Oct. 20, 1959 D. N. MacDONALD 2,909,069

MECHANICAL POWER AMPLIFIERS

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FIG. 1.

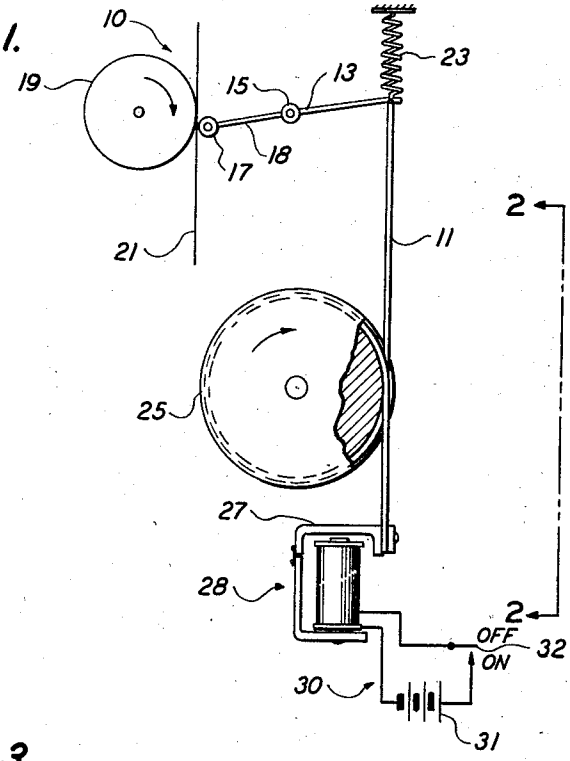


FIG. 2.

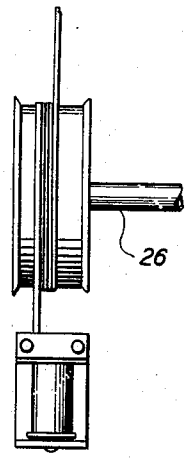


FIG. 3.

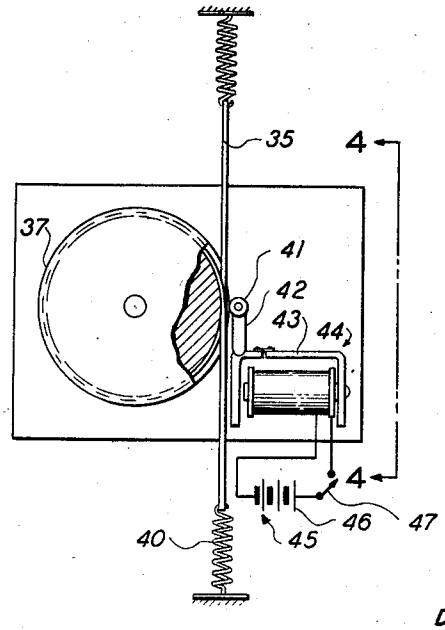
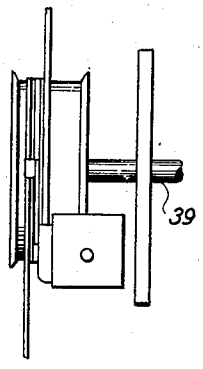


FIG. 4.



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FIG. 5.

