Oct. 18, 1966 C. J. HELMS 3,279,364

HAMMER CONSTRUCTION

Filed Aug. 2, 1965

2 Sheets-Sheet 1

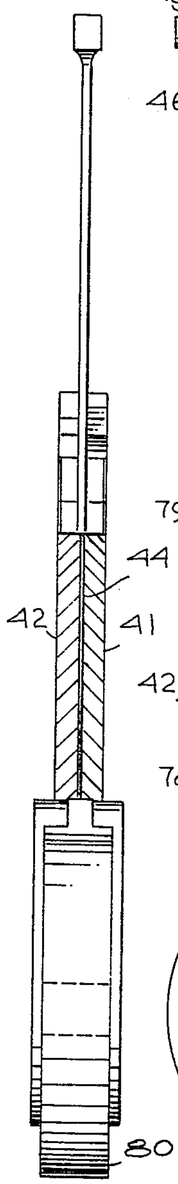

Fig. 2

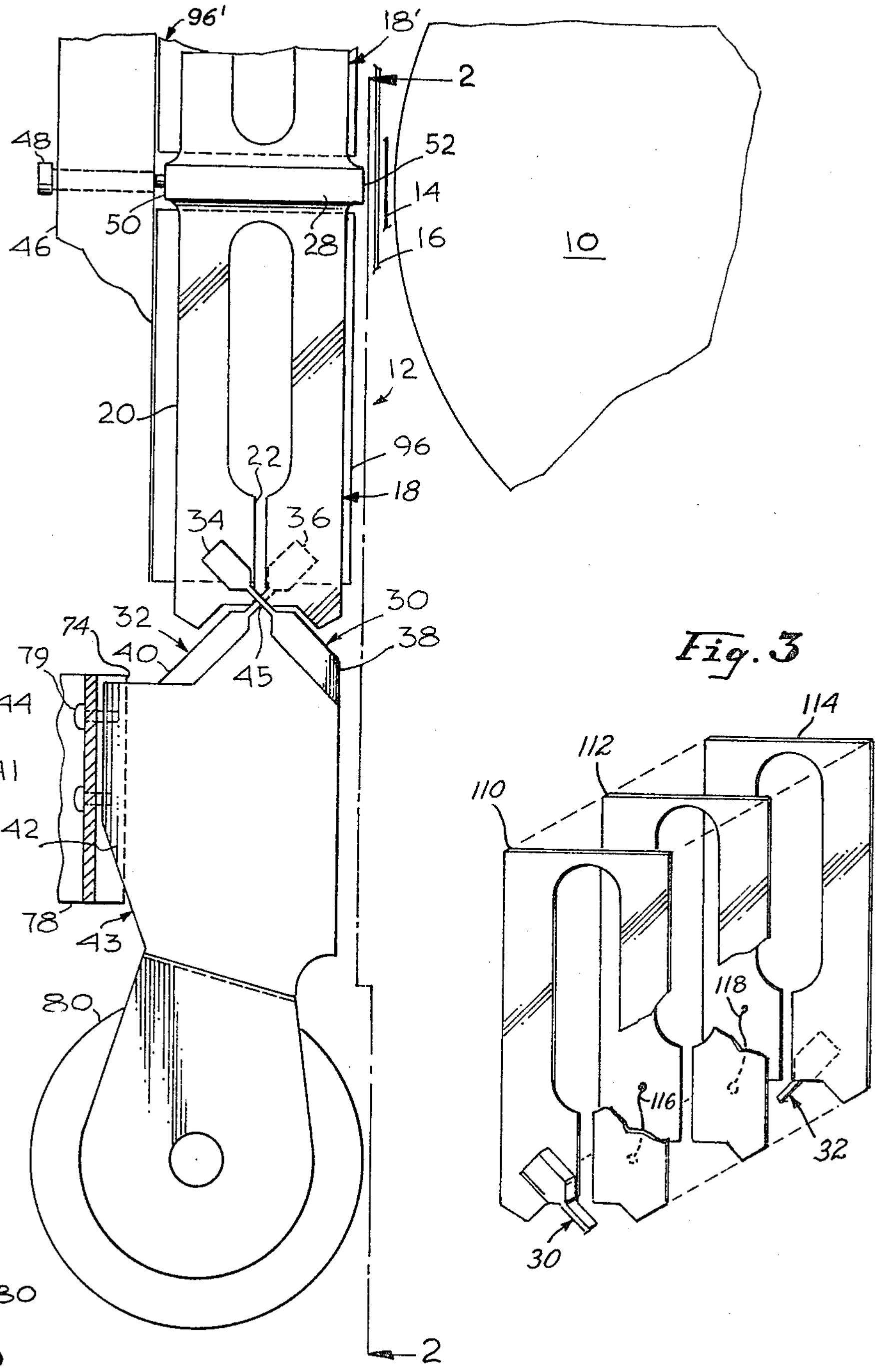

Fig. 1

Fig. 3

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2 Sheets-Sheet 2

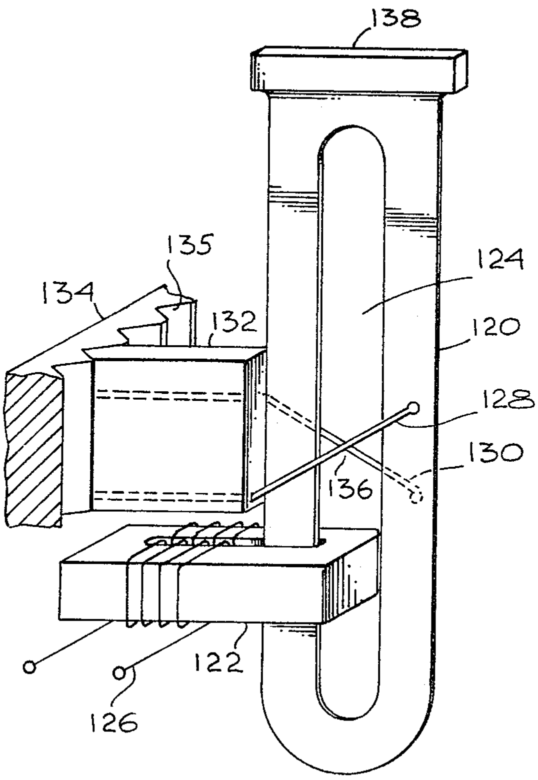

Fig. 4

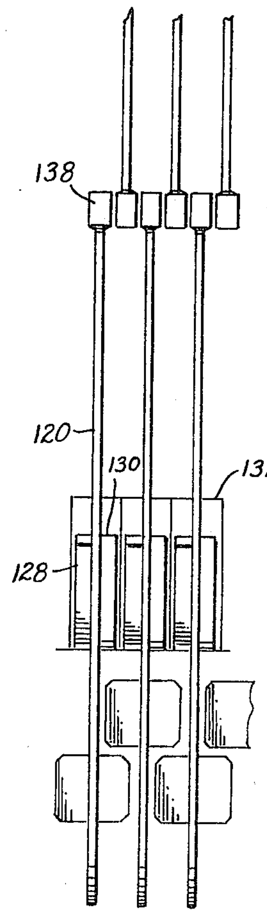

Fig. 5

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3,279,364
HAMMER CONSTRUCTION

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12 Claims. (Cl. 101—43)

This invention relates generally to high speed printing apparatus and more particularly to improved impact devices for use therein.

