United States Patent [19]

Mako et al.

[11] **3,741,113**

[45] **June 26, 1973**

[54] **HIGH ENERGY PRINT HAMMER UNIT WITH FAST SETTLE-OUT**

[75] Inventors: **John Mako,** Vestal; **Joseph E. Wallace,** Endicott, both of N.Y.

[73] Assignee: **International Business Machines Corporation,** Armonk, N.Y.

[22] Filed: **June 25, 1971**

[21] Appl. No.: **156,779**

[52] **U.S. Cl.** **101/93,** 355/277

[51] **Int. Cl.** **B41j 9/10**

[58] **Field of Search** .... 335/266, 268, 267, 335/256, 257, 271, 277, 276; 101/93 C, 297, 287

[56] **References Cited**

UNITED STATES PATENTS

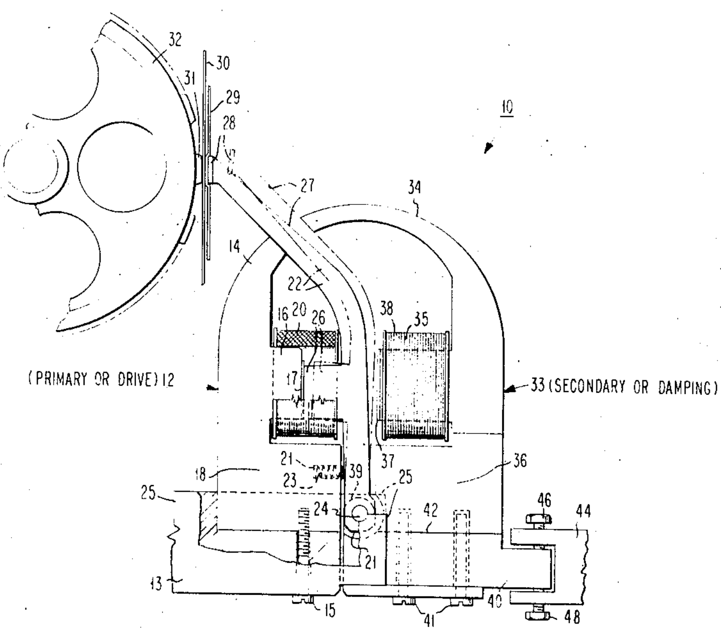
3,072,045	1/1963	Goin	101/93 C
3,188,947	6/1965	Paige	101/93 C
3,195,453	7/1965	Thiemamy	101/93 C
3,233,540	2/1966	Grottrup	101/93 C
3,241,480	3/1966	Cunningham	101/93 C
3,335,659	8/1967	Schacht et al.	101/93 C
3,354,818	11/1967	Haas	101/93 C
3,381,611	5/1968	Foley	101/111 X
3,426,675	2/1969	Dalton	101/93 C
3,468,246	9/1969	Lee et al.	101/93 C
3,543,906	12/1970	Hladky	101/93 C

Primary Examiner—William B. Penn
Attorney—Francis V. Giolma et al.

[57] **ABSTRACT**

A print hammer actuator comprises a main three-legged magnetic core having an operating winding on a middle or center leg, and an armature pivotally supported adjacent the lower leg with an extension at the other end providing a hammer face, and a projection opposite the middle leg which moves within the operating winding. A secondary magnetic core on the opposite side of the armature with a restore and damping winding operates to damp oscillations and improve settle-out.

