Dec. 4, 1962 D. P. DARWIN ETAL 3,066,859

HYDRAULIC ACTUATOR

Filed Dec. 7, 1959 5 Sheets-Sheet 1

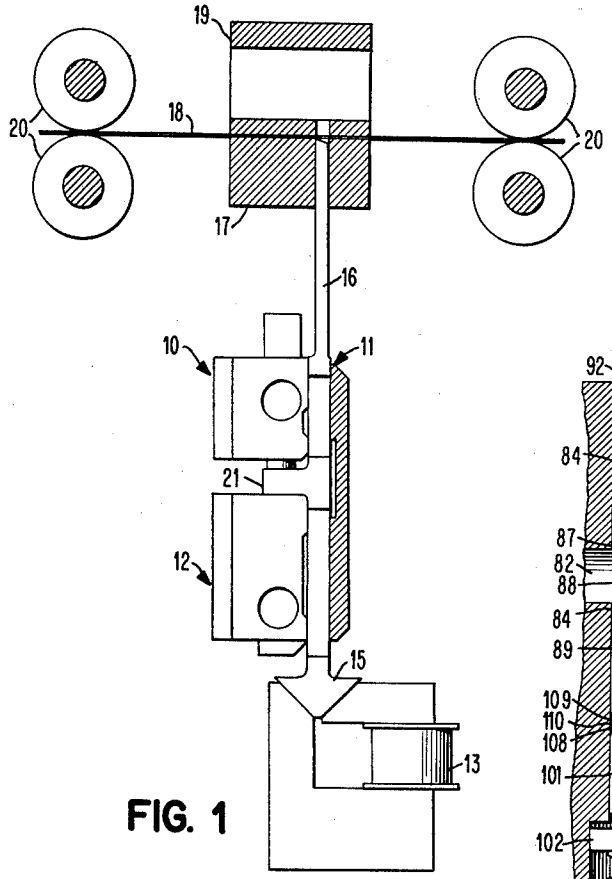


FIG. 1

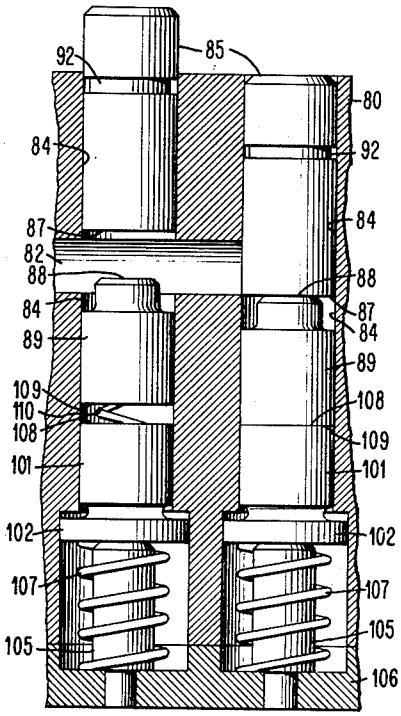


FIG. 9

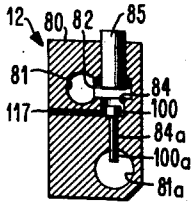


FIG. 2

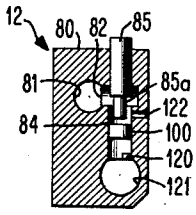


FIG. 3

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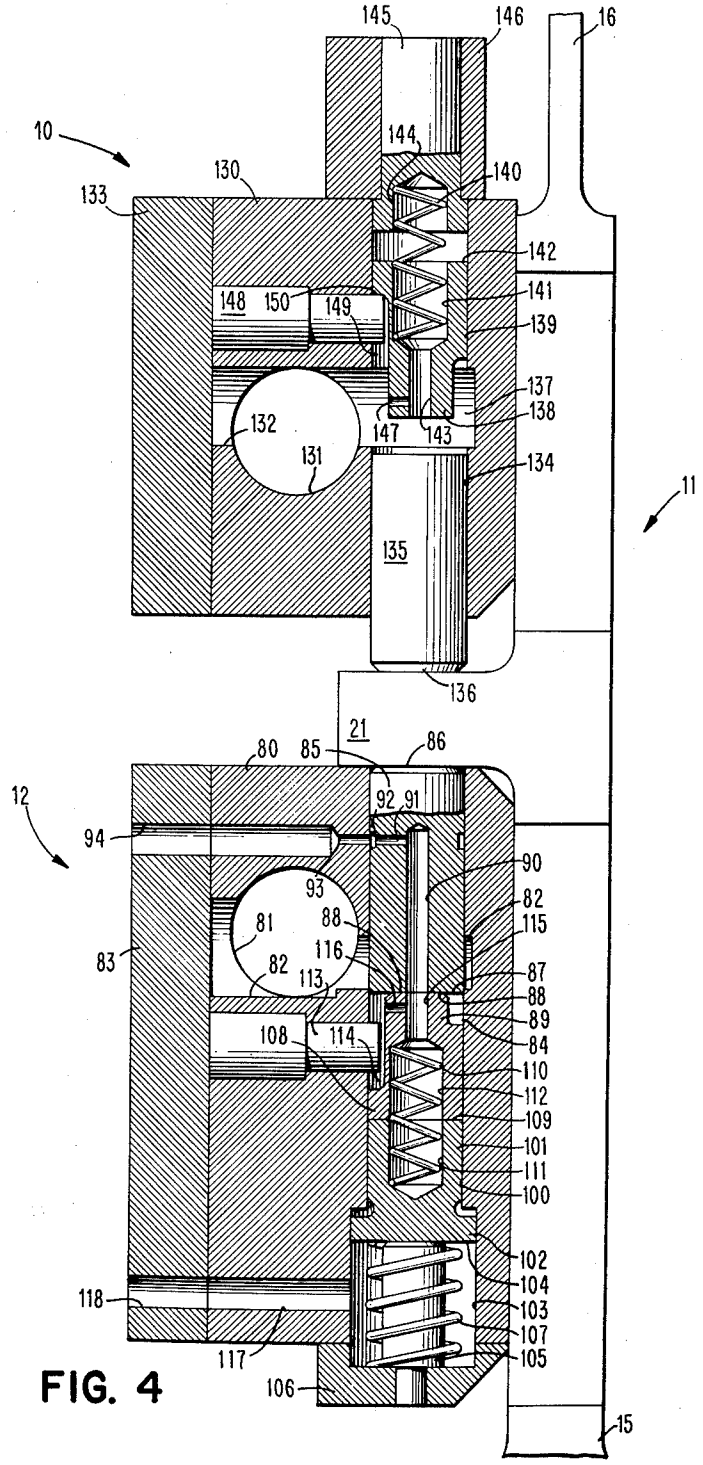


