

[54] MODULAR PUNCH DEVICE

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[51] Int. Cl. H01f 7/08, H01f 7/18

[58] Field of Search 83/575; 317/123, 148.5, 317/149, 155, DIG. 4

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Primary Examiner—L. T. Hix

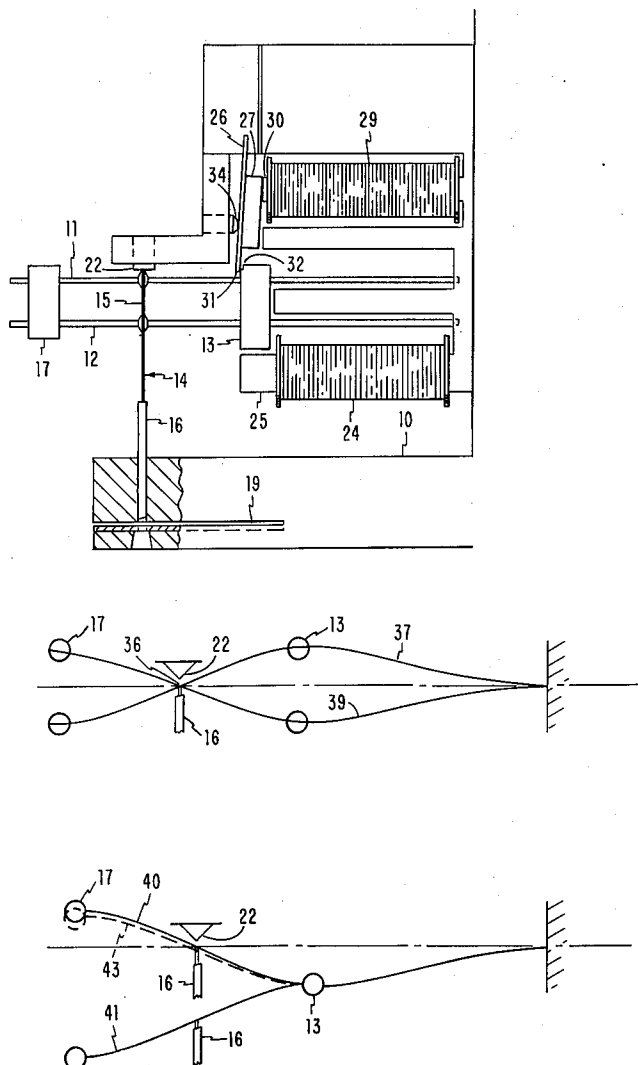
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[57]

ABSTRACT

An assembly including a pair of parallel cantilevered beams is excited near its second resonant frequency by an electromagnet. A punch is attached to the beam assembly at the node point, an armature at the anti-node and a counterweight at the distal end of the beam assembly. The energy necessary for punching is stored in the beams in the second resonant mode of oscillation. To release the stored energy to the punch, the armature is latched at the lower extremity of displacement causing the strain energy stored in the beam intermediate the armature and the counterweight to be converted to kinetic energy, producing a downward work stroke of the punch. During the work stroke some energy is removed from the system while some is reconverted to strain energy and used to withdraw the punch from the paper and die. Following the work stroke the armature is released and beam assembly excited to its prior energy level in preparation for another work stroke.

