

[54] **METHOD OF DAMPING REBOUND OF PRINT HAMMER**

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[58] **Field of Search**101/93, 426; 197/49

[56] **References Cited**

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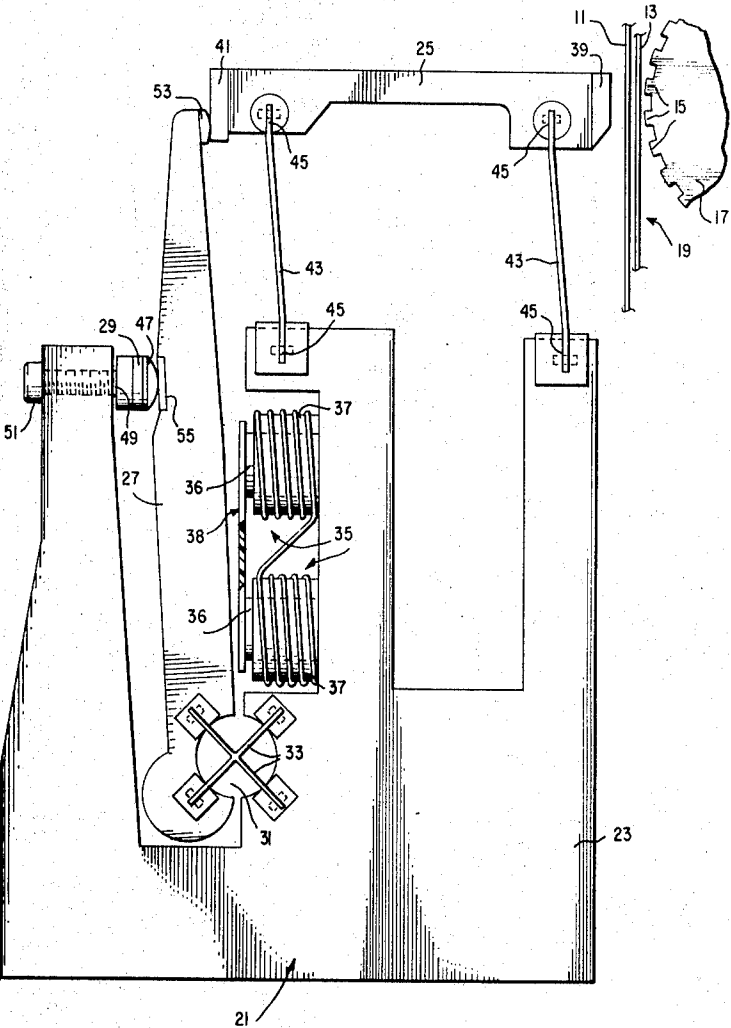
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ABSTRACT