8 Claims, 3 Drawing Figures



PATENTED JUN 26 1973

3,741,113

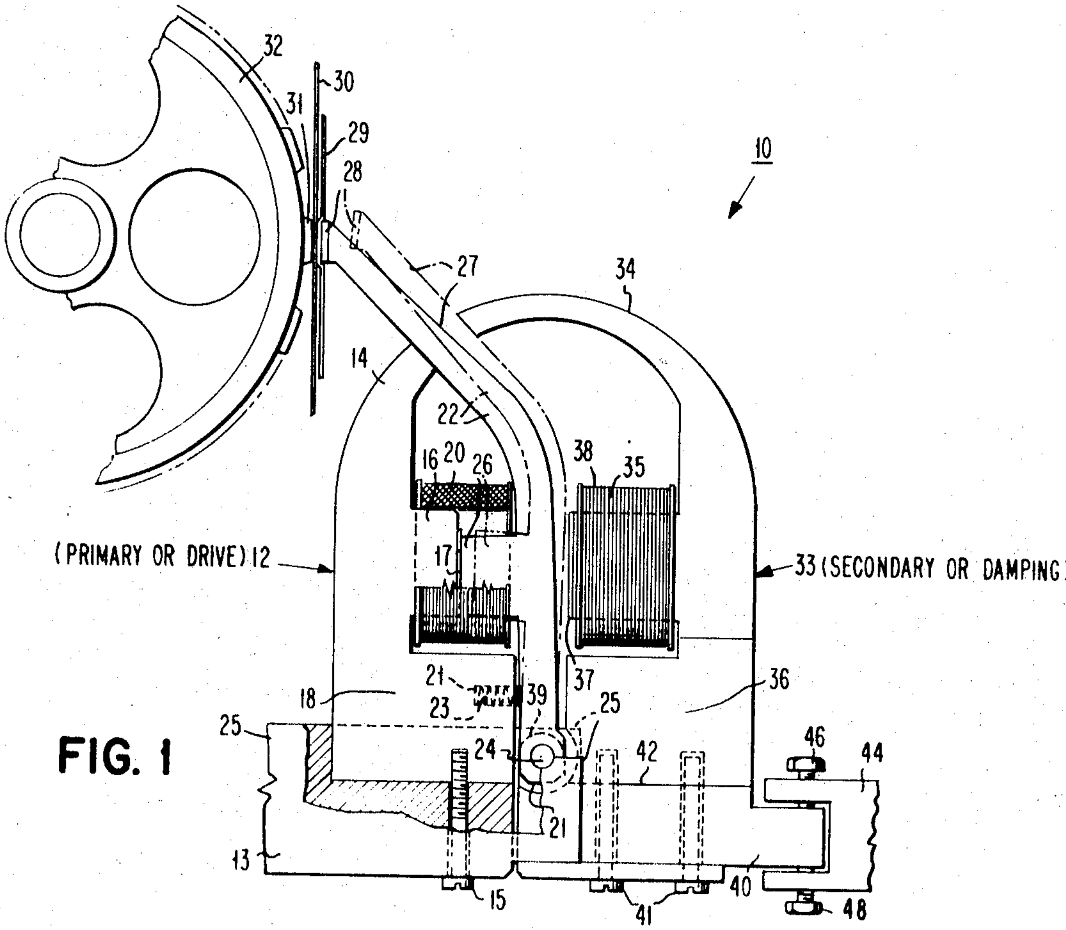


FIG. 1

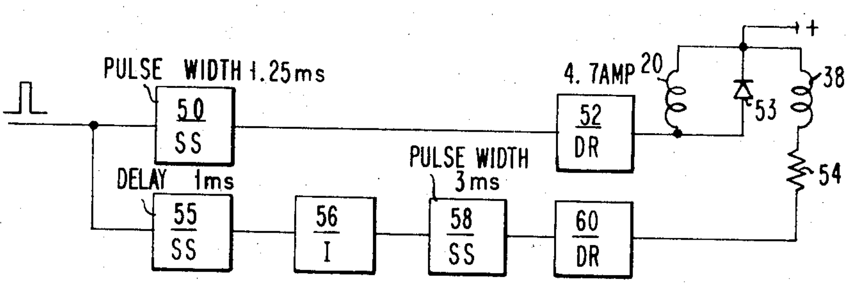
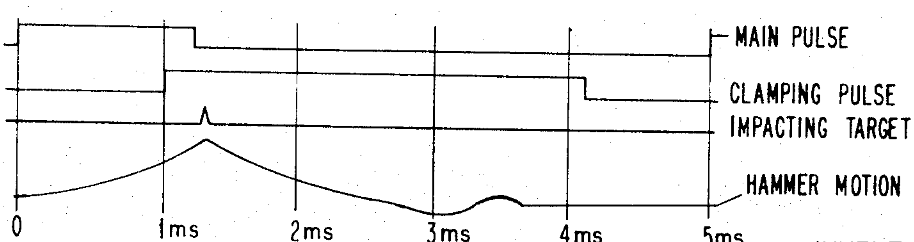


FIG. 3



TIMING CHART

FIG. 2

INVENTORS
JOHN MAKO
JOSEPH E. WALLACE

BY Francis V. Giolma
ATTORNEY

HIGH ENERGY PRINT HAMMER UNIT WITH FAST SETTLE-OUT

CROSS-REFERENCE TO RELATED APPLICATION

This invention is related to the invention of co-pending application Ser. No. 156,780 of Joseph E. Wallace and J. Gregory Hamilton, filed June 25, 1971.

FIELD OF INVENTION

This invention relates generally to electromagnetic actuators and it has reference in particular to a high energy electromagnetic print hammer.

DESCRIPTION OF PRIOR ART

Print hammers have heretofore generally comprised a hammer structure which is actuated by a separate electromagnetic actuator, either directly or through the use of push rods, as in the James M. Cunningham U.S. Pat. No. 3,241,480, which issued on Mar. 22, 1966.