14 Claims, 5 Drawing Figures



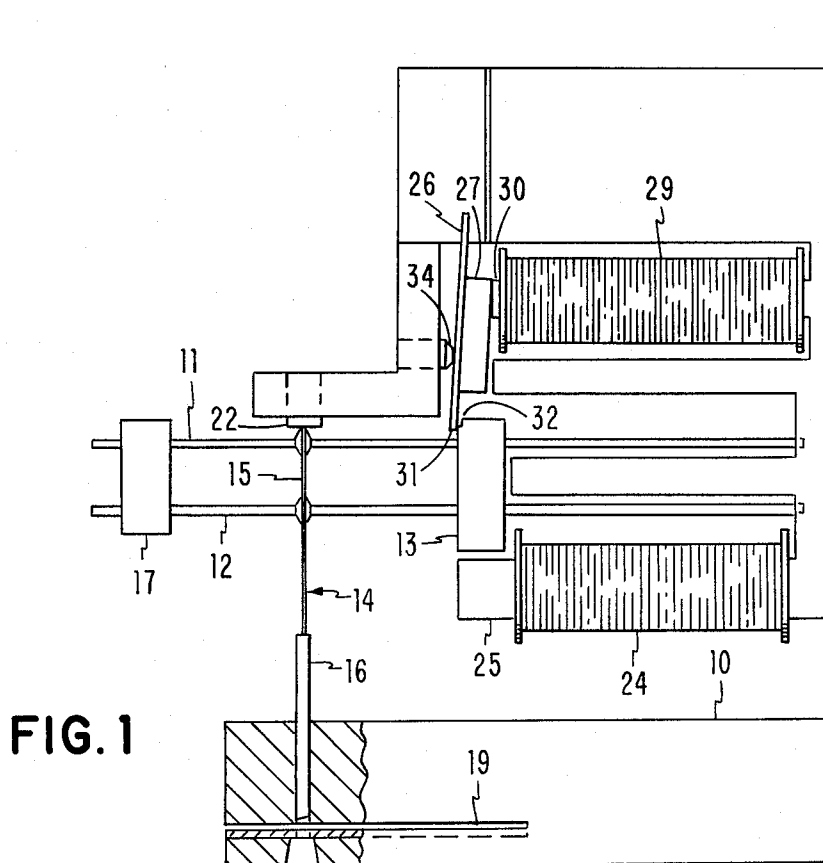


FIG. 1

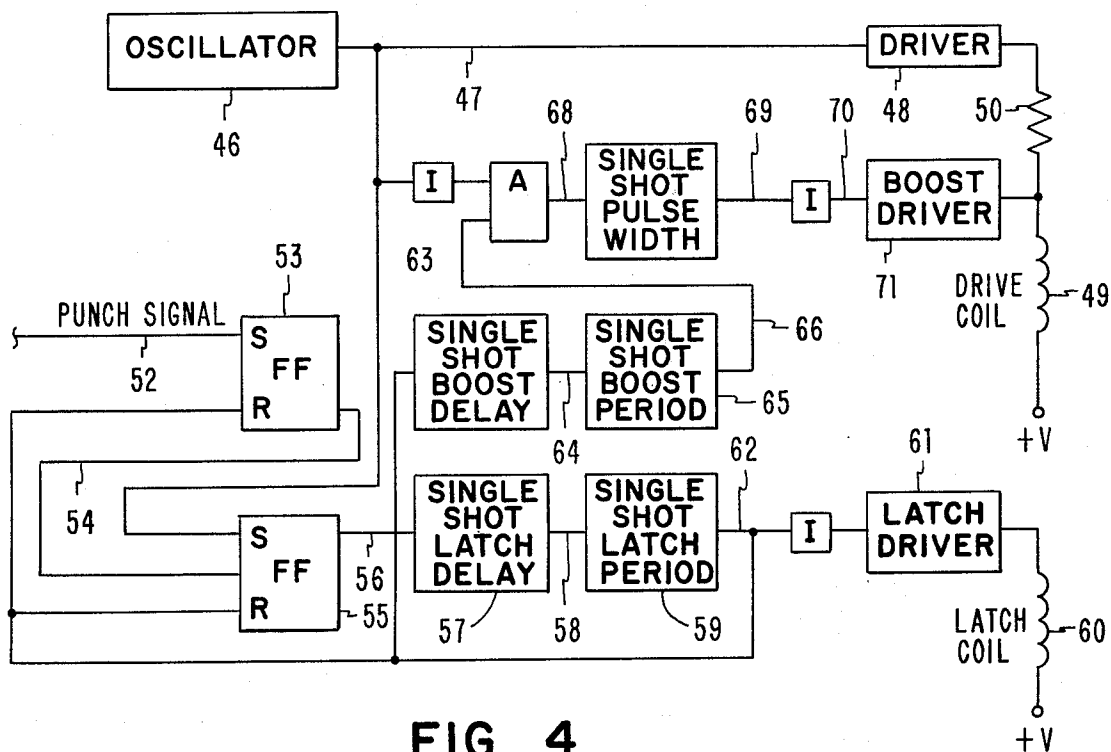


FIG. 4

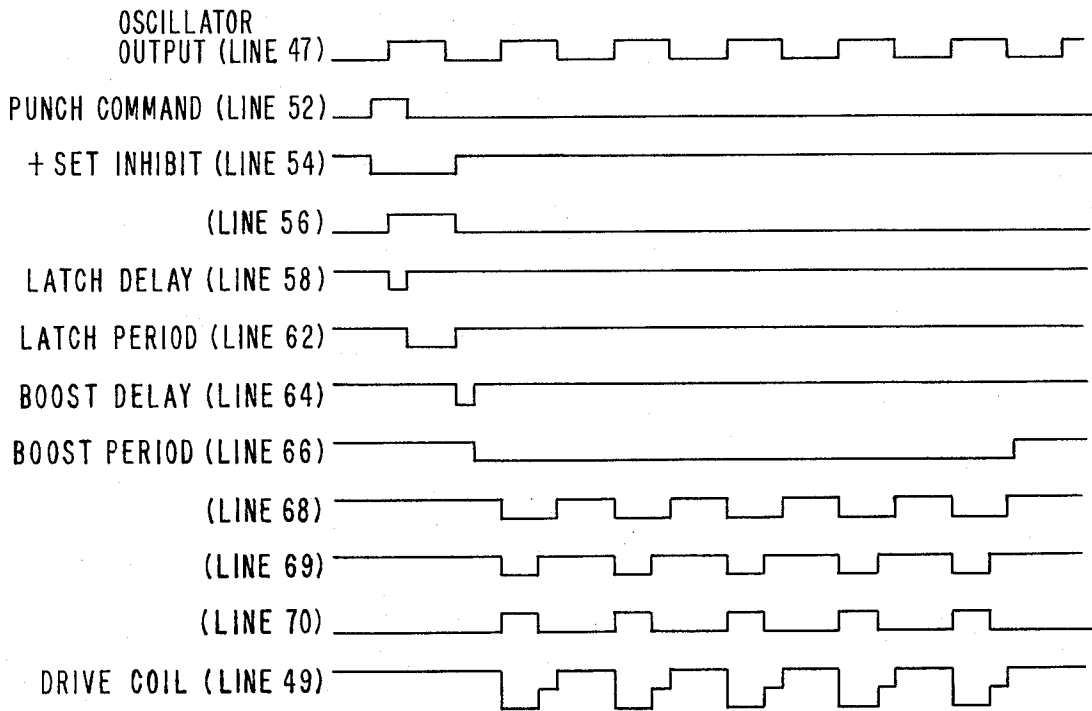


FIG. 5

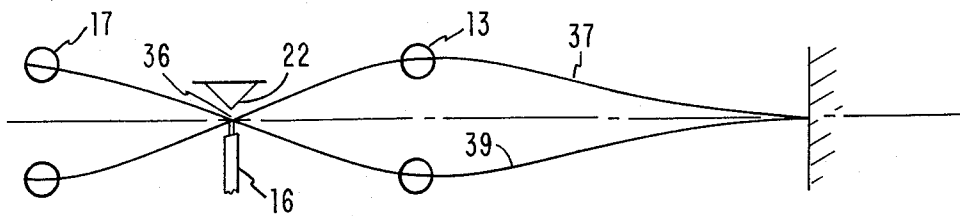


FIG. 2

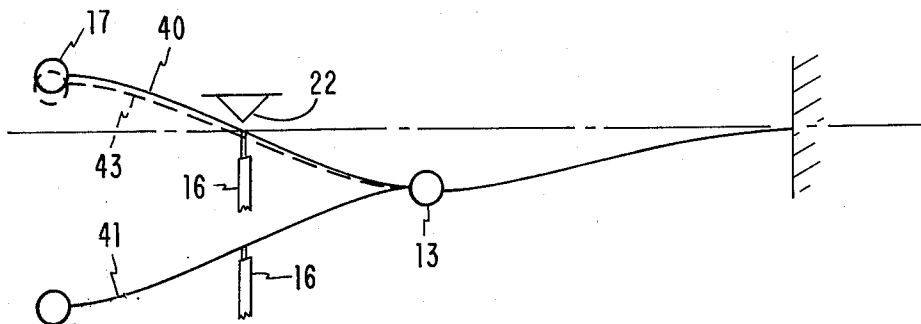


FIG. 3

MODULAR PUNCH DEVICE

BACKGROUND OF THE INVENTION

The present invention relates to high speed mechanical actuators, and more particularly, to a high speed punching device.

Typical prior mechanical punch assemblies are commonly cam-driven mechanisms and often positively driven in both directions and using an interposer to selectively actuate a punch element during a desired cycle. Such mechanically actuated devices are faced with a relatively long cycle time as a barrier to the achievement of significantly higher speeds.

The device of the present invention utilizes the strain energy of a physical element, such as a beam, oscillating at approximately the second resonant frequency. At this frequency the working element is mounted on the beam at the node and an armature for exciting the beam is mounted at the antinode. When a work stroke is desired, the armature is latched at a position approaching the maximum displacement from the neutral axis which results in an alteration of the mode of oscillation and causes the punch element to process through a work stroke. The armature is thereafter released from the latched condition and the beam restored to the second resonant mode of oscillation. To make optimum use of the energy and maximize the punching rate capability of the