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PRINT HAMMER HAVING BRAKING MEANS

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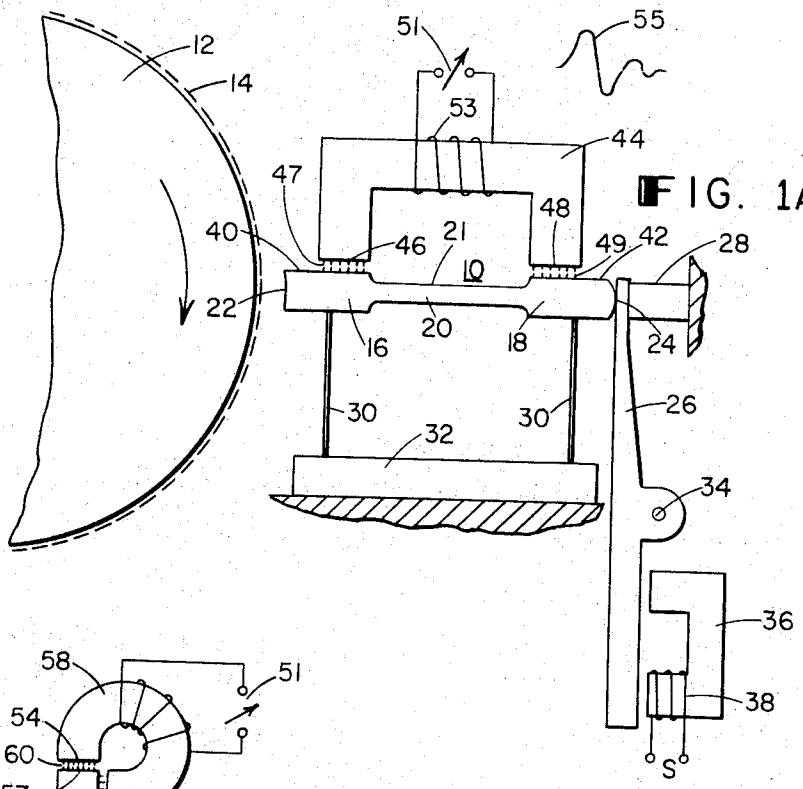


FIG. 1A

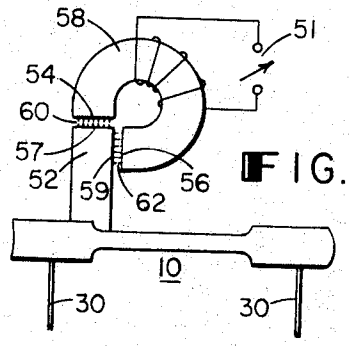


FIG. 2A

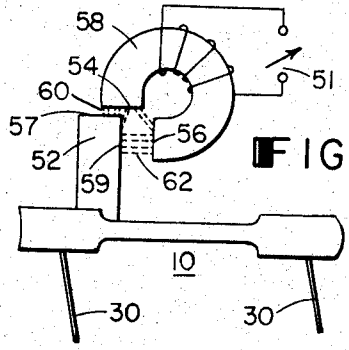


FIG. 2B

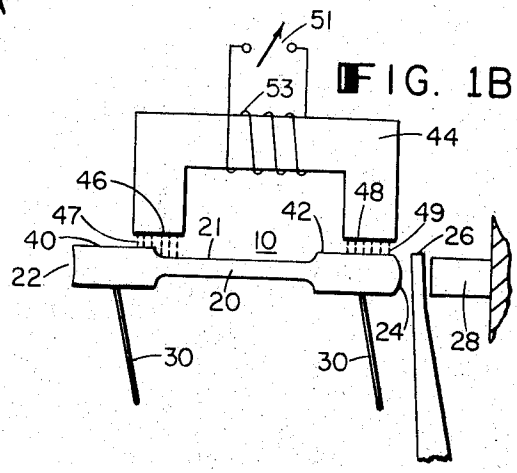


FIG. 1B

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PRINT HAMMER HAVING BRAKING MEANS

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The present invention relates in general to new and improved high-speed printers and in particular to high-speed printers of the kind wherein the print hammers selectively strike a moving type carrier to print on an intermediately stationed paper web.

