

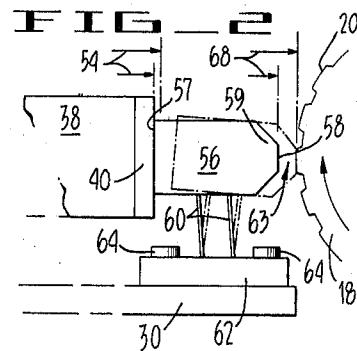
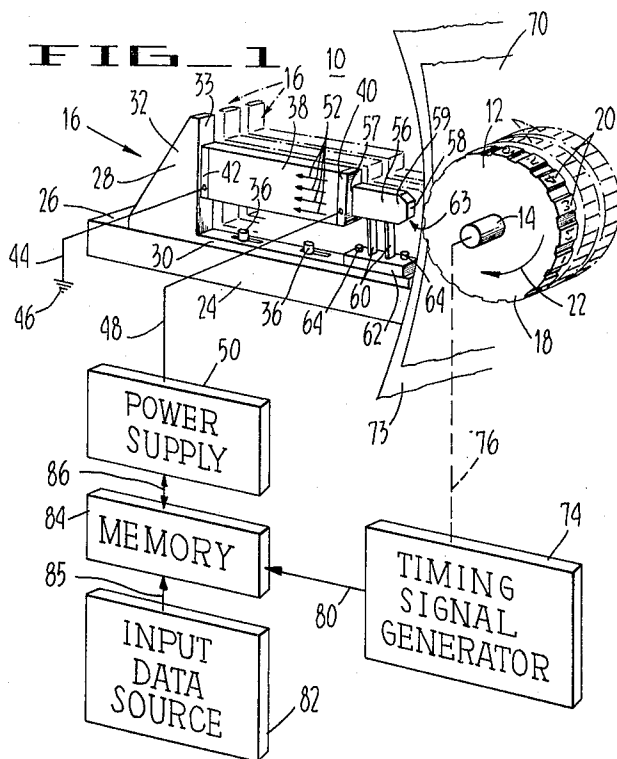
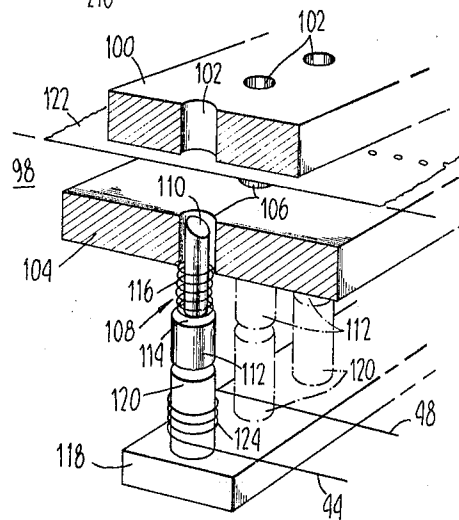
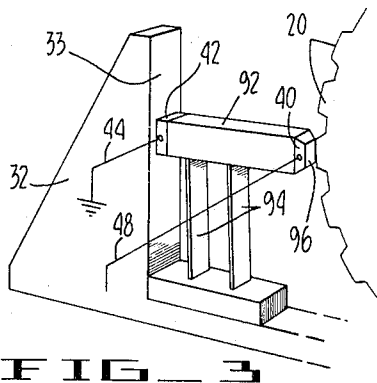
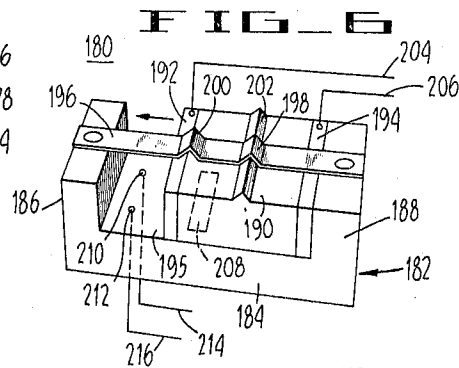
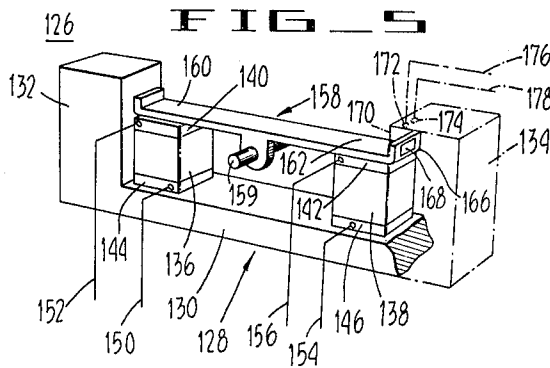
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3,482,772