system, the armature latch is released to the point in the cycle of oscillation at which the strain energy is maximum (and kinetic energy is minimum) to minimize the energy loss to the system during the transition between modes of oscillation. In addition, for several cycles following a work stroke additional excitation is imparted to the beam element assembly to quickly restore the energy level of the beam in preparation for the next work cycle.

It is an object of this invention to provide an improved high speed mechanical actuating mechanism. It is a further object of this invention to provide a mechanical system utilizing strain energy storage and release wherein minimum energy losses are experienced by the system during transitions between modes of oscillation and work strokes. It is also an object of this invention to provide an improved high speed mechanical document punch. The foregoing and objects, features and advantages of the invention will be apparent from the following more particular description of a preferred embodiment of the invention as illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevation of the strain energy storage and release punch assembly incorporating the present invention.

FIG. 2 is a schematic diagram showing the oscillation of the beam assembly of FIG. 1 when oscillating at the second resonant frequency.

FIG. 3 is a schematic diagram similar to FIG. 2, but showing the oscillation of the beam assembly with the armature latched to effect a change in the mode of oscillation and cause the working element to process through a work stroke.

FIG. 4 is a block diagram showing the control circuitry for actuating the punch assembly of FIG. 1.

FIG. 5 is a timing chart depicting the electrical states at various portions of the circuit of FIG. 4 during the execution of a punch command.

DETAILED DESCRIPTION

Referring to FIG. 1, the punch actuator assembly includes a base 10 on which the active elements are mounted. A pair of parallel cantilevered beam elements 11 and 12 are supported at one end by the base 10. Interconnected between the beam elements and supported thereby are an armature 13, a punch assembly 14 including an upper support 15 and a lower punch element 16, and a counterweight 17. The punch element 16 projects through a guide channel in base 10 and normally overlies a document path 19 and a stripper plate opening through which it is driven during a punching cycle or work stroke. An adjustable punch stop 22 overlies the punch assembly 14 to limit upward travel and aid in inducing the second resonant mode of oscillation. An excitation coil 24 surrounds one leg 25 of an electromagnet cord and is disposed to attract armature 13 when energized. An armature latch 26 is formed of a flexure which carries an armature 27. Latch coil 29 is positioned about one leg 30 to form an electromagnet which may be energized when armature 13 has excursions downward permitting lower surface 31 of latch 26 to be received in armature recess 32 to retain armature 13 in the downward excursions position. An adjustable latch stop 34 limits movement of latch 26 away from the latching position.