While very high print speeds are feasible in a printer having a movable type carrier and selectively actuated print hammers, the timing requirements for actuating the print hammers are very severe. Precise control of the time of arrival of the print hammer at the moving type carrier is necessary to avoid positional variations. The exercise of such control on a repetitive basis requires the application of the same force from the same reference position each time the print hammer is actuated.

In one embodiment of a high-speed printer, the print hammer is spring-biased to the rest position into contact with an actuator arm that abuts a back stop. By energizing the actuator arm, the print hammer is propelled forward against the moving type carrier, from which it rebounds to return to its rest position, in part under the influence of the biasing springs. The hammer return normally occurs at a high velocity so as to cause further rebounding when the rear impact surface of the print hammer meets the actuator arm. The second rebound is in a forward direction and, if sufficiently large, may cause shadow printing or "ghosting" on the paper. If the print hammer is again propelled forward by the actuator arm while it is still rebounding, i.e. before it has settled in its rest position, neither the amount of force imparted to the print hammer, nor its total travel will be the same as during the previous hammer actuation. Accordingly, the flight time of the print hammer, and hence its arrival at the type carrier, will be different and will result in a positional variation of the printed character from the norm. If the type carrier is a rotating type roll whose raised characters move columnarly past each print hammer at the print station, any variation of the flight time of the latter will result in the printing of the character above or below the print line. If the type carrier is in the form of a chain or belt which moves parallel to the aligned row of print hammers at the print station, variations in the flight time of a print hammer will result in a variable positioning of the printed character along the print line.

In a 1000-line-per-minute printer which uses a type roll as described above, actual printing for each line may occur during a period of the order of 45 milliseconds, succeeded by a period for paper feeding of the order of 15 milliseconds. It is during the latter period that the print hammers must settle in their rest positions in time to meet the worst-case condition, when the last print hammer to be actuated during the previous print cycle is actuated first in the next print cycle. Clearly, if higher printing speeds are to be achieved by shortening the print and paper feed cycles, the hammer rebounding interval following hammer actuation must not be the limiting condition.

Various damping techniques have been proposed to quench print hammer rebound oscillations more quickly but none, to date, have provided completely satisfactory performance. In one such hammer damping arrangement, an elastic material is positioned between each actuator arm back stop and a fixed support, to absorb the shock

of the returning hammer transmitted through the back stop. Past experience has shown that, during high-speed operation of such an arrangement, hammer oscillations may still be present under worst-case conditions to vary the arrival time of the hammers at the print roll during the subsequent print cycle. Apart from the fact that such arrangement is expensive to implement since each back stop must be individually provided, the rest position of the hammer has a tendency to shift with repeated use due to the compaction of the elastic material. Such a change increases the distance each hammer has to travel and, since it may vary from hammer to hammer dependent on the amount of use, it contributes to variations of the respective hammer flight times.

A further disadvantage derives from the fact that no control over the damping characteristics can be exercised once the elastic material is installed. For example, if it is necessary to exchange the hammers there may be sufficient difference in their characteristics to require a change in the amount of damping required. Where an elastic damping material is used behind each back stop, such a change cannot be readily carried out.

Accordingly, it is the primary object of the present invention to provide a print hammer damping arrangement which overcomes the foregoing disadvantages.

It is another object of the present invention to provide a print hammer damping mechanism in a high-speed printer for rapidly settling the oscillations of the returning print hammers.

It is a further object of the present invention to provide a print hammer damping arrangement for a high-speed printer which is simple in construction and economical to implement.

It is an additional object of the present invention to provide a damping arrangement for rapidly settling the rebound oscillations of a moving member whose damping characteristics are adjustable.

The foregoing objects of the present invention, together with the features and advantages thereof, will become apparent from the following detailed specification with reference to the accompanying drawings in which:

FIGURES 1A and 1B illustrate a preferred embodiment of the present invention; and

FIGURES 2A and 2B illustrate another embodiment of the invention.

With reference now to the drawings, FIGURE 1A shows an elongated print hammer **10** which is stationed opposite a type roll **12** that is adapted to rotate at a constant rate in the direction of the arrow. The type roll has raised characters **14** on its outer surface which are arranged in successive rows of characters, each row containing as many identical characters as there are hammers at the print station. In a preferred embodiment, each print station may include a row of 132 print hammers aligned side by side.