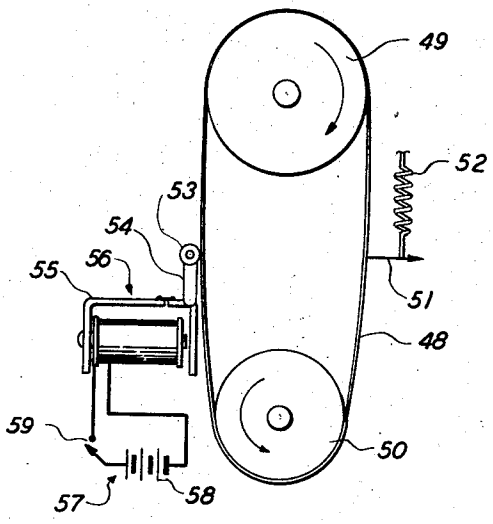
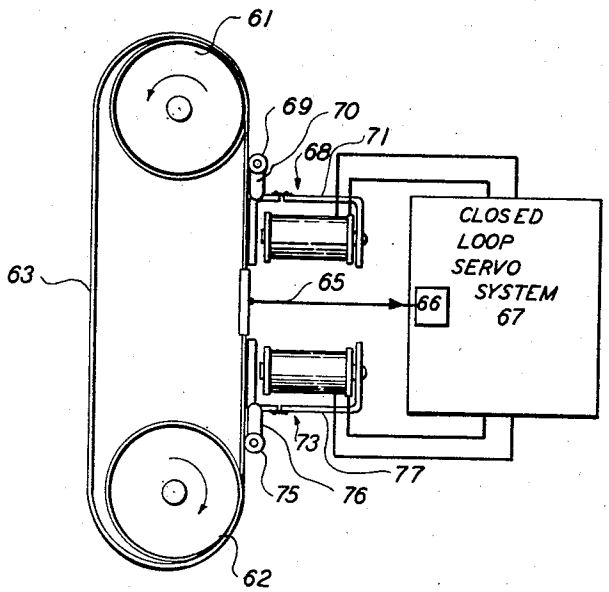


FIG. 6.



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MECHANICAL POWER AMPLIFIERS

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Application December 20, 1954, Serial No. 476,422

3 Claims. (Cl. 74—25)

This invention relates to mechanical power amplifiers and more particularly to apparatus for converting a relatively small amount of electrical energy into a strong mechanical force capable of moving heavy loads in a very short time.

In various types of installations, for example, computer systems in which magnetic tape must be accelerated and decelerated at high rates, and hydraulic servo-systems in which high speed sliding valves must be operated, relatively large mechanical loads must be moved in very short times. Quite often the movement of the heavy loads must be in response to electrical signals. Thus, there is presented the problem of moving heavy loads in a very short time in response to an electrical signal. A solenoid is a well known device which converts electrical energy into mechanical movement. However, in order for a solenoid to move a heavy load directly, the solenoid requires actuating coils with many turns of wire and heavy moving parts. These requirements are detrimental to quick operation due to the electrical and mechanical inertia of the system.

This invention solves the problem of moving heavy loads electromagnetically in a very short time by using a high speed conventional clapper-type solenoid in conjunction with a motor driven capstan or power drum around which is disposed an actuating band adapted to be connected to a relatively heavy load. The solenoid has a light weight plunger or clapper which reacts almost instantaneously in response to an electrical signal to exert a slight force on the actuating band and drive the band into driven relationship with the rotating power drum. Since the power drum is rotated at a relatively high speed, practically no inertia delay is present and the large amount of power available in the power drum is applied almost instantaneously to the actuating band.

In a presently preferred embodiment of the invention, the actuating band is wrapped loosely around the rotatable power drum. One end of the band is arranged to be connected to the load and the other end of the band is connected to move in response to the movement of the plunger of the solenoid. Thus, when the solenoid is actuated, the light-weight plunger moves swiftly to take the slack out of the actuating band and cause it to be drawn tightly around the rotating power drum. In this manner a large force is applied almost instantaneously to the actuating band and the load in response to the slight movement of the light-weight plunger in the solenoid. With this arrangement of the length of the power stroke is approximately equal to the distance through which the plunger moves. As used in this invention, the term "actuated" as applied to a solenoid includes either energizing or de-energizing the solenoid.

In another form of the invention where relatively long power strokes may be obtained, the plunger of the solenoid is arranged to move a roller positioned adjacent the power drum so that the actuating band is forced against the power drum. Thus, the length of the power stroke is independent of the length of travel of the plunger.

In another arrangement for obtaining relatively long strokes, the actuating band is disposed around a rotatable power drum and an idling drum. The plunger of the solenoid is arranged to force the band into driven relationship with the power drum by either removing the slack from the band or pressing the band against the power drum.

For obtaining movement of the load in either one of two directions, two rotatable power drums are arranged to drive a common band in opposite directions, and a separate solenoid is used with each power drum to cause the band to be moved in either one of two directions in response to an electrical signal. This provides a fast action servo-drive which may be connected in a closed servo-loop system for driving recorders, plotters, computer systems and the like.