FIG. 4

HYDRAULIC ACTUATOR

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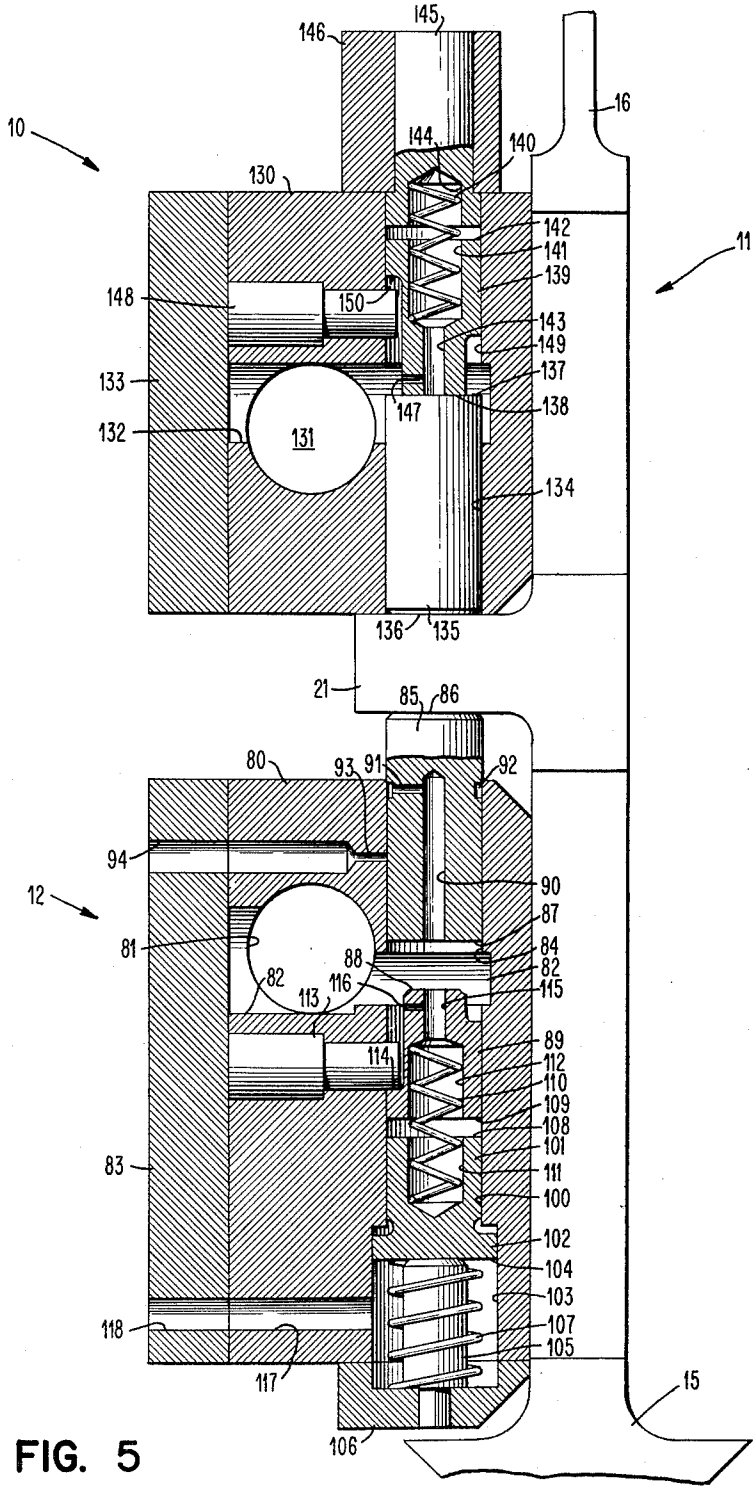