The print hammer **10** is seen to have a forward section **16** and a rear section **18** connected by a central shank **20**. All portions of the print hammer are of uniform thickness. The forward print hammer section terminates in a concave striking surface **22** which faces the type characters **14** as they rotate past the print station. The rear hammer section **18** terminates in a convex impact surface **24** which, when the hammer **10** is in the rest position shown in FIGURE 1A, abuts an actuator arm **26**. The latter in turn rests against a fixed back stop **28**. The hammer **10** is supported on a pair of leaf springs **30** which are affixed to the hammer front and rear sections respectively, as well as to a fixed hammer support **32**. The actuator arm **26** is rotatably disposed about a pivot **34**, the lower arm portion facing a solenoid **36**. A signal S may be selectively applied to the terminals of a solenoid winding **38**.

The front and rear hammer sections **16** and **18** respectively, further include a pair of planar raised surfaces **40** and **42** respectively, which project above the corresponding surface **21** of the shank **20**. A horse shoe electromagnet **44** is positioned to one side of the print hammer **20** and has a pair of pole faces **46** and **48**. The configuration of the pole face **46** is such that, in the rest position of the print hammer, it is positioned opposite the front section surface **40** to define a gap **47** therebetween of substantially uniform width. The pole face **48** is positioned opposite the rear hammer surface **42** to define a uniform gap **49** of substantially the same width as the gap **47**. A signal source **51** is connected across the terminals of a winding **53** of the magnet **44** and is selectively adapted to provide an underdamped current waveform **55**, as shown in FIGURE 1A. The applied signal may be varied as to amplitude and duration to obtain the desired damping characteristics.

The arrangement illustrated in FIGURE 1A is substantially repeated 132 times in the preferred embodiment of the invention, with respective print hammers **10** aligned in a row side by side. Each print hammer is supported on a pair of leaf springs and sufficient clearance exists between them to permit hammer movement. A single magnet **44** is preferably employed, which runs the length of the entire row of print hammers, so that successive print hammers are positioned opposite different portions of the same pair of pole faces **46** and **48**. Each support **32** may either carry a single print hammer, or a modular arrangement may be used wherein more than one print hammer is carried by a single support. The actuator arms **26** of successively positioned print hammers may alternately extend from above and below in FIGURE 1A, so as to obtain the requisite spacing to accommodate each solenoid **36**.

In the hammer rest position which is illustrated in FIGURE 1A, the convex impact surface **24** is in contact with the actuator arm **26**, which in turn rests against the fixed back stop **28**. The leaf springs **30** are either perpendicular to the support **32** in the rest position, or they are tilted slightly in a forward direction, i.e. toward the type roll **12**, in order to apply the requisite bias to the print hammer **10** to urge it to the rest position. The spacing of the concave hammer striking surface **22** from the raised characters **14** in the hammer rest position, is determined by the number of copies to be printed simultaneously which, together with interleaved sheets of carbon paper and an inked ribbon, must be accommodated therebetween.

When a signal S is applied to the winding **38** of any solenoid **36** during the print cycle, the corresponding actuator arm **26** is attracted and pivots forward about its pivot pin **34**. The forward movement of the actuator arm **25**, which is in contact with the convex impact surface **24** in the rest position of the hammer **10**, causes the latter to be propelled forward as illustrated in FIGURE 1B. In a preferred embodiment of the invention, the movement of the actuator arm **26** is limited so that the print hammer **10** travels forward toward the type roll **12** under its own momentum and at high velocity to drive the intermediately positioned paper and ribbon against the latter. Upon rebounding off the type roll, the hammer returns toward its rest position, to which it is urged by the leaf springs **30**. In its rearward travel, the hammer **10** also returns the actuator **26** into contact with the back stop **28**.

The return movement of the hammer to its rest position occurs at approximately one-half the incident velocity. Hammer rebounding off the actuator **26** and subsequent hammer oscillations must be suppressed as quickly as possible during the paper feed cycle in order to ready the hammer for printing during the next print cycle. To this end, a damping signal, having an underdamped waveform **55**, is applied to the magnet winding **53** at the termination of each print cycle. This damping signal

sets up a flux path which includes the magnet **44**, the hammer **10** and the two flux gaps **47** and **49**. The gap-bridging flux lines, which are indicated by dotted lines, in the drawings, have their minimum length in the hammer rest position shown in FIGURE 1A, so that the overall flux path similarly is at a minimum then.