U.S. Patent 3,172,352 discloses a printing hammer, including, in a preferred embodiment, a pair of flat springs which conduct current to a coil mounted on a hammer shank. The coil is situated within a magnetic field provided by spaced permanent magnets. It is pointed out in the cited patent that such a construction provides a low friction hammer which can be rapidly propelled, as a consequence of the interaction between the current in the coil and the magnetic field, from a rest position to an impact position, i.e., into engagement with a printing drum. (It will be understood throughout that the hammer does not actually engage the printing drum inasmuch as the paper being printed upon and an inked ribbon is at all times disposed between the hammer and the drum.) Inasmuch as it is desirable that the drum rotate continually if high printing speeds are to be achieved, it is important that the travel time of the hammer be minimized if the printed characters are to be aligned. That is, a signal to start the hammer traveling toward the drum must be provided prior to the character on the drum to be printed moving into printing position. If the travel time interval is relatively long, then a small variation in drum speed during this interval will result in the character being struck either prior or subsequent to it reaching its proper printing position. Thus, by reducing the hammer's travel time, greater character alignment and a generally improved printing quality can be achieved. In addition to travel time being significant, printing quality is also affected by contact time, i.e., the interval that the shank is actually in contact with the paper and urging it against the drum. If the contact time is excessive, the printed characters will be smeared since the drum is continually rotating. In order to achieve a maximum printing speed, it is also essential that the recovery time of the hammer be minimized so that no time need be wasted between successive actuations of a hammer.

The desire to minimize travel, contact, and recovery time, assuming that other conditions such as the spring constant of the paper, the force applied to the hammer, etc. are fixed, suggests that the mass of the hammer be minimized. U.S. patent application Serial No. 463,263, filed on June 11, 1965, entitled, "Printing Hammer," by Clifford J. Helms, and assigned to the same assignee as the present application, discloses a hammer construction which permits travel, contact, and recovery times to be minimized. More particularly, the cited patent application discloses a hammer construction comprised of a rigid housing having a coil therein and carrying an impact tip thereon which housing is supported on a pair of flexible conductive members for substantially rotational movement between a rest position and an impact position. It is pointed out in the cited patent application that by selecting a geometry for the hammer construction such that the forces applied to the impact tip act at the center of percussion with respect to the point about which the housing is rotated, the reaction on the supporting members is substantially reduced to zero and the effective mass of the hammer acting at the impact tip is minimized.

The present invention is directed to a hammer construction having characteristics which make it less expensive and more reliable than previously known hammer

constructions. In addition, a hammer constructed in accordance with the present invention can be more efficiently operated than previously known hammers.

Briefly, in accordance with a first aspect of the present invention, a coil structure comprised of a flat rigid single turn coil structure or a plurality of such coil structures laminated together, is utilized in lieu of multiturn coiled conductors supported within a rigid housing. A single turn or laminated coil structure can be provided at a lower cost than previously known coil structures inasmuch as the single turn coil structure can be inexpensively formed from aluminum or copper material. It should be appreciated that such a coil structure is also inherently more reliable than prior art coil structures.

Utilization of a single turn coil structure or a few such structures laminated together of course requires that a greater magnitude coil current be used than in previous multiturn coil structures if the same propelling force as was previously available is to be developed, assuming of course the existence of similar permanent magnet fields, etc. In accordance with one aspect of the present invention, high coil currents are developed by connecting the coil terminals across a transformer secondary winding. The power loss in the current carrying supporting springs, in the previously mentioned hammer embodiments, represents wasted power which is of course proportional to the square of the current through the springs. Thus, the efficiency of a high current carrying single turn or laminated coil structure could be disturbingly low, due to the power loss in the supporting springs.

Accordingly, in accordance with a further aspect of the present invention in order to avoid wasting power in this manner, current is induced in the movably mounted coil structure via transformer action. That is, a transformer core is inductively coupled to the coil structure which itself functions as a transformer secondary winding. A multiturn primary winding is also coupled to the transformer core. By driving a current through the primary winding, a current will be induced in the coil which will of course interact with the permanent magnetic field to thereby exercise a propelling force on the coil structure.

The novel features that are considered characteristic of this invention are set forth with particularity in the appended claims. The invention itself both as to its organization and method of operation, as well as additional objects and advantages thereof, will best be understood from the following description when read in connection with the accompanying drawings, in which:

FIGURE 1 is a side sectional view of one embodiment of a printing hammer constructed in accordance with the present invention;

FIGURE 2 is a vertical sectional view taken substantially along the plane **2—2** of FIGURE 1 and illustrating a front view of the hammer of FIGURE 1;

FIGURE 3 is a perspective view of a laminated coil structure which can be alternatively employed in the embodiment of FIGURE 1;

FIGURE 4 is a perspective view of a further embodiment of the invention; and

FIGURE 5 is a rear view of a portion of a hammer bank comprised of hammers as shown in FIGURE 4.