The operating modes of the beam assembly are shown schematically in FIGS. 2 and 3. FIG. 2 illustrates the normal standby mode of beam oscillation where the beam elements are excited and induced oscillate in the second resonant mode of vibration. Each beam in this mode has a node 36 at which the punch assembly 16 is mounted and an antinode 37 at which armature 13 is mounted. In this condition, punch element 16 is substantially stationary while armature 13 and counterweight 17 move upward and downward as the energy for performing a work stroke or punching operation is stored in the beam assembly.

When a punch cycle is desired, armature 13 is latched and retained in its downward position of lowest displacement as shown in FIG. 3. Thereupon the beam elements beyond the latched armature move from the solid line position at 40 to the solid line position at 41. During this motion as the punch element 16 and counterweight 17 both move downward, the strain energy of the beam system is converted to kinetic energy. After a predetermined downward movement the punch element strikes the document and the energy consumed by the punching operation is removed from the system as the punch progresses through the document. As the beam system approaches the lowermost position, some energy is reconverted to strain energy and used to extract the punch from the cooperating die and the document as the beam system reverses direction and begins to move upward. When the punch stroke is completed, latch 26 is withdrawn, armature 13 released and the beam system is again excited to the prior energy level to prepare the assembly for another punch stroke.

During the termination of the punch cycle the beam system distal portion reaches an uppermost position as indicated by the dotted position 43 of FIG. 3. This represents the position of uppermost travel as a result of the diminution of system energy resulting from the

withdrawal of energy during the punch stroke. The release of the latch is timed to occur near this position of uppermost travel where the maximum of kinetic energy has been converted to strain energy to thereby effect a transition back to the second resonant mode of oscillation as shown in FIG. 2 with a minimum reduction in system energy. The punch stop 22 both restricts the upward return motion of the punch assembly 14 and assists the system in the return to the second resonant mode of oscillation. In addition, punch stop 22 by limiting upward travel of the beam assembly, inhibits first resonant mode oscillation of the beam elements.

Operation of the punch assembly is electrically controlled by a circuit as shown in the block diagram of FIG. 4 and the timing diagrams of FIG. 5. An oscillator 46 has an output on line 47 which is near the second resonant frequency of the beam assembly including beam elements 11 and 12. The oscillator outputs supplies a driver circuit 48 to provide periodic excitation of drive coil 49. The resistor 50 cooperates with the driver circuit 48 to provide the level of excitation to the drive coil 49. It will maintain a desired energy level in the beam element assembly.

In operation, the control circuit must function on command to latch and release the armature 13 at selected positions of beam oscillation and subsequent to a work stroke, provide a higher level of excitation to the beam element assembly to quickly restore the energy level in preparation for another work stroke. The signal to execute a punch cycle appears on line 52 to set latch 53. When latch 53 is set, the positive output on line 54 which inhibits setting latch 55 is terminated. The next positive output from oscillator 46 thereupon sets latch 55. The set output of latch 55 fires the latch delay single shot 57. The negative going addage of latch delay single shot 57 initiates the latch period single shot 59. The latch period single shot not only initiates and terminates the actuation of latch coil 60 functioning through latch driver circuit 61, but also resets latches 53 and 55 and initiates the boost delay single shot 63. When the boost delay single shot 63 has timed out the boost period single shot 63 is initiated. The boost period is subsequent to the end of the latch period of single shot 59 and extends for a number of cycles, being shown as a five-cycle boost period in the timing diagram of FIG. 5. The boost pulses supplied to drive coil 49 through the boost driver circuit 71 are in phase with and of significantly greater amplitude than the pulses supplied by the driver circuit 48 since the output pulses from the boost driver circuit 71 are not attenuated by the series resistor 50. The cumulative inputs of the driver circuit 48 and boost driver circuit 71 rapidly restore the energy level of the beam assembly elements.