FIG. 5

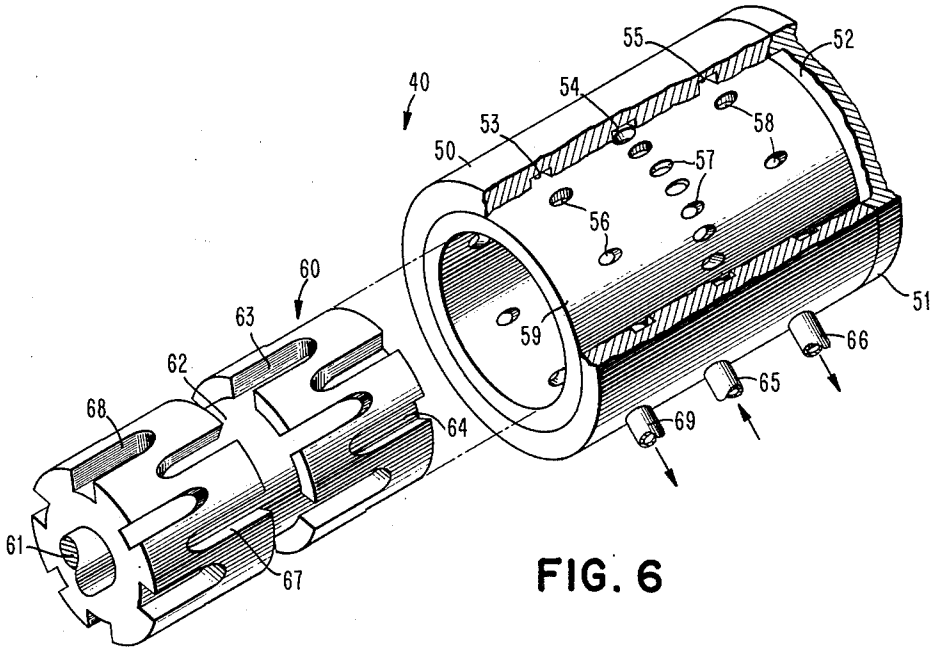

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FIG. 6

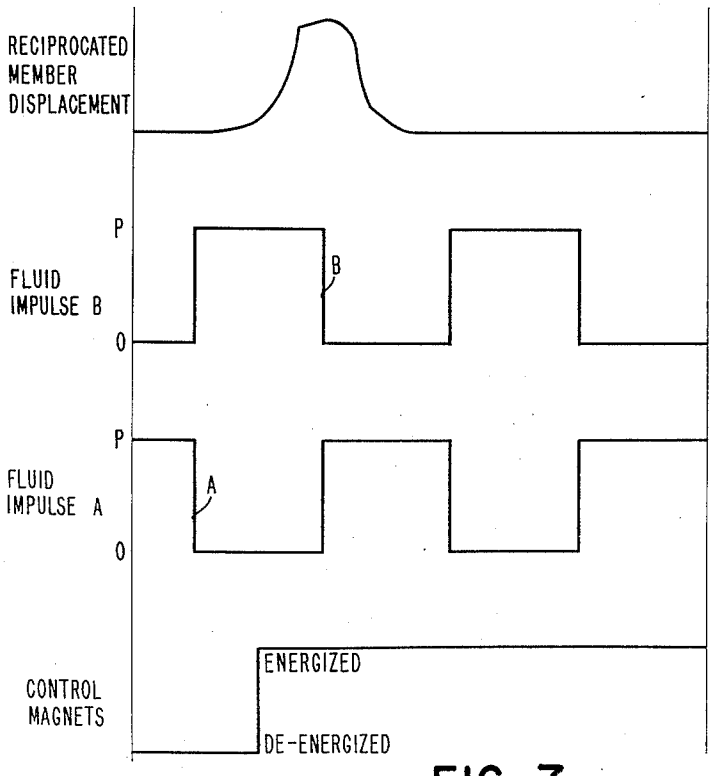

RECIPROCATED MEMBER DISPLACEMENT
FLUID IMPULSE B
P
0
B
FLUID IMPULSE A
P
0
A
CONTROL MAGNETS
ENERGIZED
DE-ENERGIZED

FIG. 7

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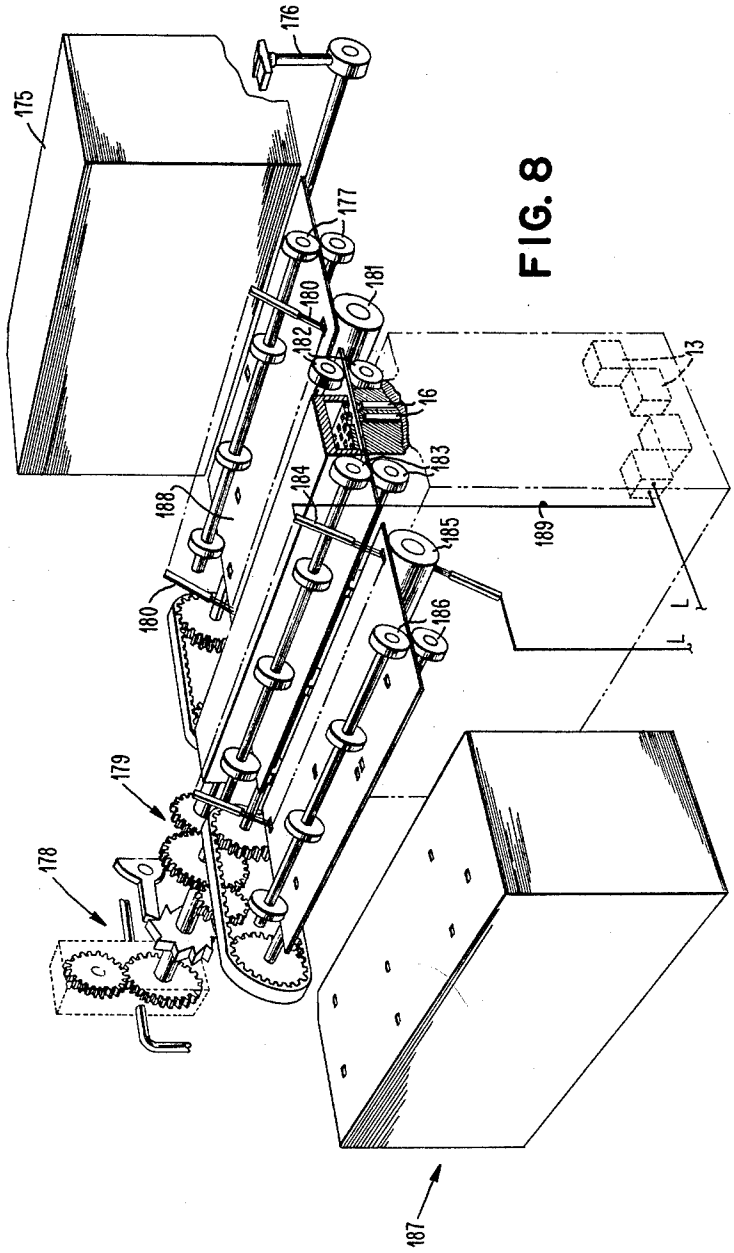


FIG. 8

United States Patent Office

3,066,859

Patented Dec. 4, 1962

3,066,859

HYDRAULIC ACTUATOR

Daniel P. Darwin, Saratoga, Calif., and Robert M. Kellogg, Binghamton, N.Y., assignors to International Business Machines Corporation, New York, N.Y., a corporation of New York

Filed Dec. 7, 1959, Ser. No. 857,822
15 Claims. (Cl. 234—107)

This invention relates to apparatus actuated by hydraulic fluid impulses and, more particularly, to selectively operable apparatus adapted to be actuated by cyclically applied hydraulic fluid impulses.

This invention is an improvement over that described in copending application, Serial No. 857,737, by Darwin et al., filed December 7, 1959, and issued as Patent No. 3,011,698. In that invention, the forces necessary to restrain actuation of the apparatus are small because the hydraulic forces resulting from cyclically applied fluid impulses are limited so long as the apparatus is restrained against movement. The apparatus is selectively restrained against movement by magnetic devices which act directly upon the apparatus. The magnetic devices are not required to move the apparatus but only hold the same against movement. If the magnetic devices are so operated to permit movement of the apparatus by the fluid impulses cyclically applied, the forces developed by the fluid impulses so applied increase as the apparatus is displaced. Hence, the magnetic devices are required to overcome only a relatively small force; but, if the magnetic devices permit movement of the apparatus, the forces for moving the same increase rapidly.

In the present invention, the apparatus is selectively restrained or permitted while fluid impulses are cyclically applied to the apparatus. However, the hydraulic forces are latched out so long as the apparatus is restrained against movement, rather than limiting the hydraulic forces during this period of time. The apparatus is selectively restrained against movement by magnetic devices which act upon the apparatus. Similar to the referenced arrangement, the magnetic devices are not required to move the apparatus but only hold the same against movement. If the magnetic devices are so operated to permit movement of the apparatus, a starting means displaces the apparatus, whereby the cyclically applied fluid impulses are able to act upon the apparatus so as to displace the same. The starting means, which may be a relatively small force, is normally restrained against movement by the magnetic devices. Because the force requirements of the magnets are relatively small to overcome the force of the starting means, the magnets may operate at relatively high speeds. Additionally, hydraulic cushioning means is provided for cushioning the apparatus as the same is returned to the starting or home position by the fluid impulses.