Attention is now called to FIGURES 1 and 2 of the drawings which illustrate a high speed line printing apparatus which employs one form of printing hammer constructed in accordance with the present invention. More particularly, the printing apparatus includes a printing drum **10** which is adapted to continually rotate about an axis through the center thereof. Raised characters (not shown) are formed on the circumferential surface of the drum **10**. The characters are arranged in tracks, each track corresponding to a different position on a line to be printed. Thus, if a maximum of 132 characters is to be printed across any one line, the printing drum **10** will preferably have 132 tracks, with each track containing all of the characters that the apparatus is adapted to print.

A bank of printing hammers **12** is provided spaced from the drum **10**. The hammer bank **12** usually includes a number of hammers equal to the number of tracks formed on the drum **10**. Positioned between the hammer bank **12** and the drum **10** is a printing ribbon **14** and the paper **16** to be printed upon. In the operation of the printing apparatus, the paper **16** is incrementally driven (by means not shown) to each new line position. After the paper settles into a new line position, a signal is usually provided to control means (not shown) which functions to actuate each hammer just prior to the character it is to print moves into printing position. When the hammer is actuated, it moves from its rest position toward the drum **10** and strikes the paper **16** urging it against the ribbon **14** and against the appropriate character on the drum, thereby printing it on the paper **16**. As previously noted, in order to assure good quality printing, both the travel and contact time of the hammers should be minimized as much as possible.

In accordance with the present invention, a printing hammer **18** is provided including a rigid flat unitary single turn coil structure **20** formed of conductive material such as aluminum or copper. A gap **22** is formed in the coil structure thereby defining coil terminals on either side thereof. The gap **22** can be filled with an insulative material (not shown). The coil structure **20** can be formed from any one of several known techniques such as stamping, precision, casting, etc. An impact tip **28**, which can also be formed of aluminum or copper, is carried on the upper end of the coil structure **20** and preferably in electrical contact therewith.

The coil structure **20** is supported on a pair of electrically conductive support members **30** and **32** which preferably comprise flat spring members having enlarged first ends **34** and **36** which are secured to opposite sides of the coil structure **20** and enlarged second ends **38** and **40** which are structurally and electrically secured to conductive portions **41** and **42** of a supporting block **43**. The conductive portions **41** and **42** are insulated from one another by epoxy **44** or such. As can clearly be seen in FIGURE 1, the supporting members **30** and **32** extend in planes which intersect each other at point **45**. Portions of the coil structure **20** preferably extend below the point **45** in order to lower the center of rotation of the coil structure as described in the aforecited patent application.

A support assembly **46** is provided which carries a plurality of individually adjustable backstops **48** adapted to engage the rear end **50** of the impact tip **28** when the printing hammer is in its rest position. The front end **52** of the impact tip **28** is of course adapted to force the paper **16** against the ribbon **14** and drum **10**.

The first ends **34** and **36** of the conductive support members **30** and **32** are electrically secured to the coil member **20** on opposite sides of the gap **22** by some conductive material such as solder. The second ends **38** and **40** of the support members **30** and **32** are respectively electrically and structurally secured to conductive portions **41** and **42** of the supporting block **43**. The rear edges of the portions **41** and **42** are preferably rounded so that they can be received in V-grooves formed in surface **74** of a positioning block **78**. Set screws **79** can be used to secure the supporting block **43** to the positioning block **78**. The utilization of precision-formed V-grooves in surface **74** permits easy registration of all of the hammers **18**. When in position, all of the impact tips **28** should be in substantial alignment with the center line of the drum **10**.