SUMMARY OF THE INVENTION

Generally stated, it is an object of this invention to provide an improved actuator or print hammer.

More specifically, it is an object of this invention to provide a high energy print hammer which has a reduced settle-out time.

Another object of the invention is to provide a high energy print hammer by improving the efficiency of the electromagnet structure therefor.

Yet another object of the invention is to improve the performance of a print hammer by having only a single moving element.

An important object of the invention is to provide for operating the armature of an electromagnetically operated print hammer so that the principal air gap is always within the operating winding.

Still another object of the invention is to provide a high energy print hammer having a primary magnetic core with an armature movable to impact a document, and a secondary magnetic core with a winding for controlling settle-out.

Another important object of the invention is to provide an electromagnetic print hammer having a magnetic core and an armature, with both primary and secondary magnetic flux operating paths.

Other objects, features and advantages of the invention will be apparent from the following more detailed description of a preferred embodiment of the invention as illustrated in the accompanying drawing.

DESCRIPTION OF THE DRAWING

In the drawing:

FIG. 1 is a partial schematic view in side elevation of a printer utilizing a magnetically operated print hammer embodying the invention in a preferred form;

FIG. 2 is a timing diagram; and

FIG. 3 is a schematic block circuit diagram of a control circuit for the primary and secondary operating windings of the print hammer of FIG. 1.

DESCRIPTION OF A PREFERRED EMBODIMENT

Referring generally to FIG. 1 of the drawing, the reference numeral **10** designates a high energy print hammer unit which comprises a three-legged magnetic Core Member **12** having an upwardly-curved Upper or Outer Leg **14**, a Middle or Center or Outer Leg **16** and a Lower Leg **18**. A Primary or Drive Winding **20** is po-

sitioned on the Middle Leg **16** and extends beyond the face of the leg. An Armature **22** is pivotally supported adjacent the Lower Leg **18** by a Pivot **24** and one or more upstanding Side Plates **25**, which may be part of a Support **13** to which Core Member **12** is secured by Screw **15**, and one of which is shown in part. The Armature **22** has a Flag or Projection **26** intermediate its end in alignment with the Middle Leg **16** of the Core Member **12**. The Projection **26** is positioned substantially within the Primary or Drive Winding **20** so that the air gap between it and the Middle Leg **16** is completely within the Winding **20**. A Spring **23** is positioned within an Opening **21** in the Lower Leg **18** for normally biasing the Armature **22** away from the Middle Leg **16** to the rest position. The Armature **22** has an upwardly-extending Arm Portion **27** provided with a Hammer Face **28** at the upper end for impacting a Ribbon **29** and Document **30** against Type Characters **31**, which may be positioned on the surface of a Type Drum, Wheel or other such Type Carrier **32**.

In addition to the primary magnetic Core Member **12**, a secondary Core Member **33** is provided having an upwardly-curved Leg **34** designed to provide a backstop for the Armature **22**, a Middle or Center Leg **35** having a Secondary or Damping Winding **38** positioned thereon, and a Lower Leg portion **36**. The secondary Magnet **33** may be pivotally supported on the Piovt **24** by means of a central Projection or Tongue **39** of a Base **42** secured to Core Member **33** by Screws **41**. The Tongue **39** fits between spaced Arms **21** of a clevis or the like at the lower end of Armature **22**. The Base **42** is provided with an Arm Portion **40** for engagement with adjusting Set Screws **46** and **48** mounted in a slotted Support Member **44**. By adjusting the Set Screws **46** and **48** the secondary Core Member **33** may be rotated about the Pivot **24** so as to adjust the rest position of the Armature **22** relative to the primary Core Member **12**. The air gap at the Middle Leg **16** of the primary Core may be set to approximately 0.025 inches in the de-energized position, which corresponds to 0.067 inches at the Hammer Face **28**. A thin, polyurethane Residual **17** approximately 0.003 inches thick is positioned between the Armature and the main Pole Face **16** and also between the Armature and the secondary Pole Face **38**.