The present invention is also particularly suited to be incorporated in machines for selectively perforating record cards to represent information in coded form. The punch elements for perforating record cards are provided with extensions which are, in effect, armatures of the magnets. The magnets, when energized, restrain the starting means and thereby the punch elements against movement. Since the magnets, when energized, restrain the starting means, the member displaceable by the cyclically applied fluid impulses is not displaced. Because, with the starting means restrained against movement by the magnetic means, the member normally displaced by the fluid impulses is in such a position, the fluid impulses are unable to act upon this member. Hence, unless this member is displaced by the starting means, there will be no movement. However, if the

starting means is permitted by the magnetic means to displace this member, the cyclically applied fluid impulses will act upon this member to displace the same rapidly.

The punch elements are adapted to be moved bidirectionally as the cyclically applied fluid impulses act upon the members for translating the punch elements. The fluid impulses are so applied that the punch elements are moved to a restored position and to a punching position. With the punch elements in the restored position, the armatures formed integral with the punch elements are abutting the cores of the control magnets. Because of this arrangement, it is only necessary for the magnets to exercise a control function only and not be required to move any elements so as to perform work. With the punches restored and if the magnets are energized, the punches will be restrained against movement to the punching position upon application of the fluid impulses. If the magnets are not energized, the starting means will displace the member to be acted upon by the fluid impulses to a position where the fluid impulses can act upon this member and thereby move the punches to the punching position. Subsequently, all punches moved to the punching position are returned to the restored position; this action takes place cyclically. Apparatus is provided to decelerate the punch elements as they approach the punching and restored positions.

Accordingly, it is a principal object of the invention to provide improved selective control for the operation of that apparatus which is to be actuated by fluid impulses applied cyclically at very high rates.

Another very important object of the invention is to latch out the cyclically applied fluid impulses until the apparatus is permitted to operate as determined by the controls therefor.

Another object of the invention is to provide deceleration control for the apparatus which is to be actuated by the fluid impulses applied cyclically.

A more specific object of the invention is to cyclically apply fluid impulses to actuate punch elements bidirectionally and selectively restrain the punch elements in one direction against movement by magnetic means.

Another object of the invention is to provide apparatus which is cyclically operable to restore selectively displaced members.

Still a more specific object of the invention is to provide apparatus for selectively controlling the movement of a member which is to be displaced bidirectionally by fluid impulses applied cyclically by selectively restraining the starting means through the member which is to be displaced by the fluid impulses.

The foregoing and other objects, features and advantages of the invention will be apparent from the following more particular description of preferred embodiments of the invention, as illustrated in the accompanying drawings.

In the drawings:

FIG. 1 is a side elevational view, partially in section, showing the invention as incorporated in a record card punching machine;

FIG. 2 is a detail sectional view showing one embodiment of that mechanism shown in outline form in FIG. 1 for displacing the punch element to the punching position;

FIG. 3 is a detail sectional view showing another embodiment of that mechanism shown in outline form in FIG. 1 for displacing the punch element to the punching position;

FIG. 4 is a sectional view of the preferred embodiment of the apparatus for moving the punch elements to the punching and restored positions, the punch element shown as being held in the restored position by the apparatus;

FIG. 5 is a sectional view of the apparatus in FIG. 4

but with the punch element shown as being held in the punching position by the apparatus;

FIG. 6 is an exploded isometric view of the apparatus for developing or generating the cyclic hydraulic fluid impulses;

FIG. 7 is a diagram showing the punch displacement curve, the relative timing for the fluid impulses, and the state of the magnet for controlling the starting member;

FIG. 8 is a perspective view showing the invention as incorporated in a punching machine; and

FIG. 9 is a partial longitudinal sectional view showing the operating members for two punching positions, where one operating member is in the unlatched position and the other is in the latched position.

With reference to FIG. 1, the invention is shown by way of example as apparatus including a hydraulically operated unit 10 for displacing a member 11 in one direction and a hydraulically operated unit 12 for displacing the member 11 in an opposite direction. The hydraulically operated units 10 and 12 are alternately supplied with fluid impulses on a cyclic basis. When the fluid impulse A, shown in FIG. 7, is applied to the unit 10, the member 11 is displaced to the position shown in FIG. 1. However, when the fluid impulse B, which occurs alternately with the fluid impulse A, is applied to the hydraulic unit 12, the member 11 will be displaced only if a magnet 13 is de-energized. The member 11 as a V-shaped end 15 which is complementary to the core of the magnet 13 and acts as the armature thereof. As it will be seen shortly, the hydraulically operated unit 12 is so comprised that the B fluid impulse applied thereto will be prevented from acting unless permitted to act as a result of the magnet 13 being de-energized at the time the B fluid impulse is applied.

As shown in FIG. 1, the member 11 also includes a punch element 16 at its other end. The punch element 16 is adapted to slide within a punch guide 17 and perforate a record card 18 positioned between the punch guide 17 and an aligned punch die 19. The record card 18 is transported into and out of the punching position by cooperating feed rollers 20 driven in the usual manner, the drive therefor is not shown.

The hydraulically operated units 10 and 12 are shown only in outline form in FIG. 1 because these units may be comprised in several different embodiments. However, before describing these different embodiments, a hydraulic fluid impulse generator 40, FIG 6, for devleoping the A and B fluid impulses will be described. While this hydraulic fluid impulse generator 40 does not form an essential part of the invention because any suitable fluid impulse generator would be satisfactory, it will be described since it works very well for supplying fluid impulses alternately emerging from two different outlets at a system pressure of approximately 500 pounds per square inch and at a frequency of approximaetly 200 cycles per second.

Referring to FIG. 6, the fluid impulse generator 40 consists of an outer stator element 50 fitted with end members 51, only the right end member is shown. The end members 51 form caps for the outer stator element 50 but are recessed so as to form fluid end chambers 52.

The outer stator element 50 is provided with three spaced apart inwardly opening annular recesses 53, 54 and 55 which form fluid conducting channels. The recesses 53, 54 and 55 are in register with and circumscribe or encircle radial bores 56, 57 and 58, respectively, spaced around the periphery of a sleeve 59 embraced by and concentric with the outer stator element 50. The length of the sleeve 59 is coextensive with the stator element 50. A rotor 60 is disposed to be rotatable within the sleeve 59 and is coextensive therewith. The ends of the rotor 60 cooperate with the end members 51 to form the fluid end chambers 52. The rotor 60 is driven by a shaft 61 attached to it to extend through the end member 51, not shown, to connect to a suitable driving source, also not shown.