The conductive portions **41, 42** of the supporting block **43** are electrically connected across a secondary winding

(not shown) on a transformer core **80**. The conductive portions **41** and **42** are preferably formed of a heavy gauge copper or other highly conductive material in order to minimize power loss therein. The ends of the supporting members **30** and **32** are enlarged of course to reduce resistance and power loss in the current path. In order to efficiently provide a substantial current through the coil structure, the transformer core will probably require a large cross-section which may in turn require that the transformer cores be arranged in two tiers spaced either vertically or horizontally from one another.

The hammer bank **12** can consist of two sections, the first section comprises of hammers **18** which are supported above a lower positioning block **78** and a second section comprised of hammers **18'** depending from an upper positioning block (not shown). Similarly, lower and upper permanent magnet sections **96, 96'** are provided each defining a plurality of gaps, each gap adapted to receive one of the hammers **18, 18'** therein. The permanent magnets can be arranged substantially as illustrated in U.S. patent application Serial No. 419,509, filed December 18, 1964, and assigned to the same assignee as the present application. However, whereas the permanent magnet banks are illustrated as being two deep in that patent application inasmuch as the coil projecting from each shank extends above and below the shank so that each hammer utilizes magnets both above and below its shank, in accordance with the present invention the permanent magnet bank need only be one deep since half of the hammers will utilize the lower magnet bank **96** and half of the hammers will utilize the upper bank **96'**. The magnet banks can be cantilevered from the support assembly **46** as illustrated.

In the operation of the printing hammer **18** illustrated in FIGURES 1 and 2, in order to propel the impact tip **28** against the drum **10**, an electrical current is produced by the transformer secondary winding (not shown) and supplied to the conductive portions **41, 42**. Consequently, a current will flow through the coil structure **20** and support members **30** and **32** thus resulting in the generation of a first magnetic field which interacts with a second magnetic field produced by the parmanent magnets on either side of the coil structure **20**. The interaction will result in a force being applied to the coil structure **20** which is perpendicular both to the permanent magnet field and the direction of current within the coil structure **20**. Inasmuch as the current flow through the coil structure **20** is substantially in a vertical direction within the plane of the paper shown in FIGURE 1, and the magnetic field is perpendicular to the plane of the paper, the resulting force on the coil structure **20** will be horizontally directed within the plane of the paper therefore acting to propel the impact tip **26** against the drum **10**.

As demonstrated in the aforecited U.S. patent application Serial No. 463,263, the coil structure carried by the support members **30** and **32** will exhibit substantially rotational movement about the point **45** defined by the intersection of the support members when in a rest position. As is also pointed out in that patent application, if the geometry of the hammer is selected so that the impact tip **28** is positioned substantially at the center of percussion with respect to the center of rotation **45**, the reactive forces acting on the support members will be minimized and in addition the effective mass of the hammer will also be minimized thus minimizing both travel and contact times.

From the foregoing description of FIGURES 1 and 2, it should be appreciated that an improved hammer construction has been disclosed herein in which both the structural and electrical properties of a rigid unitary single turn coil preferably formed of aluminum or copper has been employed. That is, the structural properties of the coil structure have been employed to carry the impact tip **28** while the electrical properties thereof have been employed to conduct current between the ends thereof for interaction with the permanent magnetic field in order to develop a propelling force. As previously pointed out, a flat rigid unitary coil member as shown in FIGURE 1 which can be formed by fabrication methods such as stamping, casting, etc., can be provided at a lower cost than a multiturn coil conductor carried within a housing. In previous hammer embodiments wherein a coiled multiturn conductor is carried within a housing, the electrical characteristics of the coil are utilized while the structural characteristics of the housing are utilized. Herein, both the structural and electrical characteristics of a unitary element are both employed. In addition to being less costly, a coil structure as disclosed herein has greater inherent reliability than a coiled conductor supported within a housing. That is, there is considerably less likelihood that the current path in the unitary coil structure illustrated herein will be ruptured than in prior art coil structures.