These and other aspects of the invention will be more completely understood from the following detailed description taken in conjunction with the accompanying drawings in which:

Fig. 1 is a schematic front elevation of the presently preferred embodiment of the invention;

Fig. 2 is a side elevation taken on line 2—2 of Fig. 1;

Fig. 3 is a schematic front elevation of an alternate embodiment of the invention;

Fig. 4 is a side elevation taken on line 4—4 of Fig. 3;

Fig. 5 is a schematic elevation of yet another embodiment of the invention; and

Fig. 6 is a schematic illustration of how the invention may be employed to drive an actuating band connected to a closed loop servo-system.

For purposes of illustration, the embodiment of the invention of Figs. 1 and 2 is shown arranged to actuate a tape driving mechanism **10** as for example in an electronic computer (not shown). One end of an actuating band **11**, which may be a flexible steel band, is connected to a first arm **13** rigidly attached to a pivot **15**. An idling roller **17** is carried at the outer end of a second arm **18** rigidly attached to the pivot **15** and is disposed adjacent the periphery of a tape driving wheel **19**. A strip of magnetic tape **21**, which is to be intermittently fed through the computer, passes between the periphery of the driving wheel and the idling roller so that when the arm **13** is rotated about pivot **15** in a clock-wise direction as viewed in Fig. 1, the tape is forced into driven relationship with the driving wheel. The arm **13** is biased in a counter-clockwise direction (as viewed in Fig. 1) by means of a tension spring **23** attached to the first arm.

Several turns of the actuating band are loosely wrapped around a rotatable power drum **25** adapted to be driven at a high rate of speed around a shaft **26** by any suitable driving means (not shown). The end of the actuating band remote from arm **13** is connected to a clapper **27** provided on a conventional clapper-type solenoid **28**. A circuit **30** for applying an electrical signal to the solenoid is shown schematically as a battery **31** and an off-on switch **32**. However, the solenoid may be arranged to receive a signal from any kind of electrical circuit such as that employed to control the movement of magnetic tape in a computer system.

The operation of the apparatus of Figs. 1 through 2 is as follows: With the solenoid not energized as shown in Figs. 1 and 2, the actuating band is loose around the power drum and arm **13** is in the position illustrated, so that the magnetic tape is not forced against the driving wheel. In order to cause magnetic tape to be delivered to a computer, the switch is closed (i.e., a signal calling for magnetic tape is applied to the solenoid) and the clapper is pulled in a downward position. The clapper is light-weight and responds almost instantaneously to the electrical signal and causes the band to be pulled snugly around the power drum. The friction between the power

drum and the actuating band is sufficient to apply a strong downward force on the first arm **13** for the shaft **15** to cause the idling roller to move the tape into driven contact with the driving wheel. When the energizing signal is removed from the solenoid, the clapper returns to its original position so that the band is no longer in driven relationship with the drum, and the spring **23** returns the pivot **15** to the position shown in Fig. 1 so that the magnetic tape is not longer driven.

Using the arrangement shown in Figs. 1 and 2, an 8 pound load was moved .005 inch in an "operate" time of 3 milliseconds and the same load was released in 1.7 milliseconds. This performance is more than ample for use in conventional computer systems employing magnetic tape.

The arrangement shown in Figs. 3 and 4 may be used where relatively long power strokes are required. In this embodiment an actuating band **35** is loosely wound around a rotatable power drum **37** adapted to be driven by a power shaft **39** turned by any suitable means (not shown). One end of the actuating band is connected to a load shown schematically as a tension spring **40**, the other end of the band is fastened to a light-weight take-up spring.

An idling roller **41** is disposed adjacent the power drum periphery and is connected to the outer end of an arm **42** carried by a clapper **43** of a conventional clapper-type solenoid **44**. A circuit **45** shown schematically as a battery **46** and an off-on switch **47** is connected to energize the solenoid intermittently.

In the position shown in Fig. 3, the solenoid is in a deenergized condition and the idling roller is not pressing the actuating band against the power drum. When the solenoid is energized, the clapper forces the roller against the actuating band which in turn is forced into driven relationship with the power drum. Thus, the load may be moved through a relatively large distance almost instantaneously and independently of the length of travel of the clapper.