The peripheral surface of the rotor 60 is provided with an outwardly opening annular groove 62 which is in register with the bores 57. A series of arcuately spaced slots 63, also formed in the peripheral surface of the rotor 60 to extend to the right and parallel to the longitudinal axis of the rotor 60, open into the annular groove 62 and terminate to form fluid passages with the bores 58 when in arcuate alignment therewith. A series of arcuately spaced slots 64, formed in the peripheral surface of the rotor 60, are disposed to lie between the arcuately spaced slots 63 to open into the right-hand end chamber 52 and to terminate to form fluid passages with the bores 58 when in arcuate alignment therewith. Hence, the bores 58 will alternately be in fluid communication with the slots 63 and 64, respectively, as the rotor 60 rotates. Of course, the slots 63 are in constant fluid communication with the annular groove 62 which, in turn, is in fluid communication with the bores 57, the same being in fluid communication with the annular recess 54. The annular recess 54 is supplied with fluid under pressure from a source, not shown, by means of a fluid conductor 65 connected between said source and the outer stator 50. The slots 64 are in constant fluid communication with the end chamber 52 which is in fluid communication by a conductor, not shown, to a fluid reservoir at zero hydraulic fluid pressure. The bores 58 are also in fluid comumnication with the annular recess 55. A fluid conductor 66 is connected to the outer stator 50 to connect with the annular recess 55. The fluid conductor 66 supplies the A fluid impulses and is connected to the input of the hydraulically operated unit 10.

The peripheral surface of the rotor 60 is also provided with a series of arcuately spaced slots 67 opening into the annular groove 62 and extending away therefrom to the left to terminate so as to form a fluid passage with the bores 56 when in arcuate alignment therewith. A series of arcuately spaced slots 68, formed in the peripheral surface of the rotor 60, are disposed to lie between the arcuately spaced slots 67 and open to the left-hand end chamber 52 while terminating at the right so as to form fluid passages with the bores 56 when in arcuate alignment therewith. Hence, the bores 56 will be alternately in fluid communication with the slots 67 and 68, respectively, as the rotor 60 rotates. Further, the slots 67 are in line with the slots 64, while the slots 68 are in line with the slots 63. Therefore, the bores 56 will be in fluid communication with the slots 67 which open to the annular groove 62 so as to receive fluid under pressure coming via the fluid conductor 65 the annular recess 54 and the bores 57, at the same time the bores 58 are in fluid communication with the slots 64 which open to the right-hand end chamber 52 which is at zero hydraulic pressure. Likewise, the bores 58 will be in fluid communication with the slots 63 so as to receive fluid under pressure via the fluid conductor 65, the annular recess 54, the bores 57, and the annular groove 62, during the time the bores 56 are in fluid communication with slots 68 which open to the left-hand end chamber 52 which is connected to be at zero hydraulic pressure.

The bores 56, which alternately communicate with the slots 67 and 68, also are in constant fluid communication with the annular recess 53 in the outer stator 50. A fluid conductor 69 is connected to the outer stator 50 so as to be in fluid communication with the annular recess 53. Hence, B fluid impulses are supplied over the fluid conductor 69 which, in turn, is connected to the input of the hydraulically operated unit 12. From the foregoing, it is seen that means have been provided to develop and supply fluid impulses alternately to the hydraulically operated units 10 and 12 on a cyclic basis. The geometry of the rotor 60 relative to the sleeve 59 determines the phase relationship between and the base width of the fluid impulses A and B, while the angular velocity of the rotor 60 determines the frequency.

Referring again to FIG. 1, the hydraulic unit 10 takes

only one form while the hydraulic unit 12 may take several different forms, each operating according to a common principle, and including a preferred form having additional features. The preferred form of the hydraulic operated unit 12 will be described first.

The preferred form of the hydraulically operated unit 12 is shown in its latched or restored position in FIG. 4 and in its unlatched and fully operated position in FIG. 5. In the preferred form, FIGS. 4 and 5, the hydraulically operated unit 12 is comprised of a bored housing 80 including a horizontally extending inlet bore 81 which is connected to the fluid conductor 69, in FIG. 6. Hence, the B fluid impulses will be supplied on a cycle basis at a predetermined frequency to the inlet bore 81 which, at all other times, will be at zero hydraulic pressure. The inlet bore 81, FIGS. 4 and 5, extends inwardly into the housing 80 to intersect a laterally extending slot 82 which is sealed off at one end by a cover plate 83 and opens at its other end into a longitudinally extending bore 84. Slidably disposed within the bore 84 is an operating member or piston 85 having one end 86 which is permitted to extend beyond the housing 80, when displaced or actuated by the B fluid impulses, and another end 87 which abuts against the upper end 88 of a damping piston 89 when in the latched or restored position, FIG. 4, and is spaced therefrom when in its fully operated or extended position, FIG. 5. The operating member 85 is provided with a longitudinal central bore 90 which terminates just beyond a cross-intersecting bore 91 which leads to an annular outwardly opening collector groove 92. The cross bore 91 and collector groove 92 are located in the operating member 85 so as to be in register with a laterally extending bore 93 provided in the housing 80 when the operating member is in the latched or restored position, as in FIG. 4. The bore 93 leads off to the left from the collector groove 92 and, as it does so, it becomes enlarged and leads to a bore 94 formed in the cover plate 83. The bore 94 is connected by a fluid conductor, not shown, to a fluid reservoir, also not shown. The function of the fluid pathway just described will become quite clear when the decelerating and latching feature of the unit 12 is described.

It will be noted that the upper end 86 of the operating member 85 normally abuts the lower side of an arm 21 extending from the member 11 at right angles. Further, with the lower side of the arm 21 abutting the top surface of the housing 80, as in FIG. 5, the end 87 of the operating member 85 lies in the bore 84 just below the lowermost portion of the intersecting slot 82, whereby the operating member 85 seals off fluid communication of the slot 82 with the bore 84. Hence, with the operating member in this position, the cyclically applied B fluid impulses are latched out so as to be unable to act upon the operating member 85. Therefore, in order for the B fluid impulses to act upon the operating member 85, the same must be displaced a sufficient amount to permit the B fluid impulses to enter the bore 84. Of course, displacement of the operating member 85 closes off fluid communication of the bore 93, with the collector groove 92, which, in turn, communicates with bore 91, the same being in fluid communication with the bore 90. With the operating member 85 in the latched position, as in FIG. 5, a small amount of the B fluid impulse will pass around the operating member 85 as leakage. This leakage fluid might develop sufficient pressure to displace the operating member 85 from the latched position even though the magnet 13 is energized. However, the leakage fluid is prevented from developing such a pressure because the leakage fluid will pass into a bleed bore 116 which leads to a bore 115 in fluid communication with the bore 90. The bore 90 communicates with the bore 91. Hence, the leakage fluid passes to the reservoir, not shown, via the collector ring 92, the bore 93 and the bore 94.

