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[54] **HIGH RELIABILITY CERAMIC BENDER**
2 Claims, 2 Drawing Figs.

[52] **U.S. Cl.** **310/8.6,** 178/30, 310/9.8
[51] **Int. Cl.** **H01v 7/00**
[50] **Field of Search** 310/8.6, 8.5, 8.3, 8.7, 8.1, 8.2, 9.4, 9.7; 178/30

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ABSTRACT: A piezoelectric ceramic hammern of the bimorph bender-type is improved by providing an outer foil layer of stainless steel, or the like, to increase the tensile and compression strength at the surface of a layer of polycrystalline piezoelectric material.

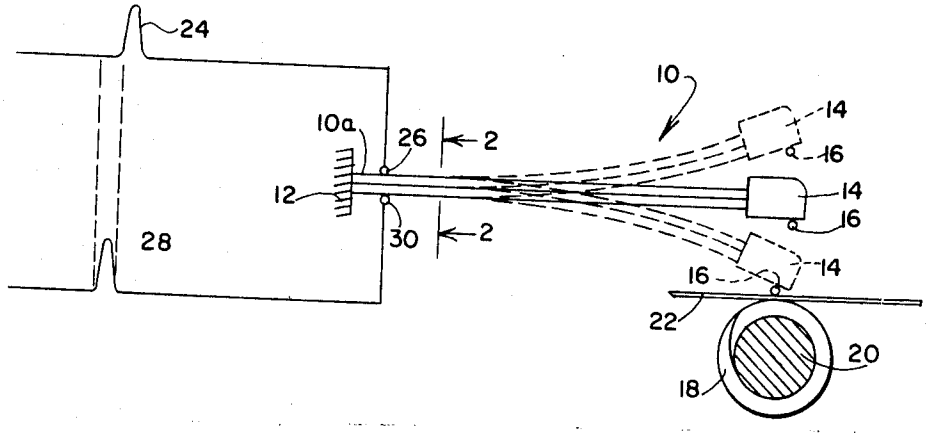


FIG. 1

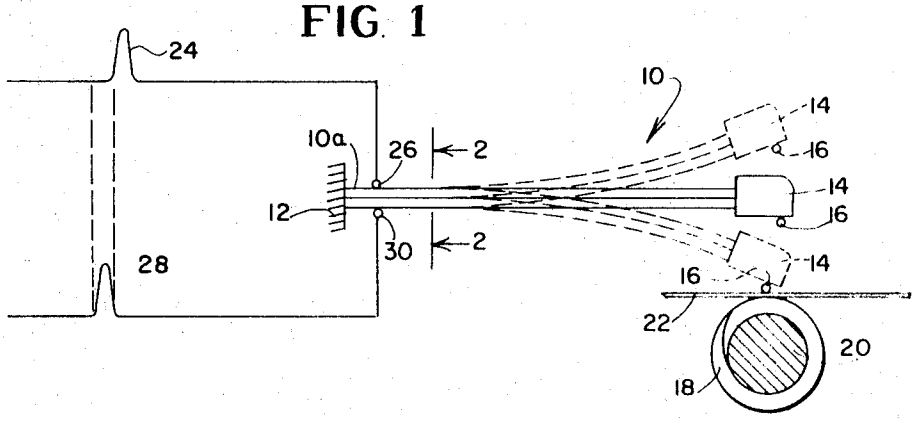
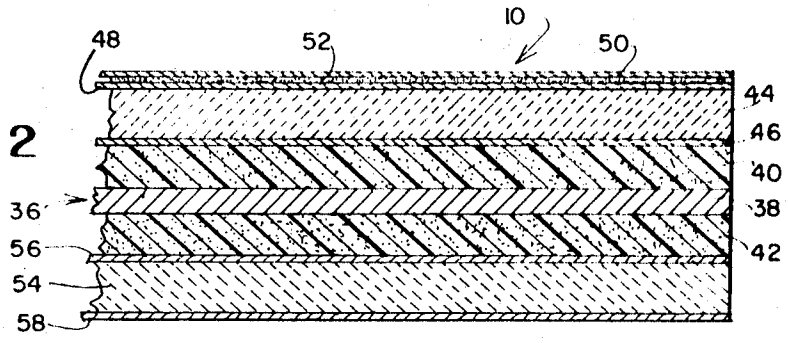


FIG. 2



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HIGH RELIABILITY CERAMIC BENDER

BACKGROUND OF THE INVENTION

This invention relates generally to piezoelectric benders, and more particularly to high-excursion motor-type piezoelectric benders.