ELECTROSTRICTIVE ACTUATOR

Original Filed March 24, 1966



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AGENT

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3,482,772

ELECTROSTRICTIVE ACTUATOR

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Original application Mar. 24, 1966, Ser. No. 537,199, now Patent No. 3,420,975, dated Jan. 7, 1969. Divided and this application June 28, 1968, Ser. No. 740,871

Int. Cl. G06k 1/05; B26f 1/04; B41j 23/36

U.S. Cl. 234-108

5 Claims

ABSTRACT OF THE DISCLOSURE

A piezoelectric or ferromagnetic element having the property of changing its dimensions upon application of an electric or magnetic field, respectively, is coupled with an essentially free-flight projectile to drive a print hammer, a paper punch, or a set of electric circuit make/break contacts.

Cross reference to related applications

This application is a division of copending application, Ser. No. 537,199, filed Mar. 24, 1966 for "Electrostrictive Actuation," now United States Patent No. 3,420,975 issued Jan. 7, 1969 and this application is assigned to the same assignee as said copending application.

Background, field of invention

This invention relates to a transducer and more particularly concerns an electrostrictive actuator for imparting movement to an operating member, such as a hammer for a high-speed printer, a punch for a paper perforating mechanism, a contact carrying member for a switch, and the like.

Background, prior art

One of the limiting factors or bottlenecks in optimum utilization of high-speed electronic data processors is the speed at which auxiliary output devices can accept and translate electrical signals commonly termed "data" into meaningful or useful form for direct utilization by other equipment or by humans. For example, electrical signals can be supplied from a data processor to a high-speed printer for translation into printed alphanumeric symbols at a rate substantially faster than the printing capability of the printer. The printing capability of a high-speed printer is dependent upon the speed at which its various moving parts can be reliably actuated. A reduction in the number and size of moving parts generally results in an increase in printing speed.

Likewise, in punching devices for punching holes in cards or paper tapes in response to data received from a data processor, a reduction in size and number of moving parts will result in a device having faster punching capability. Occasionally, data from a data processor is used to activate relays or switches for control of power to other devices. Any increase in the speed of operation of data-processor-controlled switch-type devices is highly desirable.

It is, therefore, a principal object of the present invention to provide an improved transducer.

A further object is to provide an electrostrictive actuator for inducing movement in a work element.

Still a further object is to provide an improved transducer for driving a paper punch.

These and other objects of the present invention will become more apparent as the description proceeds.

Summary

Briefly stated, the present invention contemplates the use of a small piece of material having the natural prop-

erty of rapidly expanding its dimensions in response to a rapidly applied electric or magnetic field. The material, hereinafter termed an electrostrictive member, is arranged within a frame such that one end of the member pushes against a movable object as the member expands, thereby imparting a large momentum to the object. The movable object is arranged within the frame such that it is free to continue to move by momentum to a second position where useful work is done. The present invention also contemplates that the movable object can be the electrostrictive member itself; for example, the electrostrictive member may be releasably and lightly held against an end wall of a stable frame and upon application of an electric or magnetic field to the electrostrictive member, the expansion thereof causing the member to rebound off the stable wall and move to a new location where useful work is done.