Since the propelling force applied to the hammer is proportional to the magnitude of the permanent magnetic field, the magnitude of the current through the coil, and the number of coil turns within the magnetic field, it should be clear that if the number of turns is reduced by a factor of 100 for example, the current must be increased by that same factor if the same force is to be developed, assuming that the magnitude of the magnetic field remains constant. Inasmuch as the cross-section of the unitary single turn coil structure can be many times that of a single turn of the coiled conductive ribbon previously disposed within a housing, a current can be developed by the transformer and driven through the coil structure whose magnitude is many times greater than the magnitude of current previously driven through the coiled conductor. However, in order to develop even greater propelling forces, a pluraliy of unitary coil members can be laminated together to form a rigid structure as shown in FIGURE 3 wherein three unitary coil members **110**, **112**, and **114** are held together by an insulating epoxy material (not shown) provided therebetween. The conductive support members **30**, **32** will be respectively connected to the first end of coil member **110** and the second end of coil member **114**. Jumpers **116** and **118** will respectively connect the second ends of coil member **110** to the first end of coil member **112** and the second end of coil member **112** to the first end of coil member **114**.

Although a unitary coil member as shown in FIGURES 1 and 2 or a laminated coil structure as shown in FIGURE 3 provides enough cross-sectional area to carry sufficient current for all contemplated applications of the hammer **18**, as the magnitude of the current is increased, the power loss, and thus the efficiency, decreases as a consequence of the power loss in the conductive spring members **30** and **32**. More particularly, inasmuch as power loss is proportional to the square of the current, the tremendous increase in current required as a consequence of reducing the number of turns by a hundred fold, causes a tremendous increase in power loss through the spring members. Although the resistance of the spring members can be minimized by providing them with the enlarged ends illustrated to thus increase their cross-sectional area, a limit in resistance reduction is rapidly reached since as the springs get larger, they tend to lose their necessary compliance and flexural characteristics. Consequently, in accordance with a further aspect of the present invention as is illustrated in FIGURES 4 and 5, current is directly induced, via transformer action, into the rigid flat unitary coil member **120**. The coil member **120** is similar to that illustrated in FIGURES 1 and 2 except however it defines a closed conductive loop instead of including the gap **22** (FIGURE 1). The unitary coil member **120** can also be formed by any one of a plurality of known fabrication techniques. A transformer core **122** is threaded through the central opening **124** of the unitary coil member **120**.

A multiturn primary winding **126** is wound on the transformer core **122**.

The unitary coil member **120** is supported on a pair of spring members **128** and **130**. More particularly, first ends of the spring members **128** and **130** are secured to opposite sides of the unitary coil member **120**. Second ends of the spring members **128** and **130** are structurally secured to a support block **132** which is registered within a positioning block **134** provided with positioning V-grooves **135**. In the operation of the embodiment of FIGURE 4, in order to apply a propelling force to the unitary coil member **120**, a current is driven through the primary winding **126** on the transformer core **122**. As as consequence, a current is induced in the unitary coil member **120** which acts as a transformer secondary winding. This current of course interacts with the magnetic field produced by the permanent magnets disposed on either side of the coil member **120** to thereby cause a horizontally directed force within the plane of the paper to be applied to the coil member. Consequently, the coil member **120** will substantially rotate about a point **136** defined by the intersection of the support members **128** and **130** in their rest position.

Preferably, the impact tip **138** carried by the unitary coil member **120** should be positioned at the center of percussion with respect to the center of rotation **136**. With this geometry, the hammer will have its lowest effective mass and therefore travel and contact times will be minimized. In addition, the reactive forces on the support members **128** and **130** will be minimized. Because of this, and also because the support members **128** and **130** are no longer called upon to conduct current, they can comprise very simple and inexpensive spring members. The positions of the transformer cores **122** can be staggered as shown in FIGURE 5 in order to enable the hammers to be spaced sufficiently close to one another.

The transformer core **122** should be formed of a material having a large saturation flux density so that a sufficiently large current can be induced in the coil member **120** with a sufficiently small transformer cross-sectional area. In addition, the transformer core material should have a low coercivity in order to enable the electrical efficiency to be as high as possible. A typical material which is well suited for a transformer core for the indicated application is Supermendur.