Although the piezoelectric bender of this invention is here illustrated as forming an improved teleprinter hammer, it will be understood that the bender can be used for other purposes as well.

There are many applications in various communications systems where it is desired to provide a written message so that it can be received, and recorded, without any special action on the part of an operator. This type of communications is at present well-known and widely used, and is accomplished by teleprinter units which receive signals indicative of the message to be printed and then translate such signals in a manner to produce the appropriate printed message on a sheet or roll of paper, whichever the case may be. It has, however, become relatively important to provide such teleprinter units which are relatively small and compact for use as mobile apparatus. These printers are not only required to be very compact but also to be of rugged design so they can withstand shock and vibration which is encountered by motor vehicles, such as automobiles or the like. Such compact teleprinter units for mobile use may use a piezoelectric crystal hammer as a striking mechanism to form characters, or elements of characters, on a sheet of paper ultimately to form the printed message. One such teleprinter system is disclosed in U.S. Pat. No. 3,418,427 issued Dec. 24, 1968, and assigned to the same assignee.

Generally, piezoelectric crystal hammers are constructed of two lead-zirconate-titanate plates of opposite polarity bonded to either side of a copper support plate which acts as a center vane. This laminate structure is securely held at one end in a cantilever position while the other end is free. Upon application of an electric field normal to the brass plate, one of the lead-zirconate-titanate plates will increase in length and the other will decrease in length, this action occurring rapidly to bend the crystal hammer in a given direction. That is, the free end bends either upwardly or downwardly, or rearwardly or forwardly, depending on the polarity of the applied voltage.

To produce a greater striking force of a particular piezoelectric hammer, a pulse of electrical energy of one polarity is first applied to the electrodes of the hammer to cause the hammer to bend in a first direction away from the object to be struck. This action is immediately followed by a subsequent pulse of electrical energy of opposite polarity, or of the same polarity but applied to a different layer of the hammer, to cause the hammer to move smartly in the opposite direction and strike upon the surface of the printing medium to cause a character or a character segment to be formed thereon. This action occurs very rapidly many times a minute with tremendous tensile and compression forces being created at the outer surfaces of the crystal material which form the piezoelectric hammer. The increased tensile forces have caused serious problems with respect to the reliability and efficiency of such piezoelectric crystal hammers. After a relatively short period of time, surface cracks may be formed at the outer surface of the piezoelectric material effectively to reduce the striking force and/or efficiency of the hammer. This action will ultimately cause a complete failure of the hammer so it will no longer operate with the appropriate electrical pulses applied thereto.

SUMMARY OF THE INVENTION

Accordingly, it is an object of this invention to provide a piezoelectric ceramic bender which can operate for longer periods of time without causing adverse fractures at the surfaces of the layers of piezoelectric material which form the bender.

Another object of this invention is to provide an improved piezoelectric ceramic bender to form a teleprinter hammer which is efficient and reliable in operation and relatively inexpensive to manufacture.