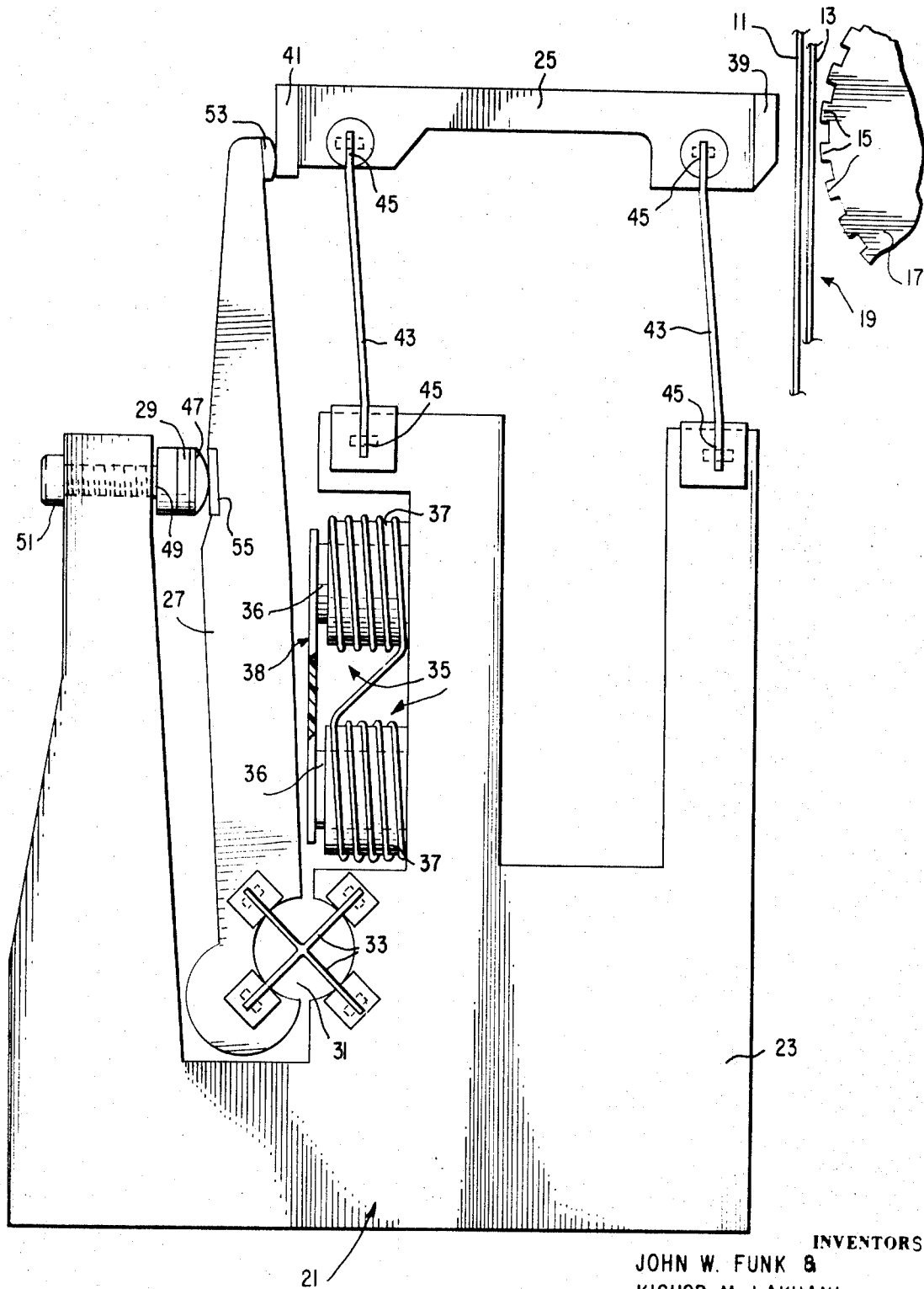
A method of oscillation-free print hammer and return is provided in an apparatus having an inertial hammer, a relay and a resilient backstop. In this method the armature of the relay is pivotably mounted and imparts motion to the hammer. The solenoid of the relay physically restrains the motion of the armature and then holds the armature by residual magnetism. The hammer continues in inertial flight until it reaches the printing area. On rebound the hammer strikes the armature and part of the kinetic energy of the hammer is absorbed as the hammer drives the armature free from the residual magnetic field. The armature and hammer continue to the backstop which absorbs or dissipates the remainder of the kinetic energy. The absorption of kinetic energy is for damping hammer oscillations and permits higher frequency of operation.

3 Claims, 1 Drawing Figure



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METHOD OF DAMPING REBOUND OF PRINT HAMMER

BACKGROUND OF THE INVENTION

This invention relates to printing and, more particularly, to a high speed electromagnetically operated print hammer and associated components, with particular reference to damping the hammer oscillations. For the purpose of firing the print hammer, several electromagnetic actuator mechanisms are well known. In one such mechanism, wherein the hammer motion is initiated by electromagnetic means, the hammer travels into the printing area under its own inertia — these are called inertial print hammers. In one class of electromagnetically actuated inertial print hammers the solenoid is stationary and, when current is introduced into the coil of the solenoid, the hammer is attracted thereto. This is seen, for example, in U.S. Pat. No. 3,335,659 to Schacht et al.

In another class of electromagnetically actuated inertial print hammers the armature of the relay is the hammer actuator. When current is introduced into the coil the armature is attracted thereto and strikes the hammer. The hammer is thus driven into the printing area. This arrangement is shown, for example, in U.S. Pat. No. 3,351,006, to Belson.

In using inertial print hammers it is known that the high velocity of the hammer rebound often causes further rebounding when the hammer reaches the backstop or rest position. This further rebounding is normally in a forward direction, and, if sufficient, may cause the hammer to again reach the printing area. This will create an additional image on the paper. Damping oscillations of the print hammer has been accomplished by maintaining current in the coil of the solenoid during the hammer rebound as seen, for example, in the aforementioned patent to Schacht et al. This has been unsatisfactory as it substantially doubles the duty cycle of the solenoid. A second method of damping oscillations, as taught by the aforementioned patent to Belson, includes the use of a backstop and a second electromagnet. However, this method has proven uneconomical since it requires additional hardware as well as substantially doubling the current requirements of the actuator apparatus.