The features of novelty that are considered characteristic of this invention are set forth with particularity in the appended claims. The organization and method of operation of the invention may best be understood from the following description when read in connection with the accompanying drawings.

Brief description of the drawings

FIG. 1 is a simplified diagrammatic perspective illustration of one embodiment of the present invention;

FIG. 2 is an enlarged side view of a portion of FIG. 1 illustrating the movement of the electrostrictive member and movable object;

FIG. 3 is a simplified diagrammatic perspective illustration of a modification of the embodiment of FIG. 1;

FIG. 4 is a simplified diagrammatic cutaway illustration of a second embodiment of the present invention;

FIG. 5 is a simplified diagrammatic perspective illustration of a third embodiment of the present invention; and

FIG. 6 is a simplified diagrammatic perspective illustration of a fourth embodiment of the present invention.

Description of the preferred embodiments

Certain dielectric crystals, such as, for example, quartz, Rochelle salt, tourmaline, etc., commonly known as piezoelectric crystals, exhibit an increase in their dimensions when an electric field is applied across the crystal. Upon removal of the electric field, the crystal again assumes its normal dimensions. A similar increase in dimensions occurs in certain materials commonly known as ferromagnetic materials when a magnetic field is impressed across the material. Upon removal of the magnetic field, the material again assumes its normal dimensions. The dimensional increase phenomena evidenced by such materials is termed magnetostriction.

The present invention contemplates taking advantage of the dimension elongation or increase encountered in both piezoelectric and ferromagnetic materials. Throughout this specification and appended claims, the terms "electrostrictive member" is used and is to be understood as including both piezoelectric and ferromagnetic materials and the term "electrostrictive effect" is to be understood as including an increase in dimensions of a material upon application of an electric or magnetic field across the material. In addition, the term "electrical signal" used in this specification and appended claims is to be understood as including an electric field induced by a source of electric power and a magnetic field generated by a source of electric current.

In FIG. 1 a high-speed printer 10, incorporating a preferred embodiment of the present invention, includes a plurality of identical type wheels 12 mounted axially along a common drive shaft 14 and a plurality of print hammer or transducer units 16. A typical high-speed

printer used in conjunction with an electronic data processor has 120 type wheels. Since each type wheel is identical, only one wheel is shown in solid lines and described. The outer periphery 18 of each print wheel is provided with a plurality of circumferentially spaced type members 20. The type members usually comprise the alphabet, cardinal numbers, and special symbols, such as, for example, the dollar sign, the decimal point, the plus and minus symbols, etc., as required. Suitable motive power means (not shown) interconnected with the drive shaft 14 causes the shaft and type wheels 12 to rotate in preferably the clockwise direction at a predetermined substantially constant speed as indicated by arrow 22.

A stable base or platform 24, having a generally horizontal upper surface 26, is disposed to one side of the type wheel 12 and somewhat lower than the axis of the shaft 14. The stable platform may be part of the overall framework (not shown) of the high-speed printer 10.

Each type wheel 12 has associated therewith a separate transducer unit 16. Since the transducer units are identical to each other, only the foremost unit, shown in solid lines in FIG. 1, is described in detail. Each transducer unit 16 includes an electrostrictive member and print hammer mounting frame 28 adjustably mounted on the top surface 26 of platform 24 for precisely spacing a print hammer 56 mounted thereon from the outer periphery of the associated type wheel 12, as will become more apparent as the description proceeds. Each mounting frame comprises a lower plate 30 having a forward end near the type wheel and a rearward end opposite to the forward end. An electrostrictive element mounting bar or member 32 extends upwardly from the rear end of the lower plate 30 and is provided with a surface 33 facing toward the type wheel 12. Set screws 36 are inserted through longitudinal openings formed in the lower plate and threaded into appropriately formed holes in the platform 24. In this manner, the mounting frame 28 may be adjusted toward and away from the associated type wheel and secured firmly in the desired location.

