FLUID POWERED DEVICE

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The present invention relates to means for multiplying the effective force of a fluid under pressure which is applied to a piston like member, and more particularly, to a new and improved card punching device.

Card punches of the prior art which have had wide application are operated with solenoids, with the punches being staggered in a circle on lever arms. While this punch means is fairly reliable, it also entails the use of several parts linking as to produce a mechanical advantage in order to achieve an effective punching force. Such mechanical linkage is subject to wear and tear of its component parts due to bearing friction, force moments, etc. The present invention obviates certain of the above disadvantages of the mechanical linkage by providing a direct acting punch powered with a fluid under pressure, such as air or the like. Only one moving part need be provided which is the punch piston itself. Although fluid under relatively low pressure is employed as the motive force, a multiplication of this force is accomplished by means of a novel configuration of the punch piston itself, without need for maintaining close tolerances in fitting the punch piston within its housing. If sufficient piston travel is provided for, the width of the overall piston may be almost equal to the punch width. Thus, the present invention results in a fluid powered punch which is relatively easy to fabricate without need for expensive machining or the like. For record card handling the overall piston width makes conventional multiple punching feasible. The punch of the present invention is therefore particularly adapted for use in the rapidly expanding fluid data processing art, wherein information is transmitted and processed via a fluid medium.

It is therefore an object of the present invention to provide a direct acting punch powered with a fluid under pressure such as air.

It is another object of the present invention to provide a direct acting punch whose configuration allows the effective multiplication of the force produced by a fluid under relatively low pressure.

The manner in which the present invention accomplishes the above described function is to fabricate a punch piston having a plurality of circumferential grooves axially spaced along its length so as to form a plurality of surfaces which are essentially normal to the direction of the dynamic force applied by the actuating fluid pressure. The punch is loosely fitted within a cylindrical housing such that there is sufficient clearance between the piston and the housing to provide a clearance diameter to allow the fluid to pass therebetween and exert its force on each of the multiple ring surfaces formed by the grooves in the piston body. The provision of these multiple surfaces, in addition to the end surface of the punch, against which the fluid is also directed, thereby allows the effective multiplication of the force due to the kinetic energy of the fluid particles which pass with high velocity through the above described clearance. Therefore, a relatively low fluid input pressure can create sufficient force at the piston faces in order to puncture a conventional record card.

It is therefore another object of the present invention to provide a card punch comprised of a loose fitting piston within a cylinder, where said piston has a plurality of axially spaced circumferential grooves for effectively multiplying the force of a relatively low pressure fluid.

In addition to driving the punch through the card, means is provided in the present invention for retracting the punch from the card to hold it in readiness for a subsequent punch stroke. Although several different embodiments of the retracting means are disclosed, all of these utilize a fluid stream under pressure, so that the present invention is completely compatible with a pure fluid system.

Yet another object of the present invention is therefore to provide a direct acting punch powered with a fluid, said fluid also being used for retracting the punch from the card subsequent to the punch stroke.

Although the principle of the present invention is particularly adapted for use as a card punch and has therefore been specifically shown in this environment, the scope of this invention is broader in that the principles here expounded can be utilized where there is desired the effective multiplication of force exerted by a pressure fluid. For example, the grooved piston may be used to drive a crank shaft by means of a connecting rod. Therefore, another object of the present invention is to generally provide a cylinder and loose fitting piston arrangement wherein effective multiplication of the force in a low pressure fluid is accomplished by means of grooving in the piston body.

These and other objects of the present invention will become apparent during the course of the following description with which the following drawings are to be used:

FIGURE 1 is a diagrammatic plan view of the invention as embodied in a card punch environment, which shows the punch and cylinder as well as the actuating and retracting mechanism;

FIGURE 2 is a detailed sectional view of the punch cylinder and piston;

FIGURE 3 is a perspective view of the punch piston which emphasizes the arrangement of its circumferential grooves;

FIGURE 4 illustrates an alternative embodiment of the retracting mechanism; and

FIGURE 5 shows a third embodiment of the retracting mechanism.