From the foregoing, it should be appreciated that an improved hammer construction has been shown herein wherein a less expensive and improved hammer has been provided utilizing a flat rigid unitary coil structure which avoids the necessity of providing a coiled conductor and a housing therefor. Substantial currents can be driven through the coil structure via transformer action and in one embodiment of the invention the coil structure itself is made to comprise the transformer secondary, thereby considerably reducing the requirements made of the supporting spring members. Although not specifically illustrated, it should be appreciated that transformer action can be utilized to induce a current in a laminated coil structure of the type shown in FIGURE 3 and also in prior art coil structures comprised of multiturn coiled conductors disposed within coil housings either through supporting members as shown in FIGURES 1 and 2 or directly as shown in FIGURES 4 and 5. Further, although the provision of a unitary coil member or laminated coil structure has been shown only in conjunction with rotatable mounting means, it should be apparent that such coil structures can be utilized in hammers in which the structure is propelled linearly as for example as described in the aforecited U.S. Patent No. 3,172,352. Similarly, currents can be induced in coil structures mounted for linear movement by transformer action.

Accordingly, inasmuch as it is clearly recognized that other structural configurations can be provided which depend on the inventive concepts disclosed herein and which do not depart from the true scope and spirit of the invention, it is intended that such modifications fall within the scope of the invention as claimed.

What is claimed is:

1. A hammer construction comprising:
means for establishing a first magnetic field;
a flat rigid unitary coil structure;
means supporting said structure in said first magnetic field for movement between a rest position and an impact position; and
means for driving current through said coil structure for interacting with said first magnetic field to apply a force to said structure to move it from said rest position to said impact position.

2. The hammer construction of claim **1** wherein said coil structure has first and second terminals;
said means supporting said structure including first and second conductive springs respectively connected to said first and second terminals; and
means coupling said means for driving current to said first and second conductive springs.

3. The hammer construction of claim **1** wherein said means for driving current includes a transformer core; and
means inductively coupling said transformer core to said coil structure.

4. A hammer construction comprising:
means for establishing a first magnetic field;
a rigid coil structure comprised of one or more flat single turn unitary conductive coil members connected in series;
means supporting said structure in said first magnetic field for movement between a rest position and an impact position; and
means for driving current through said coil members for interacting with said first magnetic field to apply a force to said structure to move it from said rest position to said impact position.

5. A hammer construction comprising:
means for establishing a first magnetic field;
a rigid structure including a current conducting means;
means supporting said structure in said first magnetic field for movement between a rest position and an impact position;
means for driving current through said current conducting means for interacting with said first magnetic field to apply a force to said structure to move it from said rest position to said impact position;
said means for driving current including a transformer core; and
means inductively coupling said transformer core to said current conducting means.

6. A printing hammer comprising:
a rigid coil structure comprised of at least one flat unitary conductive member energizable to generate a first magnetic field;
means supporting said rigid structure for substantially rotational movement about a first axis; and
means establishing a second magnetic field adapted to interact with said first magnetic field.

7. The hammer construction of claim **6** including:
an impact tip; and
means mounting said impact tip on said coil structure.

8. The hammer of claim **7** wherein said impact tip is positioned substantially coincident with the center of percussion for said structure rotatable about said first axis.

9. The hammer of claim **6** wherein means supporting said rigid member include first and second flexible support members.

10. The hammer construction of claim **9** wherein said conductive member has first and second terminals; and wherein
said first and second support members comprise electrical conductors respectively connected to said first and second terminals.

11. The hammer construction of claim **9** including a transformer core; and
means inductively coupling said transformer core to said conductive member for energizing it to generate said first magnetic field.

12. A printing hammer comprising:
a rigid coil structure including a current conducting means energizable to generate a first magnetic field;
means supporting said rigid structure for substantially rotational movement about a first axis;
means establishing a second magnetic field adapted to interact with said first magnetic field; and
means for energizing said current conducting means including a transformer core and means inductively coupling said transformer core to said current conducting means.

References Cited by the Examiner

UNITED STATES PATENTS

3,072,045	1/1963	Goin	101—93
3,172,353	3/1965	Helms	101—93

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