The operating member 85 is displaced to place the slot 82 in fluid communication with the bore 84 by means of a starting piston 100 having one portion 101 slidably disposed within the bore 84 and an integral portion 102 slidably disposed within a counter bore 103 of the bore 84. One end 104 of the starting piston 100, with the operating member 85 in the latched position, abuts the top of a stud element 105 which is fixed to extend upwardly from a cap member 106 into the counter bore 103. The stud element 105 is embraced by a compression spring 107 having one end abutting the inner surface of the cap member 106 and its other end abutting the end 104 of the starting piston 100. By this arrangement, the starting spring 107 urges the starting piston 100 upward. The movement of the starting piston 100 is limited by the shoulder on the portion 102 of the starting piston 100 which, when displaced, will abut the shoulder of the counter bore 103 and thereby be prevented from any further upward movement. Of course, adequate movement of the starting piston 100 is provided to permit the same to unlatch the operating member 85.

The other end 108 of the starting piston 100 abuts the end 109 of the damping piston 89 when the operating member 85 is in the latched position. While the starting spring 107 normally urges the starting piston 100 into engagement with the damping piston 89, a separating compression spring 110 having one end abutting the end of a longitudinal centrally disposed bore 111 provided in the portion 101 of the starting piston 100 and its other end abutting the bottom of a longitudinal centrally disposed bore 112 provided in the damping piston 89 urges the starting piston 100 and damping piston 89 away from each other. Movement of the damping piston 89 is limited in the downward direction, of course, by the starting piston 100 and in the upward direction, when the separating spring 110 is permitted to move the same upward, by a stud 113 fixed in housing 80 to extend therefrom at right angles into the bore 84 so as to engage a shoulder 114 of a longitudinal slot formed in the peripheral surface of the damping piston 89.

The damping piston 89 is a hydraulically balanced piston and also includes a centrally disposed bore 115 which is of the same diameter and in register at one end with the bore 90 provided in the operating member 85 and its other end communicates with the larger diameter bore 112 for containing a portion of the separating spring 110. A cross or bleed bore 116 intersects the bore 115 and the longitudinal slot formed in the peripheral surface of the damping piston. There is also a bleed-off bore 117 provided in the housing 80 to intersect the counter bore 103 and connect with a bore 118 provided in the cover plate 83. The bore 118 is connected to the fluid reservoir, not shown, by a conductor, also not shown.

The holding force of the magnet 13, FIG. 1, is sufficient to overcome the resultant force of the starting spring 107 and the separating spring 110. Hence, the starting spring 107 cannot displace the starting piston 100 unless the magnet 13 is de-energized. Further, the force of the starting spring 107 is greater than that of the separating spring 110 so that, when the starting spring 107 is permitted by the magnet 13 to displace the starting piston 100, the same will not separate from the damping piston. Rather, the upper end 108 of the starting piston 100 remains in engagement with the lower end 109 of the damping piston 89, whereby the damping piston 89 is displaced and, in turn, displaces the operating member 85. The amount of displacement required of the starting piston 100 is very small and only that necessary to displace the operating member so that the slot 82 is placed in fluid communication with the bore 84, whereby the B fluid impulse may act upon the operating member 85 to displace the same upwardly very rapidly and thereby carry the member 11 upwardly at a rapid rate. The force developed by the B fluid impulse is of such magnitude that it is able to easily overcome the force of the magnet 13; however, the B fluid impulse may act upon the operat-

ing member 85 only if the magnet 13 permits the starting spring 107 to displace the starting piston 100.

When the B fluid impulse acts upon the operating member 85, the same having been initially displaced by the starting piston 100, the operating member 85 moves upward while the starting piston 100 is forced downward against the stud element 105 and the damping piston 89 tends to follow the operating element 85 upward under action of the separating spring 110. The damping piston 89 follows the operating member 85 at a rate determined by separating spring 110 which has a force much less than that effected by the B fluid impulse. Further, the operating member 85 continues to move upward after the shoulder 114 on the damping piston 89 abuts the stud 113.

The movement of the operating member 85 or the movement of the member 11 in the upward direction is shown by the reciprocated member displacement curve in FIG. 7. The deceleration of the member 11 in the upward direction is effected by the hydraulically operated unit 10 which will be described subsequently. When the member 11 is moved downward from the fully extended posiiton, as in FIG. 4, to the fully retracted position, as in FIG. 5, the operating member 85, FIG. 5, is carried downward by the arm 21 of the member 11. At the time the operating member 85 starts its downward movement, the inlet bore 81 is at zero hydraulic pressure because the conductor 69, which is in fluid communication with the bores 56 of the fluid impulse generator, FIG. 6, is at zero hydraulic pressure. Because the volume of the fluid chamber provided by the bore 84 is decreased as the operating member 85 is moved downward, the fluid in the bore 84 is actually pumped into the inlet bore 81 via the bore 82. Continued downward movement of the operating member 85 will cause the same to engage the damping piston 89 and carry it downward, thereby compressing the separating spring 110 and causing further pumping of fluid through a fluid path, which is quite restrictive to fluid flow, so as to cause controlled deceleration of the member 11. This fluid path is via the comparatively large bore 112, the smaller bore 115 and the very small bore 116, through which the fluid passes into the slot 82 to be conducted to the inlet bore 81, now serving as a discharge bore for the fluid flow back to the reservoir, not shown, via the hydraulic fluid impulse generator 40. Now, when the operating member 85 seals off the bore 82 from fluid communication with the bore 84, the fluid can no longer flow via the very small bore 116 to the bore 82; however, a fluid path, highly restrictive to fluid flow, is provided via the bore 115, in the damping piston 89, the corresponding bore 90 in the operating member 85, and the very small cross bore 91, which opens to the collector groove 92, now in partial registration with the very small lead-off bore 93 which communicates with the bore 94 that leads to the fluid reservoir, not shown. By this arrangement, the member 11 is brought to rest with smooth deceleration, as shown by the displacement curve in FIG. 7.

FIG. 2 discloses another embodiment for the hydraulically operated unit 12 wherein the starting piston 100 is started by the B fluid impulse; however, the starting piston 100 includes a relatively small diameter extension portion 100*a* which is disposed in a complementary bore 84*a* to be acted upon by the B fluid impulse introduced into the housing 80 through an inlet bore 81*a*. Hence, the force on the starting piston 100 effected by the B fluid impulse is relatively small and is easily overcome by the holding force of the magnet 13. While the operating member 85 is shown extended, it functions according to the same principles as the operating member 85 in FIGS. 4 and 5; that is, it latches out the B fluid impulse when it is in the retracted position, and will be moved to an unlatched position by the starting piston 100 when the magnet 13 becomes deenergized, whereby the B fluid impulse moves the starting piston 100 which, in turn, then displaces the operating member 85 to the unlatched position, whereby the B fluid impulse is able to act upon the operating member 85 to displace the same upwardly. A bleed bore 117 is provided to permit fluid to flow from the bore 84 after the operating member is returned or restored to the position where it seals off the slot 82 from the bore 84. The bore 117 also provides a restrictive path to fluid flow upon the return of the operating member 85 so as to provide deceleration for the same and, in turn, deceleration for the member 11. The starting piston 100 returns under gravity, since the fluid forces are relatively balanced, to the position shown in FIG. 2.