An electrostrictive member or element 38, shown in FIG. 1 as a generally bar-shaped piezoelectric crystal, has electrodes 40 and 42 suitably formed on opposite ends of the crystal. The crystal is secured in the transducer unit 16 with the rear electrode 42 abutting the surface 33; suitable electrical insulating material (not shown) may be placed between the electrode 42 and surface 33. The forward electrode 40 faces the type wheel 12. A layer of electrical insulating material may be formed on the outer surface of the electrode 40 if desired. An electrical lead 44 is connected between rear electrode 42 and a terminal (shown as electrical ground symbol 46) associated with electrical power supply 50. A second electrical lead 48 is connected between forward electrode 40 and the power supply 50.

The power supply 50 is of a type that, when triggered, will supply a high power electrical signal for a very short period of time to leads 44 and 48. The electrical signal to leads 44 and 48 will impose an electric potential between the two electrodes 40 and 42 and through the crystal 38. As shown in FIG. 1, an electric field, indicated by arrows 52, is generated through the crystal. The crystal, in response to the electric field, elongates or expands along each of its three dimensions. Generally speaking, the crystal expands more along an axis parallel with the electric field than along the other two axes. Since the crystal is held securely against the surface 33 of mounting bar 32, longitudinal elongation of the crystal takes place only in the forward direction toward the type wheel 12. The result is that the forward end of the crystal and forward electrode 40 are moved forwardly a precise but small distance, as indicated in FIG. 2, by the arrows 54.

The amount of total movement of the forward or free end of crystal 38 is dependent upon a number of factors, among which is the particular material of the crystal, the particular orientation of the crystal structure or lattice with respect to the direction of the applied electric field,

and the strength of the electric field. In general, an increase in strength of the electric field across the crystal will effect an increase in the elongation of the crystal; of course, there is a maximum elongation value beyond which further electric field value increases will not effect further elongation of the crystal. In addition, it is well known that the potential difference across the two plates of a capacitor (crystal 38 and electrodes 40 and 42 form a capacitor) does not reach maximum value instantly upon application of current to the plates. A certain amount of time is required for the plates of the capacitor to become fully charged; only when the plates are fully charged is the field or potential across the plates at its maximum value. This time is generally called the time constant of the capacitor. Therefore, the elongation of the crystal 38 does not take place instantly upon application of an electrical signal to electrodes 40 and 42, but rather takes a certain small time period according to the time constant of the capacitor formed by the electrodes and crystal. The exact time constant is also a function of the size of the plates or electrodes. As an example, a cylinder of piezoelectric material, such as lead zirconate and lead titanate (PZT—4, manufactured by Clevite Corporation), having a longitudinal length of one-half inch and a diameter of one-quarter inch, will expand approximately twelve microinches, (length 54 in FIG. 2) in the direction parallel to the applied electric field 52 upon application of 1000 volts D.C. to the electrodes 40 and 42. The use of bars having a smaller dimension between electrodes 40 and 42 will, of course, facilitate the use of lower voltages. Assuming a mass of 0.005 pound for the hammer 56, the above-mentioned twelve microinches elongation of the piezoelectric material will impart a velocity of about sixty feet per second to the hammer, which is sufficient to produce acceptable printing. The illustrations in the above-mentioned example are not to be understood as showing and describing the actual configuration, construction, or dimensions of the present invention but are to be understood as illustrating and describing the principles upon which the invention is based.