FIGURE 1 is a diagrammatic view of the invention when used in a card punch environment. A punch chamber or cylinder 10 is provided within which is loosely fitted a punch piston 11 having one end 12 brought to a point for easy passage through a record card 13. When punch piston 11 is directed upwards against card 13, point 12 Pierces said card and enters the opening 14 in the block 15. The actuating fluid under pressure enters cylinder 10 via a port 16 and is applied against the face of end surface 17 of the punch piston, as well as leaking through the clearance formed between the outside piston diameter and the inside cylinder diameter to impinge upon a plurality of circumferential grooves not shown in FIGURE 1.

In this embodiment, the drive or punch stroke of piston 11 is in the upward direction against the force of gravity. After the punch point 12 has perforated record card 13, the fluid entering port 16 is terminated and an auxiliary fluid stream is forced into chamber 10 via a passageway 18. The force of this fluid impinges upon piston 11 in the downward direction so as to disengage point 12 from record card 13 and thereafter cause piston 11 to return to the bottom of cylinder 10 adjacent port 16. The force of the fluid from passageway 18 need not be large, inasmuch as it is aided by the force of gravity working against piston 11. Although not shown in FIGURE 1, since it does not comprise a part of the present invention, means are provided to move record card 13 subsequent to a retraction stroke so as to present an unpunctured surface to the punch position.
The hole placed into record card 13 by punch 11 may be interpreted in a variety of ways, depending upon the particular code utilized in the data processing system. Alternatively, the present invention may be utilized in systems other than those processing information wherever it is desired to punch a web of material.

The actuating fluid entering port 16 may be applied via a duct from one output of a typical pure fluid amplifier 20. Amplifier 20 normally comprises a solid body having a plurality of fluid passageways through which the working fluid may flow. This working fluid may be either air or another gas, or water or another liquid. Although these fluid passageways are shown invisible in the figure, it is to be understood that it is customary to mold or otherwise form the fluid passageways in one plastic laminate which is then covered on each side with solid plastic sheets so that the passageways are enclosed. A compressor or pump, not shown in FIGURE 1, supplies a suitable regulated stream of fluid to the power input passageway 21 via a duct 22. The power stream passes through a restrictor orifice 23 and emerges into chamber 24 as a high velocity jet stream. Chamber 24 is formed by the convergence of left output passageway 25 and right output passageway 26. The left wall 27 and the right wall 28 of the chamber are set back from the orifice 23 and, in accordance with Bernoulli's Principle, the high velocity jet issuing from orifice 23 creates regions of low pressure adjacent to these walls. Within these regions of low pressure are layers of fluid which move at a much slower speed than the jet stream, hence these regions are referred to as boundary layers. By properly designing chamber 24, these low pressure areas may be utilized to control the flow path of the jet issuing from the orifice 23.

Two control signal input passages 29 and 30 may be provided. Passage 29 may be selectively provided with fluid via a duct 31, with said fluid issuing from passage 29 into chamber 24 via an orifice 32 positioned in wall 27. Passage 30 may be likewise selectively supplied with fluid via duct 33, with this passage entering chamber 24 via an orifice 34 in wall 28. Both control streams are normally comprised of the same fluid as that found in the power stream within passage 21.

In order to direct the input power stream to that output connected with duct 19, a control stream is initiated from orifice 34 which breaks or disperses a boundary layer and creates from one output of instability which tends to modify the power stream into a direction away from wall 28. As the power stream is thus pushed to the left, it withdraws more and more molecules of fluid from the region adjacent wall 27, thus creating a low pressure region. The power stream thereupon moves into this low pressure region and locks onto wall 27, with the result being that the power stream now passes through passageway 25 to the duct 19 and into chamber 10 via port 16. At commencement of this operation, piston 11 begins to move upwards so that it eventually strikes record card 13 and punch 11 slides.

Subsequent to the power stroke, the control stream from orifice 34 is discontinued and the control stream from orifice 32 commenced. This control stream from orifice 32 thereupon shifts the power stream within amplifier 20 so that it now exits from a second output thereof into the duct 35 which returns the fluid to the input of the pump. A smaller duct 36 may be tapped from duct 35 so as to provide a resetting fluid stream to passageway 18 for causing the retraction of punch piston 11 in the manner hereofore described.