While the length of the flux path in the gap **49** remains the same in the forward hammer position illustrated in FIGURE 1B, the width of the gap **47** is non-uniformly increased and the flux path in the gap **47** is materially greater than that prevailing in the hammer rest position. The length of the overall flux path is therefore increased and a force is set up to return the hammer to its rest position. This behavior is due to the minimum reluctance principle whereby the flux has a tendency to seek the shortest path. Since the flux path in the gap **47** has its minimum length when the hammer is in its rest position, the effect of the flux will be to oppose a further rebound of the returning hammer off the hammer actuator **26**.

It will be noted that the damping action is controllable in degree and in time by controlling the damping signal which is applied to the winding **53**. The maximum amplitude of the applied signal, which may be of the order of 3 to 4 amperes, will depend on the desired damping characteristic of the overall arrangement. The damping signal is applied only during the paper feed cycle. Thus, there is no interference with the forward hammer movement during the print cycle. It will be understood that the damping signal, being applied immediately following the termination of the preceding print cycle, acts to settle only the hammers which are still oscillating at such time. Those hammers which are actuated early in the print cycle will normally have settled to their rest position at end of the print cycle.

The actuator arm **26** is seen to be positioned in close proximity to the aforesaid flux path, but is preferably excluded therefrom for efficient operation. Accordingly, the arm **26** may consist of stainless steel whose permeability is low compared to the permeability of the hammer **10** which may consist of hardened steel. The end of the actuator arm **26**, which is in contact with the hammer impact surface **24**, may be treated to lower its permeability still further.

FIGURES 2A and 2B illustrate a further embodiment of the present invention, applicable reference numerals having been retained. A toroid-like magnet **58** is employed whose pole faces **54** and **56** are positioned at right angles to each other. As in the embodiment of FIGURES 1A and 1B, the pole faces **54** and **56** run the entire length of the aligned row of print hammers **10**. In this embodiment, each print hammer carries a flag **52** consisting of a high-permeability material, which is positioned between the pole faces **54** and **56** in the hammer rest position shown in FIGURE 2A. A pair of uniform gaps **60** and **62** is defined between a pair of mutually perpendicular flag surfaces **57**, **59** and the pole faces **54** and **56** respectively.

FIGURE 2B illustrates the forward hammer position. The pole face **54** now faces only a portion of the flag surface **57**. Accordingly, some of the flux flowing through the pole face **54** now links the surface **59** and another portion of the flux directly links the pole face **56**. The width of the pulse gap **60** is therefore non-uniformly increased. Similarly, the width of the flux gap **62** is greater when the hammer **10** is in its forward position than in the rest position.

An important advantage of the arrangement illustrated in FIGURE 2 resides in the fact that the print hammer and the actuator arm may be effectively excluded from the magnetic flux path, which now includes only the magnet **58**, the gaps **60** and **62** and the flag **52**. Since the latter is not subject to the requirements which are applicable to the hammers, it may consist of a high-permeability material so that greater sensitivity is obtained and the damping action is more readily effected.

It will be readily realized that the present invention is

susceptible of operating in different environments and may itself be modified, depending on the particular operating conditions under which it is to be employed. For example, the damping arrangement herein disclosed may find application in chain printers where rapid settling of the hammer oscillations is similarly required. The physical configuration of the hammers **10** may vary, provided only that a projection is provided which is flux-linked to a magnetic pole through a variable gap. The hammer itself need not be supported on leaf springs, as shown, but may travel in a set of guides, urged to a rest position by resilient means. Similarly, the actuation of the hammer may be effected in various ways, directly, or indirectly as shown, and by means of different force applying means.

The present invention provides a relatively simple damping arrangement which permits a high-speed print hammer to settle to its rest position in a time interval as small as 3 milliseconds, as compared to intervals of 20 milliseconds and more required in prior art devices. Under these conditions print hammer rebounding is no longer a limitation on the increase in printing speed, as is the case in prior art damping arrangements. In addition to its simplicity, the present invention provides controllable damping to suit the requirements of different operating conditions. Moreover, the use of one magnet which spans the entire row of print hammers permits the implementation of the invention at relatively low cost.