SUMMARY OF THE INVENTION

Accordingly, with these prior art problems in mind, the invention contemplates the solution of these problems by providing a new and improved method of damping the rebound of the print hammer to eliminate multiple impressions.

It is a further object of this invention to reduce the duration of the current in the print hammer actuator.

These and other objects are accomplished in an inertial print hammer and actuator module wherein a print hammer is driven into the print area by the armature of a magnetic core electromagnetic relay and rebounds toward its rest position. In applicant's method the relay is momentarily energized for attracting the armature and actuating the hammer, the armature is held in the path of the rebounding hammer by residual magnetism, and part of the kinetic energy of the hammer is absorbed by impacting the hammer against the armature and breaking the armature free from the magnetic field. The hammer follows the armature and the balance of the energy of the hammer is dissipated through the armature by a resilient backstop for the armature. The effect of the method is increased by resiliently biasing the hammer against the armature, and the actuated position of the armature may be spaced away from the magnetic core for preventing magnetic lock.

BRIEF DESCRIPTION OF THE FIGURE

The foregoing objects and advantages of our invention, together with other advantages which may be attained by its use, will be apparent from the following detailed description of the invention read in conjunction with the drawing. The single FIGURE is an illustration of the preferred embodiment of our invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the FIGURE, a print hammer drives the paper or other recording medium 11 and the inking element or ribbon 13 into the type face 15 on revolving drum or chain 17. This occurs at the print station or printing area 19 and is well known in the high speed printing art whether the printer utilizes a single hammer, which moves along the line of print from one print position to the next, or multiple hammers — one at each of the print positions. The invention will be described with reference to a print hammer module which may be used with either type of printer. The particular logic circuitry which controls the time that the actuator fires the hammer and the structure that relatively positions the hammer module and the drum are also well known and do not form a part of the present invention.

The print hammer module 21 comprises base 23, lightweight print hammer or interposer 25, actuator or armature 27, backstop 29, and additional hardware which will be more fully described hereinafter. Armature 27 is pivotally mounted at its lower end to the base 23. At this pivot 31 springs 33 normally bias the actuator away from the printing area 19 and towards its rest position in contact with backstop 29. Means are provided to overcome the biasing effect of springs 33 and impart motion to hammer 25. Solenoid 35 includes a coil which is wound in series on two individual bobbins 37. The bobbins and coil may be encapsulated for heat dissipation. The wound bobbins are force fit onto pole pieces 36 which are attached to (or, alternatively, projections of) base 23. When current is introduced into the coil the resultant magnetic field attracts the actuator 27 to the solenoid 35. Hence actuator 27 serves as an armature and along with the solenoid forms an electromagnetic relay. Since the armature is pivoted about one end (at pivot 31) the armature travels in a clockwise direction towards the print area 19 when current flows in the coil.

Hammer 25 is flexurally mounted on the upper portion of the base 23. Although the hammer is a single unit it may be thought of as having an imprint end 39, which presses the paper and ribbon against the type face, and an acceleration end 41 which is driven by the actuator. The interposer or hammer 25, for convenience, is attached to the base 23 by two leaf springs 43 and is biased rearwardly, away from the print area 19, into contact with armature 27. The leaf springs are attached to the base and hammer by injection molding plastic into anchor holes 45.

Mounted at the left side of the base 23, at a position opposite that of the print area 19 and below the level of the interposer or hammer 25, is backstop 29. The backstop includes a bumper 47 made of a resilient shock absorbing material, such as those in the butyl rubber family, and covered with a steel cap. The bumper 47 is mounted on one end of shaft 49. The other end of shaft 49 is threaded and inserted into a suitable opening in base 23. Since the actuator is struck at one end by the returning hammer 25 and pivoted at the other end 31 it will be appreciated that on rebound there is both shear force and compressional force on the backstop 29. The butyl rubber backstop provides better damping of shear loading, hence a design consideration is to increase the ratio of shear to compressional loading. Although the overall geometry of the print hammer and actuator creates certain limits on this ratio, the higher this ratio the smaller mass backstop necessary.

A socket head cap screw, including head 51 and shank or shaft portion 49 may be turned thereby moving the backstop 29 toward or away from the print area 19. The backstop 29 may be joined to the shank 49 by an epoxy resin. Adjustment of the backstop location causes a corresponding change in the rest position of armature 27 thereby increasing or decreasing the width of the air gap from armature 27 to the solenoid 35. Changes in the air gap width result in corresponding changes in the travel time of the armature 27 when current is introduced into the coil.