Fig. 5 illustrates another arrangement in which a load can be moved almost instantaneously through a relatively long distance independent of the length of travel of the clapper. An actuating band **48** in the form of an endless belt is loosely disposed around a rotatable power drum **49** and an idling drum **50**. The power drum is constantly rotated in a clock-wise direction as viewed in Fig. 5 by any suitable driving means (not shown). A projection **51** on the band located between the two drums is connected to a load illustrated schematically as a tension spring **52**. An idling roller **53** is connected by an arm **54** to a clapper **55** of a conventional clapper-type solenoid **56** disposed adjacent the actuating band and arranged to be intermittently energized by a circuit **57** shown schematically as a battery **58** and an off-on switch **59**.

When the solenoid is energized, the idling roller is forced against the actuating band to remove the slack from the band so that the band is forced into driven relationship with the power drum.

The embodiment of Fig. 5 may also be arranged with the solenoid adjacent the power drum periphery so that when the solenoid is energized, the idling roller forces the actuating band against the power drum.

Fig. 6 shows another embodiment of the invention for moving a load in either one of two directions. A first power drum **61** is arranged to rotate in a counter-clockwise direction, as viewed in Fig. 6, and a second power drum **62**, spaced from the first, is arranged to rotate in a clockwise direction. An actuating band **63** in the form of an endless belt is loosely wound around each of the drums with several turns. One end of a mechanical link **65** is rigidly attached to this band and the other end of the link is connected to feed mechanical movement to a load or movable mass **66** in a closed loop servo-system **67** shown schematically in block form. The closed loop servo-system may be a recorder using the self-balancing potentiometer principle, a plotter, a computer system, or the like.

A first conventional clapper-type solenoid **68** is disposed adjacent the band between the mechanical link and the first power drum. A first idling roller **69** carried by an arm **70** connected to a clapper **71** of the first solenoid is arranged to take the slack out of the band between the load and the first power drum when the first solenoid is actuated and thus cause the band to move upwardly. A second conventional clapper-type solenoid **73** is disposed adjacent the actuating band between the link and the second power drum. A second idling roller **75** is carried by an arm **76** connected to a clapper **77** of the second solenoid and arranged to take the slack from the band between the link and the second power drum when the second solenoid is actuated. Each solenoid is electrically connected to receive appropriate signals from the closed loop servo-system. Thus, when the closed loop servo-system calls for the link to be moved up, the first solenoid is actuated and the link moves up until the servo-system is balanced and the first solenoid is deenergized. If the closed loop servo-system calls for the load to be moved downwardly, the second solenoid is energized and the link is moved down until the system is once again balanced and the second solenoid is deenergized.

In all of the above arrangements the tape is shown being forced into driven relationship when the solenoid is energized, i.e., supplied electrical power. However in any of the above arrangements, the clapper of the solenoid may be spring loaded so that the tape is held in driven relationship until the solenoid is energized and the clapper overcomes the action of the spring to release the band from driven relationship. With either arrangement the invention provides means for converting a relatively small electrical signal and a correspondingly small mechanical movement of a light-weight element into a relatively large amount of mechanical power almost instantaneously with the generation of the electrical signal.

I claim:

1. A mechanical power amplifier for applying power to a load in either one of two directions comprising a first power drum, means for rotating the first power drum continuously in one direction, a second power drum, means for rotating the second power drum continuously in the opposite direction from the first drum, an actuating band disposed around the drums, and adapted to be connected to the load, a first solenoid having a plunger arranged to move the band into driven relationship with the first drum when the first solenoid is actuated, and a second solenoid having a plunger arranged to move the band into driven relationship with the second drum when the second solenoid is actuated.

2. A mechanical power amplifier for applying power to a load in either one of two directions comprising a first power drum, means for rotating the first power drum continuously in one direction, a second power drum, means for rotating the second power drum continuously in the opposite direction from the first drum, an actuating band disposed around the drums, and adapted to be connected to the load, a first solenoid having a plunger arranged between the load and first drum to move the band into driven relationship with the first drum when the first solenoid is actuated, and a second solenoid having a plunger arranged between the load and second drum to move the band into driven relationship with the second drum when the second solenoid is actuated.

3. A mechanical power amplifier capable of high speed control for amplifying power to a load comprising a rotatable power drum, an actuating band disposed around the drum, a support, a spring connected to the support, one end of the band being connected to the spring and adapted to be connected to the load, and a fast acting

solenoid having a lightweight movable plunger connected to the other end of the band to vary the strain on the band and move the band into and out of driving relationship with the drum when the solenoid is actuated.

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