In FIG. 3, the starting piston 100 is a piston of the same diameter as the operating member 85 and is slidably disposed within the bore 84 to act upon a reduced section 85*a* of the operating member 85. This reduced portion 85 permits separation of the starting piston 100 from the operating member 85. The starting piston 100 is urged upwardly by starting fluid under pressure coming from an independent fluid supply, not shown, to enter an inlet bore 121, the pressure of the fluid being sufficiently small so that the force produced thereby may be overcome by the holding force of the magnet 13. Hence, the starting piston 100 is unable to displace the operating member 85 from the unlatched position unless permitted to do so by the magnet 13, which must then be in the de-energized state. The force developed by the B fluid impulse is much greater than that developed by the fluid under pressure applied to the starting piston 100 from the independent fluid supply, not shown; and, therefore, as the operating member 85 is displaced by the starting piston 100 to place the slot 82 in fluid communication with the bore 84, the B fluid impulse is admitted to act upon the operating member 85 to displace the same upwardly and to act upon the starting piston 100 to displace the same downwardly. The downward displacement of the starting piston 100 is limited by a fixed stop member 120 disposed to project from the housing 80 into the bore 84, as shown in FIG. 3. The fluid displaced as the starting piston 100 is moved downwardly by the B fluid impulse is absorbed in the independent system for supplying fluid under pressure to the bore 84 via the inlet bore 121. Further, when the operating member 85 is moved downwardly to the position where it seals off the slot 82 from communicating with the bore 84, fluid contained in the bore 84 between the end of the operating member 85 and the starting piston 100 flows through a bleed-off bore 122 to the fluid reservoir, not shown. Since there is no opposing downward force acting upon the starting piston 100, when the operating member is in the fully retracted position, the starting piston is urged by the fluid under pressure from the independent supply to engage the extension 85*a* of the operating member 85. It should be noted that the bleed-off bore 122 provides deceleration for the operating member 85 and, in turn, for the member 11.

From the immediate foregoing description, it is seen that several different embodiments, including a preferred embodiment, have been provided for the hydraulically operated unit 12. Each embodiment included the feature of normally latching the operating member by magnetic means in a position whereby the cyclically applied fluid impulse could not act upon the same until the magnetic means permitted a starting member to displace the operating member. Further, each embodiment included the feature for decelerating the operating member when the same is returned to the latched position. In one embodiment, the starting member is actuated by a starting spring and, in another embodiment, by the B fluid impulse itself acting upon a reduced area of the starting member; while in still another embodiment an independent source of fluid under pressure is utilized to act upon the starting member.

Before describing the structure of the hydraulically

operated unit 10, the general function of the same will be described. The function of the hydraulically operated unit 10 is to cyclically return the member 11 and, in turn, the operating member 85 to the latched position by bringing the member 11 under control of the magnet 13. The unit 10 also functions to decelerate the operating member 85 and, in turn, the member 11 as the same reaches its fully extended position. Since the unit 10 is to operate cyclically rather than selectively, as does the unit 12, the feature of latching an operating member to prevent the cyclically applied fluid impulse from acting upon the same is not contained in the unit 10.

Referring to FIGS. 4 and 5, the unit 10 includes a bored housing 130 having a horizontally disposed fluid inlet bore 131 connected to the conductor 66, FIG. 6, to receive the A fluid impulses. The inlet bore 131 extends into the housing 130 to intersect a laterally extending bore 132 sealed off at one end by a cover plate 133 and intersecting a longitudinally disposed bore 134 at its other end. An operating member 135 is slidably disposed within the bore 134. The operating member 135 has one end 136 in constant engagement with the upper side of the arm 21 of the member 11. The other end 137 of the operating member 135 abuts an end 138 of a damping piston 139 also slidably disposed in the bore 134 when the operating member 135 is in its fully retracted position. The damping piston 139 is very similar in structure and function to the damping piston 89 of the unit 12. However, the operating member 135 is slightly different from the operating member 85, because the operating member 135 does not require any fluid passage or bore for conducting any entrapped fluid to the fluid reservoir. The end 137 of the operating member 135 is exposed at all times to be acted upon by the A fluid impulse.

The damping piston 139 is urged into contact with the operating member 135 by a compression spring 140 having one end bearing against the shoulders of a central bore 141 provided in the damping piston 139 extending from one end 142 thereof to communicate with a smaller diameter centrally located longitudinal bore 143 which extends to the other end 138 of the piston 139. The other end of the spring 140 bears against the shoulder of a central longitudinal bore 144 provided in a retaining member 145 fixed in a cap 146 to extend into the bore 134. The cap 146 is secured to the housing 130. The damping piston 139 also is provided with a laterally extending bleed bore 147 which affords an escape path for the fluid from the central bore 143 to the bore 134. Downward movement of the damping piston 139 is limited by a stud 148 fixed within the housing 130 to extend at right angles into the bore 134. The damping piston 139 is provided with a longitudinal slot 149 formed in peripheral surface thereof, whereby a shoulder 150 is formed. The shoulder 150 engages the stud 148 so as to limit the movement of the damping piston 139. By the arrangement just described, the operating member 135 is moved downward from its position shown in FIG. 5, when the A fluid impulse enters the inlet bore 131, and passes through the bore 132 to act upon the end 137 of the operating member 135. Further, the operating member 135 carries the member 11 downward, whereby, when the operating member 135 is fully extended, the V-shaped end 15 of the member 11 is seated upon the core of the magnet 13. During the downward movement of the operating member 135, the damping piston 139 separates therefrom as it tries to follow the operating member moving at a faster rate determined by the A fluid impulse, whereas the damping piston 139 is moving at a rate determined by the compression spring 140. Further, the movement of the damping piston 139 is arrested when the shoulder 150 of the groove 149 therein engages the stud 148, while the operating member 135 continues in its downward movement.

With the end 15 of the member carried to the position where it is seated upon the core of the magnet 13, the same does not have to perform any work because it does not have to move its armature, which, in this example, is the end 15 of the member 11. The magnet 13 exercises a control function only.