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 detail may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. A mechanical actuating device comprising a beam element;

excitation means operatively connected to said beam element for imparting mechanical energy thereto as an oscillatory mechanical motion;

means controlling said excitation means for inducing a first mode of oscillatory motion in said beam in-

cluding a node intermediate the ends of said beam when said beam is subject to a first condition of constraint;

a moveable mechanical element carried by said beam and positioned at said node; and

selectively engageable means operable to engage said beam for imparting a second condition of constraint,

said second condition of constraint causing a second mode of oscillatory motion to be induced in said beam which eliminates said node and causes said mechanical element to excursion through a work stroke.

2. The mechanical actuating device of claim 1, wherein said beam element comprises a cantilevered beam and said excitation means comprises an excitation coil mounted adjacent said beam to periodically attract an armature carried by said beam.

3. The mechanical actuating device of claim 2, wherein said cantilevered beam is formed of a pair of parallel beam elements and said device further comprises a base member to which the fixed ends of said beam elements are attached to permit one degree of freedom.

4. The mechanical actuating device of claim 3 further comprising a counterweight interconnecting the distal ends of said parallel beam elements and wherein said armature and said mechanical element interconnect said parallel beam elements to cause said parallel beam elements to move in unison.

5. The mechanical actuating device of claim 2, wherein said means for controlling said excitation means comprises first circuit means for energizing said excitation means to provide two levels of excitation, a first level of excitation which is operable to maintain a predetermined oscillatory mechanical motion of said beam element at a second higher level of excitation for rapid restoration of said predetermined oscillatory mechanical motion following a work stroke of said mechanical element.

6. The mechanical actuating device of claim 5, wherein said selectively engageable means comprises an electrically actuated latch engageable with said armature and said device further includes second circuit means to actuate said latch during a selected portion of the cycle of motion of said armature.

7. The mechanical actuating device of claim 6 wherein said moveable mechanical element is connected to and drives a reciprocating punch and said base further includes an adjustable stop member positioned to limit travel of said moveable mechanical element in a nonpunching direction.

8. The mechanical actuating device of claim 1 further comprising an armature carried by said beam element and wherein said selectively engageable means comprises a latch means selectively engaging said armature to retain said armature at a position approaching the position of maximum displacement from the neutral axis during said first mode of oscillatory motion of said beam.

9. The mechanical actuating device of claim 8, wherein said excitation means comprises a cyclically excited electromagnet and said latch means is electromechanically actuated and further comprising electrical control means for engaging and disengaging said latch means,

said control means functioning to disengage said latch means when said beam element has approached a position in said cycle of oscillation whereat a maximum portion of system energy has been converted to strain energy.

10. A high speed mechanical actuating device comprising:

a base member;

a cantilevered beam element for storing mechanical energy which is connected to and supported from said base member;

excitation means operatively associated with said cantilever beam element for imparting mechanical energy thereto as an oscillatory mechanical motion to induce a first mode of oscillation having a node intermediate the ends of said beam;

a mechanical element connected to said beam element at the location of said node during said first mode of oscillation; and

selectively operable means for altering the constraint of said cantilevered beam to produce a second mode of oscillation causing said mechanical element to excursion through a work stroke.

11. The high speed mechanical actuating device of claim **10**, wherein said cantilevered beam element comprises a pair of parallel beam members interconnected to oscillate in unison and further includes an ar-

mature interconnecting said parallel beam members and said excitation means comprises electromagnetic means for attracting said armature.

12. The high speed mechanical actuating device of claim **11**, further comprising excitation control means for periodically energizing said electromagnetic means to induce said first mode of oscillation and an electromechanically actuated latch means for engaging and restraining said armature to induce a second mode of oscillation.

13. The high speed mechanical actuating device of claim **12** wherein said excitation control means further includes means for synchronizing operation of said electromagnetically actuated latch means to effect engagement of said latch means with said armature during a predetermined portion of the oscillation cycle of said armature upon receiving a command to execute a work stroke.

14. The high speed mechanical actuating device of claim **13** wherein said excitation control means further provides a first level of excitation for maintaining said first mode of oscillation at a predetermined energy storage level and a second level of excitation to rapidly restore said predetermined energy storage level following a work stroke.

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