FIGURE 2 is a sectional view of the punch cylinder and piston which clearly shows the novel configuration of the piston and the loose fit between it and the cylinder. Piston 11, preferably sharpened at one end 19 to enable its passage through record card 13. The diameter of the peripheral surface of piston 11 is less than the inner diameter of cylinder 10, so that there is a clearance therebetween which allows the input fluid to leak along the longitudinal axis of the piston in the manner shown by the dotted lines. The greater portion of the piston peripheral surface has multiple grooves 37 through 44 which may be machined therein. Although eight such grooves have been shown axially disposed along the length of piston 11 in FIGURE 2, a large number of such grooves may actually be provided. Each groove is delimited by two parallel side walls, one of which is noted by the letter a. This side wall of a groove is that which is normal to the path of the fluid leaking between the outside piston diameter and inside cylinder diameter, such that the force exerted on said side wall due to the kinetic energy of the leakage fluid is in a direction tending to force the piston into record card 13.

The principle of operation of the present invention is believed to be the following. Fluid is admitted by port 16 into chamber 10 having a relatively low pressure on the order of five to thirty-five p.s.i.g. Ordinarily, if the punch pistons were accurately fitted to the inside of cylinder 10 so as to prevent fluid leakage therebetween, the amount of pressure required would be of considerable magnitude in order to create sufficient force at piston end 19 sufficient to cause the surface 25 and 26 of the chamber to be set back from orifice 23. However, due to the loose fit of piston 11 within cylinder 10, a portion of the fluid leaks between the piston peripheral surface and the cylinder inside diameter at a relatively high velocity due to the small cross sectional area of this clearance part. As this high velocity fluid passes down along the longitudinal axis of the piston, it expands into each of the multiple grooves and applies a force against the wall surface a to this high velocity leakage fluid effectively multiplies its force which is enough to drive the piston point 12 through the record card. With these multiple grooves and a small fluid leakage, punching is made feasible even though the piston is not accurately fitted within cylinder 10. Therefore, since there is no need for a close tolerance between the piston outside diameter and the cylinder inside diameter, fabrication of the punch arrangement is extremely simple and cheaper than that of the prior art. Indeed, it is ideally desirable to have the punch occupy a space which is close to the inside diameter of the containing cylinder, but not so close as to seriously effect the fluid velocity of the leakage fluid. With the configuration shown, no O-rings or lubrication are required.

It is to be emphasized, too, that the multiplication of force in the piston-cylinder arrangement of FIGURE 2 is not caused by the static pressure of the entering fluid. Instead, it is due to the kinetic energy of the high velocity leakage fluid. Since this leakage fluid is directed toward record card 13, it initially applies a force only against surface a of a groove as it expands into the volume of the groove. In this case, it never applies any substantial force against the opposite side wall of the groove which, if present, would tend to maintain the piston in its retracted position. Therefore, the multiple grooved piston is acted upon by the dynamic energy of moving fluid particles, at least as regards the force applied to walls a of the grooves. With respect to the end surface 17 of the piston 11, the force there applied may be due to both static and dynamic pressures.

As before described in connection with FIGURE 1, a passageway 18 is provided in the wall of cylinder 10 through which a fluid stream travels to impinge upon the punch piston in order to effect the retraction thereof subsequent to the punch stroke. As more clearly shown in FIGURE 2, passageway 18 enters the chamber at an angle so that the fluid stream exerts a downward force on the punch piston opposite to the direction taken by the piston. A punch card placed below record card 13, as is the case in the preferred embodiment of the invention, then the force exerted
by the retracting fluid stream from passageway 18 need only be great enough to overcome the friction of the record card upon end 12 of the piston so as to disengage same from the card. However, punch cylinder 10 may be placed on top of the record card if desired, with due changes being made in the force of the retracting stream.

FIGURE 4 is an alternative embodiment of the retracting means wherein passageway 18 is no longer provided in the wall of cylinder 10. Instead, the opening 14 in die block 15 is elongated into a passageway at the opposite end of which is provided a fluid input via duct 36 from the appropriate output of the fluid amplifier shown in FIGURE 1. As in FIGURE 3, the retraction fluid stream cannot impinge upon the punch piston until point 12 punctures the record card and exposes itself to the retractive fluid stream which enters passageway 14 in the die block. Although the retraction fluid may be supplied to conduit 36 by the fluid amplifier as shown in FIGURE 1, i.e., at only a certain period of time during the punch cycle, an alternative mode of operation of FIGURE 4 is as follows: A source of fluid may be applied to passageway 14 which is maintained even during the punch stroke. As long as there is no perforation in record card 13, fluid in passageway 14 cannot effect the motion of the punch piston in cylinder 10. However, as soon as the sharpened punch point 12 passes through the record card and enters passageway 14, it is immediately exposed to the fluid pressure therein which thereupon forces the piston to return to its original retracted position. Upon termination of the fluid entering port 16, record card 13 is then moved so as to remove the newly punched hole from alignment with passage 14 and cylinder 10. The effect of the retraction fluid in passageway 14 is thereby blocked by an unperfomed portion of record card 13. Continued fluid flow at conduit 36 causes faster retraction of the punch than if flow at conduit 36 were initiated only after termination of flow at port 16.