It should be immediately clear, in view of the above discussion, that if the charging time constant of the electrodes 40 and 42 is very small, the forward end of the crystal 38 and attached electrode 40 will be moved forwardly very rapidly, i.e., with a high acceleration or impulse. This very rapid movement of the forward end of the crystal is utilized to impart momentum to a projectile or object, such as print hammer member 56. The hammer member is essentially a block or bar of hard elastic material having a rearward end 57 adjacent the forward end of crystal 38, and a forward end 59 having a printing surface 58 facing the type wheel 12 at substantially the same level as the axis of rotation of the type wheel. The hammer member is held in position by means of two upstanding flat springs 60, the lower ends of which are fixed to a spring support plate 62 adjustably secured to the lower plate 30 of the mounting frame 28 by means of a pair of set screws 64 extending through longitudinal openings provided in the support plate 62 and threadedly engaged in suitably formed holes in plate 30. The support plate is adjusted so that the rear end 57 of the hammer member 56 abuts the forward end of the crystal 38 and is urged or biased thereagainst with a small predetermined force by means of the springs 60 when the crystal 38 is in its normal nonelongated state, as shown in solid lines in FIG. 2. Also, when the hammer member is in its normal position, as indicated by solid lines in FIG. 2, a space 63 of predetermined dimensions, as indicated by arrows 68, separates the printing surface 58 of the hammer member from the immediately adjacent type member 20. It is to be noted that space 63 is larger than the distance that the forward end of the crystal moves (indicated by arrows 54) when excited by an electrical signal.

As illustrated in FIG. 1, a portion of an inked ribbon 70 passes substantially vertically through the space 63;

suitable feed and takeup rolls (not shown) attached to the printer furnish a supply of fresh inked ribbon. In addition, a portion of a paper web 73 passes substantially vertically through the space 63 between ribbon 70 and printing surface 58 of hammer member 56; likewise, feed and takeup rolls (not shown) attached to the printer move the paper at appropriate times to present a blank area of paper for imprinting thereon with the present invention.

When the forward end of the crystal 38 is rapidly moved or accelerated toward the type wheel 12 in response to an electrical signal, as previously described, it pushes rapidly against the rear end 57 of the hammer member 56, thereby moving or accelerating the hammer member toward the type wheel 12. When the crystal 38 ceases to elongate any further, the momentum of the moving hammer member overcomes the slight biasing force of springs 60 and continues to move toward the type wheel. In other words, the hammer member acts like a projectile in that it separates from the accelerating medium (in this case the crystal 38) and continues to move by momentum. The printing surface 58 presses against the paper 73 which, in turn, presses against the inked ribbon 70 which is then pressed into firm contact with the adjacent type member 20 on the type wheel 12. The impact or momentum of the hammer member 56 imposes a pressure on the paper, carbon and type member sufficient to cause printing of a character on the forward surface of the paper.

After the printing action takes place, there will be a rebounding of the hammer member away from the type member 20 back toward the crystal 38. In addition, the force of springs 60 will aid and assure the return of the hammer member to its normal position abutting the forward end of crystal 38. As the hammer member returns to its normal position, impact of the hammer member with the crystal will generally induce a potential difference across the electrodes 40 and 42. This potential difference may cause a current flow in the electrical leads 44 and 48 which may be suitably absorbed by provision of appropriate damping resistors and unidirectional current control devices, such as diodes or the like, included as part of the power supply 50.

In operation of the printer 10, any well-known timing signal generator unit 74 may be coupled with the mechanical drive 76 of the rotating shaft 14 for generating a series of timing and control signals indicative of the particular type member 20 in or about to be in proper printing position just opposite or adjacent the hammer member 56. The timing signal generator unit will furnish these signals periodically to a memory unit 84 by way of a transmission line 80.

Input data, indicative of the alphanumeric character to be printed, is furnished from an input data source 82 which may be, for example, a manually operated keyboard, a punched paper tape or punched card reader, or a high-speed electronic data processor, to the memory unit 84 by way of a data channel 85. The input data transferred to the memory is stored therein until the proper time for printing occurs, as described below. Signals received from the timing signal generator unit 74 are compared with the data stored in the memory. When a signal from the timing signal generator unit 74 (indicative of a particular type member 20 in or about to be in printing position) matches with the data in the memory unit (indicative of the character to be printed), a triggering signal is sent to power supply 50 by means of a lead 86. The power supply is then triggered or turned on and furnishes an electrical signal to lead 48 thereby causing elongation of the crystal 38 and consequent printing of the desired character, as previously described.