Briefly, the piezoelectric ceramic hammer includes a conductive, resilient center vane of relatively thin planar configuration which forms a first electrode member. The center vane may be any suitable conductive material, such as a thin brass or copper plate which, in accordance with this invention, forms only an electrode member and serves not as a support member. A first layer of piezoelectric ceramic material is formed over one surface of the center vane, and the second layer of the piezoelectric ceramic material is formed over the opposite surface of the center vane. Conductive layers are formed at the exposed surfaces of each of the ceramic layers and are arranged for connection to a suitable pulsing circuit which applies electrical pulse signal across the layers of ceramic material to cause the bending and striking action of the hammer. Most advantageously, the layer or foil, preferably of a metal such as stainless steel or the like, is secured to the exposed outer surface of at least one of the conductive layers. This metal foil may be adhesively secured to the ceramic material or it may be electroplated thereon, as desired. The foil causes a uniform stress distribution over the outer surface of the piezoelectric bender and thus serves to increase the tensile strength at the surface to which it is secured so that the piezoelectric hammer so formed can then operate in a much more efficient and reliable manner without surface cracks being caused in the ceramic material.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic representation of a piezoelectric ceramic bimorph hammer constructed in accordance with this invention and which shows the drawback and striking positions of the hammer in phantom lines and the neutral position shown in solid line; and

FIG. 2 is an enlarged fragmentary sectional view of the piezoelectric hammer of this invention as taken along section line 2—2 of FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. 1, there is seen a piezoelectric ceramic hammer designated generally by reference numeral **10**, its neutral position being shown in solid line while its initial pulled back position and its forward striking position are shown in phantom line. The piezoelectric ceramic hammer **10** has one end **10***a* fastened securely to a suitable support, designated by reference numeral **12**, so that this end of the hammer does not move under any condition. A movable head **14** is fastened to the free end of the piezoelectric hammer **10**, this head preferably being formed of plastic or other moldable material. A striking bar **16** is securely held by the head **14** and extends in the transverse direction of the head so as to form a plurality of discrete hammer contact portions therealong. The portion utilized to form a discrete character mark will depend on the location of a platen thread **18** formed on the platen shaft **20**. The platen shaft **20** rotates at a given speed to cause the spiral platen thread **18** to take various positions along the axial extend of the shaft **20** which, in turn, will cause relative axial movement of the platen thread **18** with respect to the hammer bar **16**. This particular configuration of the hammer bar and platen thread form discrete portions of characters on a record medium **22**, such as a roll or sheet of paper which is interposed between the hammer bar **16** and the platen thread **18**.

The piezoelectric hammer **10** may be of the type constructed of two lead-zirconate-titanate plates of opposite polarity. In the preferred mode of operation a first electrical impulse, designated by reference numeral **24**, is applied to one electrode surface via a terminal **26** and ground potential which may be formed by the support surface **12**. This action will cause the piezoelectric ceramic hammer to bend upwardly, or rearwardly, in any event away from the record medium **22**. The electrical impulse **24** is immediately followed

by a similar electrical impulse **28** which is then applied to another electrode surface via terminal **30** and the ground potential provided by the support **12**. The rapid succession of pulses **24** and **28** to opposite piezoelectric ceramic materials cause the hammer to quickly pull back and smartly strike forward to form a discrete mark on the record medium **22** on that portion of the record medium which is then between the hammer bar **16** and the platen thread **18**. The exact location of the discrete mark or marks is controlled by synchronizing the rotation of the platen shaft **20** together with the forward striking action of the piezoelectric hammer **10** so that complete characters of the alphabet as well as numbers are formed in a rapid efficient manner.

FIG. **2** illustrates an enlarged fragmentary sectional view of the piezoelectric ceramic hammer **10** of FIG. **1**. Here there is illustrated a conductive, resilient center vane **36** which may be formed by any suitable conductive resilient material to cause the piezoelectric hammer **10** to easily bend in either direction upon the application of the electrical pulses **24** and **28**. The center vane **36** may be formed of several thin components starting with a thin sheet of brass **38**, which may be in the order of 3 mils thick. On either side of the layer of brass **38** is iron powder filled clear epoxy **40** and **42**, this material being easily flexed in either direction without causing cracks or the like to appear in the conductive layers since it is very near the center of the bendable portion of the hammer **10**. The primary object of the center vane **36** is to provide a resilient member through which electrical current can flow to establish the proper electric field across the piezoelectric material which, in turn, will cause mechanical movement of a first layer **44** of piezoelectric material. The fist layer of the piezoelectric ceramic material **44** is formed over the conductive layer **40** and includes at the innerface thereof a conductive electrode **46** which may be electroplated to the piezoelectric ceramic layer **44** during a prior operation. Formed on the opposite side of the piezoelectric layer **44** is another conductive layer **48** which also may be formed by a suitable electroplating process.