FIGURE 5 shows still another embodiment of fluid retraction mechanism which may be used in conjunction with the present invention. Retraction of piston 11 is here caused by the creation of a suction force in the end of the cylinder opposite that adjacent record card 13. This force is created by a stream of fluid entering this cylinder end via an input conduit 40 and exiting through a conduit 42 in the direction of the arrow. Inserted within conduit 40 is a conventional ball and check valve 42 which serves to prevent fluid flow in the conduit in a direction opposite to that indicated by the arrow.

Also constructed within this cylinder end is a guided ball check valve comprising a guide or raceway 44 so that said ball is moveable to either port 16 or port 45, the latter providing the outlet from the cylinder to conduit 41. When the power stream flows through conduit 19 and enters cylinder 10 via port 45, ball 43 is moved to block port 45 and so prevent exit of fluid from conduit 41. The ball and check valve 42 in conduit 40 likewise prevents any portion of the power stream from escaping from cylinder through port 46. Thus, the power stream is applied against piston 11 and drives same through the record card in the manner previously described. Upon cessation of the power stream through port 16, ball 43 returns to block port 16 either through the force of gravity (in the event that the piston is driven upwards) or by a spring which may be attached between the inner wall of cylinder 10 and ball 43 in order to retain the latter at port 16 in the absence of power stream flow in conduit 19. Thereafter, fluid flow is initiated in conduit 40 which enters cylinder 10 and exits therefrom via conduit 41 since port 45 is no longer blocked by ball 43. The transverse flow of fluid in cylinder 10 lowers the pressure so as to exert a suction force against piston 11 to thereby return it to its retracted position in preparation for the next subsequent power stroke.

Fluid flow in conduit 42 may also be used to maintain piston 11 in its retracted position in the event that the punch cylinder 10 is not vertically arranged to utilize the force of gravity for this function. Alternatively, the arrangement shown in FIGURE 5 may be used in combination with the arrangements in FIGURES 2 or 4. For example, fluid in conduit 42 of FIGURE 2 might be used to effect the retraction of the punch, and fluid through conduit 42 might thereafter be used to maintain and hold the punch in its retracted position. Therefore, depending upon the particular environment in which the invention finds itself, the retracting mechanisms shown in FIGURES 2, 4, and 5 hereof may be used singly or in combination with one another.

Although the present invention has been described in connection with a card punch, it is to be observed that the loose fitting multiple groove punch may be employed to perform work other than that of punching holes in web like material. Furthermore, when used in a card punch environment, the punch cylinder may be placed above the record card instead of below, so that the force of gravity upon the punch piston is used to assist the actuating fluid pressure during the punch stroke. In such a fluid stream must exist for what greater force in order to raise the punch piston and maintain same in its retracted position. Horizontal arrangements of cylinder 10 may be utilized. It is therefore apparent that many modifications and alterations may be made by one skilled in the art without departing from the spirit of the invention as defined in the appended claims.

I claim:

1. Apparatus for converting fluid pressure into mechanical motion which comprises: an elongated chamber having one end adapted to admit a fluid under pressure, and a piston slidably located within said chamber and loosely fitted therewith to provide a clearance between its peripheral surface and said chamber which has a cross-sectional area to permit fluid flow from said chamber one end to be substantially maintained throughout in the direction of the chamber opposite end at relatively high velocity for the entire axial length of at least a portion of said piston peripheral surface, where said piston peripheral surface portion has formed therein at least one circumferential groove into which a portion of said clearance fluid enters to strike its interior in a direction towards said chamber opposite end at relatively high velocity and thereby continuously apply an unbalanced dynamic force to said piston in the direction of said chamber opposite end for the duration of fluid admission to said chamber one end.