It should be evident from the foregoing description that the principles of the present invention may be accomplished with an electrostrictive member 38, made of ferroelectric material rather than a piezoelectric crystal. When using a ferroelectric material, an electrical conduc-

tor is wound about the ferroelectric material and connected to leads 44 and 48. An electrical signal from the power supply 50 will cause current to flow through the winding, thereby generating a magnetic field through the ferroelectric material and thus causing elongation of the material and consequent acceleration of the hammer member 56.

In FIG. 3 there is illustrated another form of the present invention. An electrostrictive member 92 having a rear electrode 42 and a forward electrode 40 with associated leads 44 and 48 is supported upon two flat upstanding springs 94. The electrostrictive member 92 is not secured to the mounting bar surface 33 but is rather releasably biased thereagainst by the spring 94 in the same manner that hammer member 56 of FIG. 1 is biased against the forward end of the crystal 38. In FIG. 3, the forward end of the electrostrictive member 92 forms an impact surface 96 comparable to printing surface 58 of hammer member 56 in FIG. 1. Upon application of an electrical signal to leads 44 and 48, the electrostrictive member 92 rapidly elongates. Since the electrostrictive member 92 is initially mechanically biased against the surface 33, all movement of the member takes place in the forward direction. Since the electrostrictive member is free to move away from the surface 33, the momentum of the member overcomes the small retarding force of springs 94 and moves forwardly to cause the paper and carbon to be pressed into contact with the type member 20. The electrostrictive member will be returned to its normal position by the force of springs 94 and the rebound effect from the type member. Thus, in the modification shown in FIG. 3, the electrostrictive member 92 acts both as an accelerating medium and as a projectile for doing useful work.

In FIG. 4 there is shown a paper tape punching apparatus 98 utilizing the principles of the present invention. As is usual in paper tape punches, there is an upper die member 100 having formed therein a straight row of punch receiving cylindrical holes 102. Directly below the die member is a punch guiding member 104 having a plurality of punch retaining holes 106, individual ones of which are associated with corresponding punch receiving holes 102. Each punch retaining hole 106 has slidably disposed therein a punch member 108. The upper end 110 of each punch member is generally beveled and sharpened for easy penetration of paper. The lower end of the punch member is secured to a stop member 112, having an upwardly facing shoulder 114 and having an outer diameter substantially greater than the diameter of the hole 106 and the punch 108. A coiled spring 116 is disposed about the lower portion of the punch between the shoulder 114 and lower surface of the punch guiding member 104. A portion of a paper tape 122 is disposed between the die member 110 and the guide member 104. The paper tape may be fed from and taken up by suitably arranged spools and associated drive mechanisms (not shown) well known in the art.

A support base 118 is secured to a main frame (not shown) of the punching apparatus 98 and disposed beneath the stop members 112. A plurality of electrostrictive elements 120 (shown in the figure as being made of ferroelectric material) are secured to the support base 118. Individual ones of the electrostrictive elements 120 are disposed directly beneath the lower end of an associated stop member 112. The force of the spring 116, plus the force of gravity, biases the stop members against the top of their associated electrostrictive elements.

A separate electrical conductor 124, terminating in leads 44 and 48, is wound about each electrostrictive element 120. Selective application of electrical power to the leads 44 and 48 will cause the electrostrictive element to elongate and impart upward momentum to the stop member and punch. Upward momentum of the stop member and punch will force the beveled upper end of the punch against the paper. The paper, in turn, will be

urged against the underside of the die member and the continued momentum of the stop member and punch forces the beveled end of the punch through the paper and into the corresponding punch receiving hole, thereby forming a hole in the paper. The spring 116 returns the stop member and punch to their former normal position.