From the foregoing disclosure of the invention it will be apparent that numerous modifications and departures may now occur to those skilled in the art, all of which fall within the spirit and scope contemplated by the invention.

What is claimed is:

1. A damping mechanism comprising a component movable between two extreme positions, means for resiliently urging said component to one extreme position, means for selectively driving said component to said other extreme position, and means for damping out the oscillations of said component upon its return to said one extreme position, said damping means comprising a magnetically passive projection of relatively high permeability on said component, and magnet means external to said component adapted to provide a magnetic field, said magnet means having at least one magnetic pole positioned opposite said projection and spaced therefrom in said one extreme position to provide a variable reluctance flux path, including said projection, which has its minimum reluctance in said one extreme position.

2. The apparatus of claim **1** wherein said magnet means external to said component comprises a magnetic core and an associated winding, and a variable signal source adapted to energize said winding.

3. In an on-the-fly printer, a print station, a type roll rotatably adapted to present different characters to said print station for printing on an intermediately positioned paper web, said print station including a plurality of aligned hammers of relatively high permeability each comprising an elongated structure of uniform width having front and rear sections connected by a central shank, said front section having a concave forward surface facing said type roll and spaced therefrom, said rear section having a convex rear surface, said front and rear sections each having parallel upper and lower surfaces lying in a pair of common planes disposed above and below respectively, corresponding surfaces of said central shank, a support parallel to said planes, a pair of parallel leaf springs transverse to said planes and coupling said bottom surfaces to said support to permit movement of said hammer in a direction substantially parallel to said planes, a magnet including first and second pole faces positioned opposite respective ones of said pair of co-planar upper surfaces in the rest position of said hammer to define first and second gaps respectively of uniform width therebetween, and an actuator arm selectively adapted to strike said convex rear surface to drive said hammer forward against said type roll, the forward movement of said hammer causing the upper surface of said central member to move at least partly opposite said first pole surface to increase the effective length of the flux path in said first gap.

4. The apparatus of claim **3** wherein said magnet includes a winding, and a variable signal source adapted to energize said winding.

5. The apparatus of claim **3** wherein said magnet includes a winding, and a current source selectively adapted to energize said winding.

6. The apparatus of claim **3** wherein said hammer consists of a material whose permeability is large relative to that of said actuator arm.

7. In an on-the-fly printer, a print station, a type carrier movably adapted to present different type characters to said print station for printing on an intermediately positioned paper web, said print station comprising a plurality of aligned, elongated print hammers of relatively high permeability each having a striking surface facing said type characters and a rear impact surface, a pair of raised surfaces on one side of each hammer lying in a common plane spaced from the central hammer structure therebetween, a pair of spaced leaf springs anchored in the other side of each hammer transverse thereto, said leaf springs being further anchored in a fixed support and permitting substantially linear hammer movement toward said type roll from a resiliently maintained rest position, a magnet disposed on said one side of each hammer and including a pair of pole faces uniformly spaced from and opposite to said raised surfaces when said hammer is in its rest position, and an actuator selectively adapted to strike said rear impact surface to drive said hammer forward against said type characters, thereby moving said central hammer structure at least partly opposite one of said pole faces.

8. A high-speed printer comprising a platen, a print station including a print hammer resiliently urged to a rest position, means for selectively driving said hammer out of said rest position against said platen to print on an intermediately positioned paper web, means for damping out hammer oscillations upon the return of said hammer to said rest position, said damping means comprising at least one magnetically passive projection of relatively high permeability on said hammer, and magnet means external to said hammer adapted to provide a magnetic field, said magnet means including a magnetic pole positioned opposite said hammer projection and spaced therefrom in the hammer rest position to provide a variable reluctance flux path, including said projection, which has its minimum reluctance in said rest position.

9. In an on-the-fly printer, a print station, a type carrier movably adapted to present different characters to said print station for printing on an intermediately positioned paper web, said print station comprising a plurality of elongated, aligned hammers each having a striking surface facing said characters, each of said hammers being supported on a pair of transverse leaf springs resiliently urging it to a rearward hammer rest position but permitting forward hammer movement, means for selectively driving said hammers out of said rest position against said characters, and means for damping out hammer oscillations upon the return of each hammer to its rest position, said damping means comprising at least one magnetically passave projection of relatively high permeability on each hammer, and magnet means external to said hammers adapted to provide a magnetic field, said magnet means including at least one magnetic pole positioned opposite said hammer projection and spaced therefrom in said hammer rest position to provide a variable reluctance flux path, including said projection, which has its minimum reluctance in said rest position.