When current is introduced into the coil an electro-magnetic field is created which attracts the armature or actuator 27. This defines a first electromagnetic condition. The leading or striker portion 53 of the actuator which is in contact with end 41 of the hammer 25 drives the hammer towards the print area with a sling-shot effect. As the actuator continues its clockwise rotation it comes into contact with a mylar or urethane shim 38 which is attached to solenoid 35. The pole pieces 36 of solenoid 35 protrude a slight amount past the coil and bobbins and the shim 38 is attached to the pole pieces. This shim 38 maintains an air gap between armature 27 and solenoid 35 and prevents the armature from becoming magnetically locked to the solenoid. The physical contact between the actuator 27 and the shim 38 of solenoid 35 stops the clockwise rotation of the armature. Current in the coil is turned off about the time the actuator comes into contact with the solenoid 35. Although the precise time is not critical, to minimize both use of current and the amount of heat generated, the current should be turned off after the actuator has been attracted by a sufficient electromagnetic force that it will drive the hammer into the print area yet before the hammer reaches the actuator on rebound. The hammer 25 continues to travel under its own inertia into the print area to provide the printing operation as explained previously. Although the current in the coil of the solenoid 35 has been turned off, the actuator is maintained in contact with the solenoid 35 by the residual magnetic flux. This defines the second electromagnetic condition. Well known circuitry is available for supplying appropriate current, such as a pulse, to the coil.

After the imprint end 39 of the hammer strikes the print area, the hammer rebounds from the impact as is understood from the principles of conservation of energy and momentum. As the hammer rebounds, end 41 impacts the striking face 53 of the actuator. Under the influence of the returning hammer the actuator breaks through the residual magnetism of solenoid 35 and starts rotating in a counterclockwise direction away from the print area and towards the backstop 29. This uses up some of the kinetic energy of the light-weight hammer 25. The continued lateral motion of the hammer 25 and the counterclockwise motion of armature 27 are ultimately stopped by the resilient backstop 29. The resilient backstop 29, which is struck by the rear portion 55 of actuator 27 dissipates the remaining kinetic energy of the hammer and all the kinetic energy of the returning actuator. The leaf springs 43 urge the hammer 25 toward its rest position in contact with the armature 27.

For example, in using a hammer made of hardened steel and having a mass of 1.5×10^{-5} lb-in⁻¹-sec.² (gravitational system) and a backstop of buna-n (a butyl rubber), it was found that

the force necessary to break the actuator free of the residual magnetic field used up about 25 percent of the kinetic energy of the hammer and the resilient backstop dissipated the remaining kinetic energy of the hammer and all the kinetic energy of the actuator.

The absorption of the kinetic energy of the hammer by both breaking free from the residual magnetism of the solenoid and by contact with the backstop, provides a damping effect. This reduces hammer oscillations and prevents a second rebound of the hammer into the print area. Furthermore, the absorption of part of the kinetic energy when the hammer breaks the armature free from the residual magnetic field permits the use of a smaller backstop 29, and, by early damping, permits higher frequency of operation.

What is claimed is:

1. A method of damping the rebound of an inertial print hammer to prevent secondary rebound, in a print hammer apparatus having an inertial hammer mounted for actuation from an inoperative position to a print position and rebound to the inoperative position, and a magnetic core electromagnetic relay having an armature, said armature being the actuator for said hammer and being biased to an inoperative position, comprising:

supplying current to said relay for attracting said armature and actuating said hammer;
eliminating current from said relay before the rebound of said hammer;

passively holding said armature in the path of rebound of said hammer by the residual magnetism of said relay;
impacting said rebounding hammer against said magnetically held armature and breaking said armature from the residual magnetic bonds to absorb a portion of the kinetic energy of the rebounding hammer; and

resiliently damping the balance of the kinetic energy of the rebounding hammer upon said hammer's return to the inoperative position.

2. The method of claim 1 additionally including the step of resiliently biasing said hammer against said armature when each is in its inoperative position; and

wherein the step of resiliently damping the balance of the kinetic energy of the rebounding hammer includes the step of
distorting a butyl rubber member in both shear and compression.

3. The method of claim 2 also including after the step of energizing the step of

spacing the energized position of said armature away from said core for preventing said armature from magnetically locking with said core.

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