In FIG. 5 there is shown a novel switch or bistable element 126 incorporating the principles of the present invention. The switch comprises a U-shaped frame 128 having a base portion 130 plus two leg portions 132 and 134 upstanding from the base portion. Electrostrictive elements 136 and 138 (illustrated as piezoelectric crystals) having respective upper electrodes 140 and 142 and respective lower electrodes 144 and 146, are attached to the base portion near the opposed leg portions. Leads 150 and 152, associated with the electrodes of the left-hand electrostrictive element 136, may be suitably connected to an electrical power circuit, and leads 154 and 156, associated with the electrodes of the right-hand electrostrictive element 138, may be suitably attached to an electrical power circuit.

A switching arm or member 158 is mounted on a shaft 159 for pivotal movement about an axis disposed horizontally below the switching arm. Opposite ends 160 and 162 of the switching arm are disposed directly over the upper ends of respective electrostrictive elements 136 and 138. With the particular mounting of the switching arm shown in FIG. 5, the center of gravity of the arm is disposed above the axis of the shaft 159 and in the same vertical plane as the axis when the arm is exactly horizontal. When the arm is pivoted or teetered one way or another, the center of gravity is caused to be offset one way or another from the mentioned vertical plane. Offsetting of the center of gravity imposes a torque on the arm which acts as a bias, causing further pivoting in one direction to bring the associated end of the arm into contact with the upper end of its associated electrostrictive element. As illustrated in FIG. 5, the arm 158 is biased in the clockwise direction and its right-hand end 162 is resting on top of right-hand electrostrictive element 138. Upon application of an electrical signal to leads 154 and 156, the electrostrictive element 138 elongates vertically and pivots the arm 138 in the counter-clockwise direction. Momentum of the arm will cause continued pivoting thereof until the left-hand end 160 of the arm contacts the upper end of left-hand electrostrictive element 136. This action also moves the center of gravity of the arm to the left of the vertical plane containing the pivot axis of shaft 159. This new position of the switch arm's center of gravity imposes a biasing force for maintaining the arm in its new position. Other types of biasing devices for releasably holding the arm in its positions will be apparent to those skilled in the art and may be utilized as desired.

Outwardly facing surface 166 of the arm 158 is provided with an electrically conducting member or strip 168. Inwardly facing wall 170 of the right-hand leg portion 134 is provided with a pair of spaced conductor pads 172 and 174, so arranged that when the arm 158 is pivoted to its clockwise position, the conductor strip 168 does not make contact with the conductor pads, and when the arm 158 is pivoted to its counterclockwise position, the conductor strip 168 makes contact with the conductor pads for electrically connecting the conductor pads together.

Each conductor pad 172 and 174 has attached thereto a respective lead or electrically conductive paths 176 and 178 which may be utilized as desired in an electrical circuit to be controlled by movement of the switch arm. It should be clear that a conductor strip and associated conductor pads may also be provided on the other end 160 of the arm 158 and the left-hand leg portion 132 of the U-shaped member if desired to provide further electrical control of other circuits. Other suitable arrangements of contacts and leads may be incorporated, as will be apparent to those skilled in the art.

Another switch or bistable element 180 incorporating the principles of the present invention is shown in FIG. 6. The switch includes a U-shaped support member 182 having a horizontal base portion 184 and two upstanding leg portions 186 and 188. An electrostrictive element 190, having a pair of electrodes 192 and 194 suitably formed on two opposite faces, is disposed on the upper surface 195 of the base portion 184 for slidable movement between the upstanding leg portions. A generally flat spring 196, having its ends secured to the upper surfaces of the leg portions 186 and 188, provides a means for releasably retaining the electrostrictive element 190 in either of two positions and also keeps the electrostrictive element in physical contact with the upper surface 195 of the base portion when the element is stimulated by an electrical signal, as will be more fully described below. It is to be noted that the spring 196 is formed with two downwardly facing transversely extending shallow notches 198 and 200 spaced on opposed sides of the spring's transverse midline. An upwardly protruding detent 202 attached to the upper wall of the electrostrictive element 190 slidably engages the lower surface of the spring so as to slightly bias the spring upwardly, thereby reacting with the spring to bias the electrostrictive element into contact with the upper surface of the base portion. When the electrostrictive element is in its right-hand position (as shown in FIG. 6), the detent 202 fits into the right-hand notch 198, thereby releasably maintaining the electrostrictive element in that position. Likewise, when the electrostrictive element is in its other position (with its left-hand end in contact with the left-leg portion), the detent 202 is fitted into the left-hand notch 200, thereby releasably maintaining the electrostrictive element in its other position.