Most advantageously, a foil **50**, preferably of conductive material such as stainless steel or the like, is adhesively secured to the upper surface of the piezoelectric layer **44**, i.e., at the electrode surface **48**, greatly to increase the tensile and compression strength of the piezoelectric ceramic layer **44** particularly at the outer surface thereof. The stainless steel foil **50** is bonded to the electrode surface **48** by a quantity of conductive bonding material such as impregnated epoxy, or the like, indicated at reference numeral **52**, this glue line being as thin as possible to form a secure bond between the conductive electrode surface **48** and the foil **50**. The advantageous result obtained by utilizing a foil layer at the outer surface of at least one exposed surface of a piezoelectric hammer is that the usable life of the piezoelectric hammer is greatly increased as compared to piezoelectric hammers which do not have the foil **50** formed thereon.

The second layer **54** of piezoelectric ceramic material is secured to the opposite side of the center vane **36** and also includes an electroded surface **56** in contact with the center vane **36** to form an electrical connection therewith. Additionally, an electroded surface **58** is formed at the exposed surface of the piezoelectric layer **54**. Electrical connection to the piezoelectric hammer is then made between the center vane **36** and the exposed electrode surface **58** to cause the hammer to move in one direction upon the application of one of the operating pulses, and electrical connection is made between the center vane **36** and the foil **50** to cause the piezoelectric layer **44** to bend in the opposite direction upon the application of the other control pulses. However, it is noted that the electrical connection to the foil **50** may be made to the electrode layer **48**, if desired.

It will be understood that a second foil, also of stainless steel or the like, can be formed at the exposed outer surface of the piezoelectric layer **54** over the electrode surface **58**. This will substantially increase the tensile and compression strength of both piezoelectric elements **44** and **54** at their extreme outer surfaces during operation so as to greatly increase the usable life of such piezoelectric hammer.

What has been described is an improved piezoelectric hammer which utilizes an outer foil of stainless steel or the like to improve the tensile and compression strength of the piezoelectric ceramic layers which form such a hammer. Accordingly, it will be understood that variations and modifications of this invention may be effected without departing from the spirit and scope of the novel concepts disclosed and claimed herein.

I claim:

1. A hammer structure for use in printing apparatus and including an elongated laminated body fixedly secured at one end and having striker means secured to the free end thereof, said elongated laminated body including in combination, a conductive resilient center vane of relatively thin planar configuration, a layer of conductive adhesive epoxy on each side of said resilient center vane, first and second layers of piezoelectric ceramic material secured to said resilient center vane by means of said conductive adhesive epoxy, said first layer of piezoelectric ceramic material being secured to one side of said resilient center vane and said second layer of piezoelectric ceramic material being secured to the other side of said resilient center vane, first and second electrode means formed on the outer surfaces of first and second layers of piezoelectric ceramic material respectively to cooperate with said center vane for receiving energizing electric pulses which causes bending of the laminated body, a metal foil secured to at least one of said layers of piezoelectric ceramic material over its associated electrode, said metal foil serving to increase the tensile and compression strength of the associated layer of piezoelectric ceramic material while allowing substantially maximum flexibility of said laminated body, and circuit means electrically connected to said center vane and said first and second electrode means for applying a first pulse between said center vane and said first electrode means to produce an electric field across said first layer of piezoelectric ceramic material and bend said laminated body in one direction along its length and for applying a second pulse following said first pulse between said center vane and said second electrode means to produce an electric field across said second layer of piezoelectric ceramic material and bend said laminated body along its length in the opposite direction thereby producing a hammer-striking action.

2. The hammer structure of claim **1** further including a second metal foil secured to the other layer of piezoelectric ceramic material over its associated electrode, said second metal foil serving to increase the tensile and compression strength of said other layer of piezoelectric ceramic material.

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