FIGURE 2 is a front view of the mechanism showing the close side-by-side spacing of the solenoids,

FIGURE 3 is a top view of the solenoid tips taken as indicated in FIGURE 1,

FIGURE 4 is an enlarged section view through a solenoid pivot taken as indicated by lines 4—4 in FIGURE 1,

FIGURE 5 is an enlarged exploded view of a portion of a solenoid pivot, and

FIGURE 6 is an exploded perspective view of several solenoids showing their mounting in the printer mechanism.

The printer mechanism **10** shown in FIGURE 1, which is part of a high speed printer, includes a frame generally indicated at **12**. This includes vertical end plates **14**, horizontal upper plates **16**, and horizontal lower plates **18**, all of which are rigidly fastened together. Mounted on the frame for rotation on a horizontal axis is a print drum **20**, which has alpha-numeric characters around its rim and which is spaced closely above an ink ribbon **22**, and a strip of paper **24**. The latter is advanced a line at a time in the direction of the arrow **25** during operation of the machine. Positioned in a horizontal line closely beneath the print drum and paper is a row of individual hammers **26**, which are typically spaced ten to the inch. Each hammer has a shank **28** which is adapted to slide up or down in a guide assembly **30**. The lower end of each hammer shank has a limber spring **32** which biases the hammer downward to a rest position (not shown).

The bottom of the hammer shank is engageable by a small plastic cap **34** fixed on an adjusting screw **36**. The latter is threaded through an end sleeve **38** carried on the short movable arm **40** of an upper solenoid generally indicated at **42**, or on the long movable arm **44** of a lower solenoid generally indicated at **46**. These upper and lower solenoids are arranged in two upper and two lower banks on both sides as shown, the solenoids in each bank being spaced on 0.4 inch centers perpendicular to the plane of FIGURE 1. FIGURES 2, 3, and 6 show how the solenoids are interleaved.

When a solenoid is energized by a pulse of current, the arm of the solenoid drives its respective hammer upward a short distance to force paper and ribbon against a selected one of the print characters around the rim of drum **20**. Since the print drum moves continuously with a rim speed of, for example, 200 inches per second, the blow of each hammer against the drum must be timed within a few microseconds to achieve precise registration of the characters printed across a line.

Each solenoid arm **40** and **44** comes down to reset near its outer end upon a plastic stop **48** carried on a respective one of the adjustable timing screws **50** supported by the frame.

As seen best in FIGURE 6, upper solenoid arm **40** is hairpin shaped and is pivoted at its inner end about a pivot member generally indicated at **52**. This, as seen also in FIGURES 4 and 5, includes a light annular hub **54** and a center post **56**, the two being bonded together by a rubber annulus **58**. Center post **56** has a rivet pin **60** which is staked in a hole **61** provided in a stamped metal solenoid frame **62**. The latter has a right-angle base **64** which is screwed to the frame of the machine.

Now, when the solenoid is energized, its arm is swung through a small angle about pivot **52**, thus flexing rubber **58** in the pivot. Upon deenergization of the solenoid, the rubber (which is under stress) returns the solenoid arm **40** to its rest position (shown only in FIGURE 6) against stop **48**. Though the use of rubber in a solenoid pivot is broadly old, according to one feature of the present arrangement arm **40** is supported in cantilever fashion from solenoid frame **62** by pivot **52**. This permits the frame to be an inexpensive metal stamping. In order to minimize sidewise play or wobble of the solenoid arm, and as seen best in FIGURE 4, the inner end of hub **54** has a face **66** which bears against the vertical side of solenoid frame **62**. A light axial pull by the rubber **58** holds face **66** engaged with frame **62**.

Each pivot **52** is fabricated separate from arm **40** and frame **62**. In manufacture, center post **56** is offset slightly

to the left of its position relative to hub **54** shown in FIGURE 4. While held in the offset position, the two are bonded to each other by the rubber. Then hub **54** is seated and cemented in arm **40**. Finally, post **56** is staked onto solenoid frame **62** with the post's inner end shoulder **68** (see FIGURE 4) tightly flush against frame **62**. In the course of staking the post onto the frame, the rubber in pivot **52** is axially stressed and hub face **66** is pulled against the frame. The arm is angularly oriented on the post so that in the rest position shown in FIGURE 6, the rubber in pivot **52** is torsionally stressed and arm **40** is lightly held against stop **48**.

As seen in FIGURE 4, the outer end face **70** of center post **56** protrudes slightly to the left beyond the other members shown in cross-section. This end face **70** is closely placed near the back of the next adjacent solenoid. If face **70** touches the adjacent solenoid frame, post **56** will act as a lateral spacer and none of the moving elements of the solenoid will rub against an adjacent one.