Electrical leads 204 and 206, which may be attached to a source of electrical power, are connected to respective electrodes 192 and 194. Upon application of an electrical signal to the leads, the electrostrictive element 190 will expand and react against the abutting leg portion, which in FIG. 6 is right-hand leg 188, in a manner similar to that described in the discussion of the apparatus of FIG. 3. Elongation of the electrostrictive element and its reaction against the leg portion 188 causes the detent 202 to be urged out of the spring's notch 198 and the element moves by momentum to its other position. When the element reaches its other or second position, the detent 202 is captured or slips into the other notch 200, thereby causing the electrostrictive element to remain in its other position, abutting leg portion 186. Upon application of another electrical signal to leads 204 and 206, the electrostrictive element will react against the left-leg portion 186 and move back to its former or first position.

Thus, it can be seen that the device of FIG. 6 acts as a bistable or two-state device which changes states upon application of an electrical signal. The state of the device or position of the electrostrictive element 190 in the frame may be detected by forming an electrically conductive strip 208 on the bottom wall of the electrostrictive element and by securing two contacts 210 and 212 to the upper surface 195 of the base portion 184 so that the strip is in electrical contact with both contacts 210 and 212 when the electrostrictive element is in its second position, and out of electrical contact with the contacts 210 and 212 when the electrostrictive element is in its first position. Suitable leads or electrically conductive paths 214 and 216 are attached to the respective contacts for connection to an electrical circuit for utilization as required.

It is to be noted that the force of spring 196 reacts with the electrostrictive element 190 through the detent 202 to overcome any tendency for the element to move up, out of support member 182, when the element elongates in the vertical direction upon application of an electrical signal to the electrodes 192 and 194.

What is claimed is:

1. In an apparatus for forming perforations in a portion of a sheet-like material, the combination comprising: a pair of members;
said members being movable relative to each other between a first position wherein said members are in contact with each other, and a second position wherein said members are out of contact with each other;
one of said members being an electrostrictive means responsive to an electrical signal for expanding its dimensions and being responsive to physical impact for generating an electric field therethrough;
said members reacting with each other upon expansion of said electrostrictive means to impart a momentum to one of said members, said momentum imparting relative displacement of said members from said first position to said second position;
a base;
said portion of the sheet-like material being disposed at a predetermined location with respect to said base;
said members being located on one side of said portion of sheet-like material;
a first one of said members being fixed with respect to said base;
the second one of said members being movably mounted on said base between said fixed member and said portion of said sheet-like material;
said second one of said members having a sheet perforating means formed thereon;
said sheet perforating means engaging and perforating said portion of said sheet-like material when moving from its first position to its second position, said second one of said members rebounding to its first position after engagement with said sheet-like material and impacts said first one of said members as it returns to its first position;

- electrode means disposed about said electrostrictive means;
said electric field generated through said electrostrictive means upon physical impact inducing electric charges on said electrode means; and
electric charge conducting circuit means operatively coupled with said electrode means, said charge conducting circuit means including means for absorbing the electrical energy generated when said second one of said members impacts said first one of said members after rebounding.
2. In an apparatus according to claim 1 wherein there is further included bias means releasably urging at least one of said members toward their first position.
 3. In an apparatus according to claim 1 wherein said first one of said members is said electrostrictive means.
 4. In an apparatus according to claim 1 wherein said electrostrictive member is comprised of a ferromagnetic material.
 5. In an apparatus according to claim 1 wherein said electrostrictive member is comprised of a piezoelectric material.

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83—523; 101—1; 318—116, 118