2. Apparatus for converting fluid pressure into mechanical motion which comprises: an elongated chamber having one end adapted to admit fluid under pressure, and a piston slidably located within said chamber and loosely fitted therewith to provide a clearance between its peripheral surface and said chamber which has a cross-sectional area to permit fluid flow from said chamber one end to be substantially maintained therethrough in the direction of the chamber opposite end at relatively high velocity for the entire axial length of at least a portion of said piston peripheral surface, where said piston peripheral surface portion has formed therein a plurality of axially spaced circumferential grooves into each of which a portion of said clearance fluid enters to strike its interior in a direction towards said chamber opposite end at relatively high velocity and thereby continuously apply an unbalanced dynamic force to said piston in the direction of said chamber opposite end for the duration of fluid admission to said chamber one end.

3. Apparatus according to claim 2 wherein said piston has at least four circumferential grooves.

4. Fluid powered punch apparatus comprising: an elongated chamber having one end adapted to admit fluid under pressure for driving a punch body and the other
end adapted to expose the material to be punched to the driven punch body, a piston-like punch body slidably located within said chamber and loosely fitted therewith to provide a clearance between its peripheral surface and said chamber which has a cross-sectional area to permit fluid flow from said chamber one end to be substantially maintained therethrough in the direction of the chamber other end at relatively high velocity for the entire axial length of at least a portion of said punch body peripheral surface, and means for retracting said punch body subsequent to the punch operation, where said punch body peripheral surface portion has formed therein at least one circumferential groove into which a portion of said clearance fluid enters to strike its interior in a direction towards said chamber opposite end at relatively high velocity and thereby continuously apply an unbalanced dynamic force to said punch body in the direction of said chamber other end for the duration of fluid admission to said chamber one end.

5. Fluid powered punch apparatus comprising: an elongated chamber having one end adapted to admit fluid under pressure for driving a punch body and the other end adapted to expose the material to be punched to the driven punch body, a piston-like punch body slidably located within said chamber and loosely fitted therewith to provide a clearance between its peripheral surface and said chamber which has a cross-sectional area to permit fluid flow from said chamber one end to be substantially maintained therethrough in the direction of the chamber other end at relatively high velocity for the entire axial length of at least a portion of said punch body peripheral surface, and means for retracting said punch body subsequent to the punch operation, where said punch body peripheral surface portion has formed therein a plurality of axially spaced circumferential grooves into each of which a portion of said clearance fluid enters to strike its interior in a direction towards said chamber opposite end at relatively high velocity and thereby continuously apply an unbalanced dynamic force to said punch body in the direction of said chamber other end for the duration of fluid admission to said chamber one end.

6. Apparatus according to claim 5 wherein said punch body has at least four circumferential grooves.

7. Apparatus according to claim 5 wherein said retracting means comprises an orifice in the wall of said chamber positioned near said other end which is adapted to receive fluid for directing same against said punch body to effect retraction thereof.

8. Apparatus according to claim 5 wherein said retracting means comprises a nozzle positioned opposite said chamber other end, between which two elements the material to be punched passes, where said nozzle is adapted to receive fluid for directing same against said punched body whenever the latter is exposed thereto in order to effect retraction thereof.

9. Fluid powered punch apparatus comprising: an elongated chamber having one end adapted to admit fluid under pressure for driving a punch body and the other end adapted to expose the material to be punched to the driven punch body, a piston-like punch body slidably located within said chamber and loosely fitted therewith to provide a clearance between its peripheral surface and said chamber which has a cross-sectional area to permit fluid flow from said chamber one end to be substantially maintained therethrough in the direction of the chamber other end at relatively high velocity for the entire axial length of at least a portion of said punch body peripheral surface, and means for creating a suction force at said chamber one end to retract said punch body subsequent to the punch operation, where said punch body peripheral surface portion has formed therein a plurality of axially spaced circumferential grooves into each of which a portion of said clearance fluid enters to strike its interior in a direction towards said chamber opposite end at relatively high velocity and thereby continuously apply an unbalanced dynamic force to said piston in the direction of said chamber other end for the duration of fluid admission to said chamber one end.

10. Apparatus according to claim 9 wherein said retracting means comprises means to introduce a transverse fluid flow in said chamber one end to thereby create the suction force for retracting said punch body.

11. Apparatus according to claim 10 wherein said punch body has at least four circumferential grooves.

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