An important feature of the invention is that the operating characteristics of the upper and lower solenoids are closely matched. It will be seen in FIGURES 1 and 6 that the upper solenoid arm **40** is bent over like a hairpin with pivot **52** at its rear. On the other hand, the lower solenoid arm **44** is straight (in effect, an unbent arm **40**) and is fulcrummed near its center at a pivot **72**. The latter supports arm 44 in cantilever fashion from a solenoid frame **62**, and is fabricated and assembled in the same way as pivot **52**. However, pivot **72** has a center post **74** of slightly larger diameter than post **56** and a rubber annulus **76** of correspondingly smaller thickness than rubber **58**. In other respects the two pivots **52** and **72** are identical. This difference in pivots **52** and **72**, and the respective shapes of arms **40** and **44** match the upper and lower solenoids with respect to actuation of the hammers, as will be explained more fully below.

Now, it will be noted in FIGURE 6 that upper solenoid arm **40** has forward of pivot **52** a pole piece **80**, and that arm **44** has to the rear of its pivot **72** a similar pole piece **82**. These pole pieces close against a respective one of the U-shaped magnetic yokes **84** riveted to the solenoid frames. Each yoke contains a pair of coils **86** electrically connected together and which when energized produce a strong magnetic field in the yoke. Alongside each coil and extending above the air gap between the yoke and the arm pole piece is a magnetic shield **88** which prevents magnetic interaction of one solenoid with the adjacent one. In the absence of the shields over the solenoid gaps, magnetic interaction would be a troublesome problem, whereas with shields **88** present, this interaction is effectively eliminated. The configuration and the small lateral spaces occupied by pole pieces **80** and **82** in this new arrangement permit shields **88** to extend into the very close spaces between laterally adjacent pole pieces **80** and laterally adjacent pole pieces **82**.

When upper solenoid **42** is energized by a short, strong pulse of current, its pole piece is quickly pulled up to the position shown in FIGURE 1. The arm is made of spring steel and though stiff can be flexed slightly in a vertical plane. In the course of the rapid movement of pole **80**, and since the outer tip of the arm is engaged with a hammer **26** and works against its inertia, arm **40** flexes and unbends slightly. Also, the rubber in pivot **52** is momentarily deflected sideways relative to its axis, thus permitting the rear end of the arm to move upward slightly. The overall effect is to permit pole piece **80** to close against yoke **84** before the outer or tip end of arm **40** has completed its travel. Thereafter, the tip end of the arm "whips" the hammer upward and allows it to travel in free flight (see FIGURE 6) a short distance before striking the paper and print drum **20**. This whip action of the arm is analogous to that of a limber fishing or casting pole. A strong pull at pole piece **80** is transformed efficiently into high velocity at the tip end of the arm. An added benefit is that pole piece **80** closes against the solenoid yoke with much lower velocity than if arm **40** and pivot **52** did not have springiness. This means that very little mechanical shock is transmitted to the frame when the solenoid closes. Because the generation of shock waves is reduced in the first place, and because adjacent solenoid arms are cushioned by their rubber pivots, there is greatly reduced interaction of adjacent solenoids. The end result of this is much better alignment of the characters printed on the paper.

Lower solenoid arm **44** is similar in its springiness to arm **40**, and by matching the total springiness of the lower arm and its pivot to the arm and pivot of an upper solenoid, the two solenoids have closely matched characteristics.

The tip screw **36** of an upper solenoid is adjusted so that with the solenoid held closed (as shown in FIGURE 1) hammer **26** is raised 0.030 inch from a reference point on the frame. In the same way, the tip screw **36** of a lower solenoid is adjusted so that its hammer is raised 0.040 inch. These adjustments can be made in the machine as finally assembled and permit the achieving of extreme precision.

In a machine which has been built and successfully operated, pivot hub **54** has an internal diameter of 0.312 inch, and post **56** an external diameter of 0.188 inch. Post **74** has an external diameter of 0.250 inch. The faces **70** of the posts, when staked on their solenoid frames extend 0.005 inch beyond hub **54**. The axial length of hub **54** is 0.110 inch and, in relaxed condition, shoulder **68** is offset 0.010 inch from shoulder **66**. The rubber in the pivots is a silicone rubber made by General Electric Co. and sold as RTV–30. It withstands high frequency vibrations and shocks and has a suitable durometer and chemical inertness, whereas numerous other materials were found to be unsuitable. The drawings herein are drawn as nearly as possible to exact scale.

The above description is intended in illustration and not in limitation of the invention. Various modifications and changes in the embodiment set forth may occur to those skilled in the art and may be made without departing from the spirit or scope of the invention.