10. The apparatus of claim **9** wherein said hammer driving means comprises an actuator corresponding to each hammer having a pivotably mounted arm selectively

adapted to propel said hammer forward, a back stop, said hammer urging said actuator arm against said back stop in said rest position.

11. The apparatus of claim **10** wherein each of said actuator arms consists of a material whose permeability is low compared to that of said hammers.

12. The apparatus of claim **9** wherein said magnet means external to said hammers comprises a magnetic core and an associated winding, and a variable signal source adapted to energize said winding.

13. The apparatus of claim **9** wherein each of said hammers includes a pair of projections terminating in a pair of co-planar surfaces spaced from a parallel surface of an intermediately positioned central hammer portion, said magnet means external to said hammers including a pair of magnetic poles terminating in a pair of pole faces positioned opposite respective ones of said pair of co-planar surfaces to define a pair of gaps of uniform width in said hammer rest position, said forward hammer movement causing the effective width of at least one of said gaps to be non-uniformly increased by bringing said central hammer portion surface at least partly opposite one of said pole faces.

14. The apparatus of claim **13** wherein said hammers are aligned in a row, said pole faces extending the length of said hammer row.

15. In an on-the-fly printer, a print station, a type carrier movably adapted to present different characters to said print station for printing on an intermediately positioned paper web, said print station comprising a plurality of elongated, aligned hammers each having a striking surface facing said characters, each of said hammers being supported on a pair of transverse leaf springs resiliently urging it to a rearward hammer rest position but permitting forward hammer movement, means for selectively driving said hammers out of said rest position against said characters, means for damping out hammer oscillations upon the return of each hammer to its rest position, said damping means comprising a substantially toroidal, magnetic core terminating in a pair of mutually perpendicular pole faces, and at least one projecting flag on each hammer including a pair of surfaces substantially parallel to respective ones of said pole faces and uniformly spaced therefrom in said hammer rest position, each of said flags providing a flux path with said core which has its minimum length in said hammer rest position.

16. The apparatus of claim **15** wherein said hammers are aligned in a row, said pole faces extending the length of said hammer row.

17. The apparatus of claim **15** wherein said core and said flag consist of a magnetic material having a permeability which is substantially greater than that of said hammer.

18. In an on-the-fly printer, a print station, a type roll rotatably adapted to present different rows of identical characters to said print station for printing on an intermediately positioned paper web, said print station comprising a plurality of elongated print hammers of uniform thickness aligned in a row parallel to the axis of said type roll, each of said hammers including front and rear hammer sections connected by a central shank, said front hammer section having a concave striking surface facing said type roll and upper and lower surfaces spaced respectively above and below corresponding surfaces of said shank, said rear hammer section terminating in a convex impact surface and including upper and lower surfaces coplanar with the corresponding surfaces of said front section, a fixed support spaced from said lower surfaces and parallel thereto, a pair of leaf springs corresponding to each hammer and having their ends anchored in said lower surfaces and in said support respectively, each pair of leaf springs resiliently urging its hammer to a rest position but permitting forward hammer movement toward said type roll, an actuator corresponding to each hammer including a pivoted arm consisting of a material whose permeability is high relative to that of said hammer, a back stop, said hammer impact surface bearing against said actuator arm in said rest position to urge the latter against said back stop, solenoid means for selectively rotating said actuator arm about its pivot to drive said hammer against said type roll, and means for damping out hammer oscillations upon the return of each hammer to said rest position, said damping means including a horse shoe magnet having first and second pole faces extending the length of said hammer row, each of said pole faces being positioned directly opposite one of each pair of said upper hammer surfaces in the rest position of the corresponding hammer and being uniformly spaced therefrom to provide a pair of flux paths through said upper hammer surfaces, at least one of which has its minimum length in said hammer rest position, said one flux path at least partly including the upper surface of said central shank during said forward hammer movement.

19. The apparatus of claim **18** wherein said magnet includes a winding and a variable current source selectively adapted to energize said winding.

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