In order to print the character, the main Primary or Drive Winding **20** is energized. The Armature **22** is attracted towards the primary Core Member **12** causing the Hammer Face **28** to impact the ribbon and Document **30** against the Type Characters **31**. If fast settle-out is desired, the Secondary or Clamping Winding **38** is energized about one millisecond after the primary coil is energized, as shown in FIG. **2**. Shortly before the Armature **22** seals with the primary Core Member **12**, the main pulse is cut off. With the Armature Projection **26** engaging the Residual **17**, there is a gap of approximately 0.002 inches between the Arm **27** and the Upper Leg **14**. The Hammer **28** continues to move and impacts the Type Characters in about 1.3 milliseconds. During printing the Hammer **28** loses some of its kinetic energy. It rebounds and starts moving back at roughly half the imact velocity. Since the Damping or Secondary Winding **38** is energized as the gap between the secondary Core Member and the Armature narrows, the increasing magnetic force accelerates the returning armature slightly. After impacting the Upper or Support Arm **34** and Residual **37**, the Armature **22** would tend to bounce several times. However, since the

Secondary or Damping Winding **38** is still energized, the Armature **22** will stay in contact with the Support Arm **34** due to the magnetic force. Therefore, the oscillations set up by the impact force will decay at about 4.2 milliseconds. At this time, the clamping pulse is turned off and the hammer unit is ready for the next operation.

Referring to FIGS. **2** and **3**, it will be seen that the Primary or Drive Winding **20** is energized through a Single Shot **50**, which provides a pulse width on the order of 1.2 milliseconds and a Driver **52** which provides a peak current on the order of 4.7 amperes. A Diode **53** connected about the Drive Winding **20** minimizes transients. The Secondary or Damping Winding **38** is energized through a current-limiting Resistor **54** and delay means comprising a Single Shot **55** and an Inverter **56.** An additional Single Shot **58** provides a pulse width on the order of 3 milliseconds to a Driver **60** which energizes the Secondary Winding **38.**

Typical operating characteristics of the high energy print hammer unit are as follows:

Hammer mass = 2.46 grams
Material = 2 ½% silicon iron
Kinetic energy ≅ 200,000 ergs
Maximum print force = 80–100 pounds
Hammer velocity = 160 inches/second
Contact time = 35–70 × 10^{-6} seconds
Highest repetition rate = 5 × 10^{-3} seconds
Operating voltage = 60 volts D.C.
Peak current = 4.7 amperes
Flight time = 1,322 × 10^{-6} seconds
Hammer motion = 0.067 inches

From the above description and accompanying drawing it will be apparent that there is provided a high energy print hammer unit which has only a single moving part. The subject print hammer unit has a high kinetic energy and it is possible to adjust the magnet so that heavier forms will automatically absorb more of the armature's kinetic energy, so that no impression control is required. An important feature of the design is that the main working gap has been placed inside the operating winding near its center point by use of the projecting flag on the armature. The third arm on the core serves two purposes, (**1**) to provide mechanical damping of the armature and also (**2**) to increase the magnetic force by providing an additional working gap. It will be noted however that the Outer Leg **14** has a much smaller cross-section than the Outer Leg **18** so that it has a much higher magnetic reluctance and hence does not detract appreciably from the main operating magnetic flux.

While the invention has been particularly shown and described with reference to a preferred embodiment thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention.

The claims are appended hereto:

1. An electromagnetic actuator comprising,

a three-legged core of magnetic material having a middle leg and two outer legs,

an actuator armature pivotally supported by a pivot at one end adjacent one outer leg of said magnetic core and having a projecting intermediate portion spaced from and disposed to move into abutting relation with the middle leg of said yoke,

and an operating winding on said middle leg extending beyond the end of said middle leg to receive said projecting portion of said armature so that said intermediate portion and said middle leg abut within said operating winding and said intermediate portion moves within said winding.

2. The invention as defined in claim **1** characterized by said armature having an extension at the end remote from said pivot support with a print hammer face and being movable on said pivot for impacting a document to print thereon when said intermediate portion and said middle leg abut.

3. The invention as defined in claim **2** characterized by means including an additional core of magnetic material positioned in spaced relation with said three-legged core and on the side of the armature away from said three-legged magnetic core to engage and define the rest position of said armature.

4. The invention as defined in claim **2** characterized by said one outer leg having a relatively large cross section providing a relatively low reluctance main magnetic flux path with said armature for said operating winding, and said other outer leg extending upwardly to engage said extension portion remote from said projecting armature portion and having a smaller cross-section than said intermediate portion so as to provide a higher reluctance secondary flux path for the magnetic flux produced by said operating winding.

5. The invention as defined in claim **4** characterized by said secondary magnetic core having a control winding thereon.

6. The invention as defined in claim **5** characterized by circuit means including delay means in series with said control winding connected to effect energization of said operating and control windings in predetermined timed relation so that said control winding is energized after said operating winding as said print hammer returns to its rest position.

7. The invention as defined in claim **6** characterized by said secondary magnetic core being pivotally supported by said armature pivot.

8. The invention as defined in claim **5** characterized by said secondary magnetic core having three legs positioned in substantially aligned relation with the legs of said first-mentioned three-legged core and with said armature pivotally mounted to move therebetween.

* * * * *