I claim:

1. In a high speed printer of the character described, a first elongated hammer adapted to be fired end first against a type font and the like, a first hammer firing solenoid comprising a thin springy arm, an outer end of which engages said hammer, a pivot on said arm at a point along its length, an upstanding frame for supporting said pivot, said frame supporting said pivot in cantilever fashion, said pivot including an annular portion of rubber-like material which provides springiness in conjunction with the springiness of said arm, a yoke and coil assembly on said frame for actuating said arm, a second hammer similar to the first, a second solenoid similar to the first and containing a second arm, pivot and yoke assembly, said first arm being straight with its pivot intermediate its ends, said second arm being bent with said pivot near the area of bend, said first pivot being matched to said first arm and said second pivot being matched to said second arm to give substantially identical operating characteristics for said first and second solenoids, whereby said solenoids can be tightly packed in the printer and will operate said hammers uniformly.

2. The arrangement in claim **1** wherein the hammer engaging end of each of said arms carries a transversely adjustable hammer engaging tip, whereby a number of said solenoids can be placed in a printer and adjusted to extreme precision with respect to the hammers therein.

3. The arrangement in claim **1** wherein there are a number of said solenoids packed closely side by side in a printer, each of said yoke and coil assemblies including a magnetic shield which extends above the space or gap between arm and yoke to minimize magnetic coupling between adjacent solenoids.

4. In a hammer firing solenoid, a hammer actuating arm engaged for actuation over a small arc, a rubber-like pivot arrangement for said arm including a center post

affixed in cantilever fashion to a frame, and an annulus of rubber-like material bonded to said post and fixed to the arm, there being steady axial tension in said annulus so that said arm is pulled toward said frame by axial tension in said rubber-like annulus, whereby wobbling of said arm is minimized.

5. The arrangement in claim 4 wherein the deflectability of said annulus is matched to the springiness of said arm and its configuration.

6. An improved hammer firing solenoid comprising a thin formed metal frame having an upstanding portion with a flat face, a pivot cantilevered from said face of said frame, and a thin spring metal arm mounted on said pivot for actuation over a small angle of arc, said pivot containing concentric portions held coaxial by a rubber-like annulus bonded therebetween, one portion being affixed to said arm, the other portion being affixed to said frame, said rubber-like annulus being axially stressed to hold said arm from wobbling laterally.

7. An improved hammer firing solenoid arrangement comprising a lightweight elongated hammer adapted to be fired axially against a print font, a transverse actuating arm having an inner end and an outer tip and lying generally transverse to the axis of said hammer, the tip of said arm being engageable with the end of said hammer to fling it at high velocity toward said print font, said arm being swingable over a small arc and allowing said hammer to continue in free flight toward said print wheel, a solenoid frame, a yoke and coil mounted on said frame to actuate said arm, and a pivot connecting said arm to said frame adjacent said yoke, the tip of said arm including adjustable screw means having an end which engages said hammer whereby said solenoid can be adjusted with extreme precision, said pivot including a torsion rubber-like mount which permits said arm to swing and is stressed both axially and torsionally to return said arm to a rest position and to keep it from wobbling laterally.

8. The arrangement in claim 7 wherein there are a number of said hammers spaced closely in a row, and a corresponding number of solenoids each having an arm and frame, each of said pivots having a stationary part which extends beyond the movable part of pivot and arm and which serve as spacers, each arm having an adjustable tip which is individually adjusted to give the same hammer rise.

9. The arrangement in claim 7 wherein said arm and pivot have a combined spring rate, said rate being adjusted to provide a whip action in firing said hammer, whereby said arm closes against said yoke with reduced velocity and shock.

10. The arrangement in claim 9 wherein said arm is straight and is pivoted near its center, and in further combination with a second solenoid and hammer, said second solenoid having an arm which is generally U-shaped and is pivoted near its end, the spring rate of said second arm and its pivot being substantially matched to the spring rate of said first arm and pivot.

11. An improved hammer firing solenoid arrangement comprising a lightweight elongated hammer adapted to be fired axially against a print font, a transverse actuating arm having an inner end and an outer tip and lying generally transverse to the axis of said hammer, the tip of said arm being engageable with the end of said hammer to fling it at high velocity toward said print font, said arm being swingable over a small arc and allowing said hammer to continue in free flight toward said print wheel, a solenoid frame, a yoke and coil mounted on said frame to actuate said arm, and a pivot connecting said arm to said frame adjacent said yoke, the tip of said arm including an adjustable screw threaded in a barrel and mounted with its axis substantially along the axis of said hammer, one end of said screw carrying a plastic head which engages said hammer, whereby said solenoid can be adjusted with extreme precision with respect to said hammer.

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