With the operating member 135 in the fully extended position, the same will not be retracted unless the magnet 13 becomes de-energized so as to permit the starting spring 107 to displace the starting piston 100, so as to move the operating member 85 to an unlatched position, whereby the B fluid impulse is able to act upon the same to carry it upward. Of course, if the magnet 13 is not de-energized to permit this action to take place, the A fluid impulse will not cause any further displacement of its associated operating member 135; and the B fluid impulse is latched out from acting upon its associated operating member 85.

When the member 11 is displaced upwardly by the operating member 85, the operating member 135 is also carried upwardly. As the operating member 135 is carried upwardly, fluid is forced or pumped from the bore 134 into the bore 132 to be returned via the inlet bore 131 and the fluid impulse generator 40 to the fluid reservoir. Further, when the end 137 of the operating member 135 engages the end 138 of the damping piston 139, the same will be carried upward, whereby the fluid contained between the retaining member 145 and the end 142 of the damping piston 139 and the fluid within the bores 141, 143 and 144 will escape through the narrow bleed bore 147 to the bore 132. The fluid escapes through the bleed bore 147 which offers high resistance to fluid flow; hence, the operating members 85 and 135 and the member 11 all move at a decelerated rate, as shown in the displacement curve in FIG. 7, until the operating member 85 is fully extended, as in FIG. 5.

From the foregoing just described, it is seen that the hydraulically operated unit 10 acts to restore the member 11 and operating member 85 to a latched position. Whether or not the member 11 and operating member 85 are in fact restored depends upon if they, in fact, had been extended. Further, it is seen that the unit 10 functions to decelerate the member 11 and operating member 85 as the same approach the fully extended position.

While the unit 12 operates broadly as an actuator for selectively reciprocating an element and the unit 10 acts to restore the unit 12 and reciprocated element to a home or restored position, the invention finds particular application in punching machines for selectively punching record cards. It is not only desirable to selectively perforate record cards according to a particular code, but the machine perforating the record cards should have the facility for operating at very high speeds, so as to be able to keep up to some extent with the rate that information can be furnished to the punching machine. In this instance, the invention may be incorporated in a punching machine to provide selective punching at a relatively rapid rate. The invention successfully increases punching speed approximately threefold over that speed successfully obtained by devices known heretofore.

The general schematic arrangement of the punching machine is shown in FIG. 8. Blank cards 175 contained in a hopper or magazine, not shown, are advanced in seriatim by a conventional picker knife 176, operated in the conventional manner, to a pair of cooperating feed rollers 177. The feed rollers 177 are driven from an intermittent hydraulic drive 178, shown schematically, through a gear train 179. The intermittent hydraulic drive 178 may be of the type described in the application of S. C. Titcomb, Serial No. 698,840, filed November 25, 1957, issued as Patent No. 2,938,501. As the blank cards 175 are fed by the feed rolls 177, they pass between conventional sensing brushes 180 and a contact roll 181 to a pair of cooperating feed rollers 182, which are also driven from the intermittent hydraulic

drive 178. By means of the hydraulic drive 178, the feed rollers 182 feed the blank cards 175 in successive increments at high speed into punching position relative to the punches 16.

The cards 175 advance from the feed rollers 182 to a pair of feed rollers 183, also driven from the intermittent hydraulic drive 178. The feed rollers 183 feed the cards 175 between sensing brushes 184 and contact roll 185 to cooperating feed rollers 186 which feed the cards 175 to a card stacker, not shown, to form a stack of punched cards 187.

As the blank cards 175, FIG. 4, are fed relative to the punches 16, the magnets 13 for controlling the movement of the members 11 are selectively de-energized. The impulses for selectively causing the magnets 13 to become de-energized may come from a card reader or from the results of analyzing a pattern card 188 leading a group of the blank cards 175, as described in the patent to C. D. Lake, Patent No. 2,032,805. The perforations in the pattern card 188 are analyzed by the brushes 184, thereby permitting the closing of a circuit diagrammatically shown for one order, as from line L, contact roll 185, through brush 184, conductor 189, magnet 13 to line L. The magnet 13, normally latched or energized, is of the type which unlatches or becomes de-energized when it receives an impulse. When the brush 184 senses a perforation at an index position of the pattern card, the corresponding index position of the following blank card 175 is over one of the punches 16; and, as a result of de-energization of the magnet 13 and a B fluid impulse applied to act upon the operating member 85, the blank card 175 is perforated by the associated punch 16. After the first blank card is perforated, it may act as a pattern card for the following blank cards of the group, as is well known in this form of card punching machine.

Once punching takes place, it is necessary to restore the punches 16 to enable a subsequent punching operation. The punches 16 are restored as the A fluid impulse acts upon the operating members 135 which, in turn, act upon the arms 21 of the members 11 carrying the punches 16.

Referring to FIG. 7, it is seen that, during the time that the B fluid impulse is applied, one of the magnets 13 becomes de-energized, whereby the starting spring 107, FIG. 5, displaces the starting piston 100 which, in turn, moves the damping piston 89 to unlatch the operating member 85, whereby the B fluid impulse acts upon the same to move it upwardly at a rapid rate. The starting piston 100 is driven against the stop 105 by the B fluid impulse, thereby compressing the spring 107; while the damping piston 89 separates from the operating member 85 and follows it at a rate determined by the spring 110 until the shoulder 114 engages the stud 113.

The operating member 85 carries the member 11 and thereby the associated punch element 16 upward. The operating member 135 is forced upward, whereby fluid is forced out of the bore 134 and back to the fluid reservoir via the bore 132, the inlet bore 131 and the fluid impulse generator 40. Escape of the fluid from the bore 134 to the bore 132 takes place through the bleed bore 147 after the operating member 135 engages the damping piston 139. Hence, the damping piston 139, by means of the bleed bore 147, decelerates the punch as it reaches the end of its stroke, as in FIG. 5. Referring back to FIG. 7, it is seen that as the punch 16 reaches the end of its stroke, the A fluid impulse is admitted into the bore 131 to act upon the operating member 135. The operating member 135 separates from the damping piston 139 which moves at a slower rate in the same direction as the operating member 135 under action of the spring 140. The end 15 of the member 11 is carried into the core of the associated magnet 13, which may be energized at any time after the member 11 was moved by the B impulse, because the magnet 13 is designed to have a high attracting force only when its armature is in close proximity to the core. With the armature 15 forced to seat upon the core of the magnet 13, it will be held in the seated position by the energized magnet 13. The A impulse is so timed and has a duration such that the end 15 of the member 11 seats upon the core of the magnet 13 just before the A impulse ceases. Further, the armature 15 seats upon the core of the magnet 13 at a decelerated velocity because the damping piston 89 will be effective at this time to decelerate the member 11.

From the immediate foregoing, it is seen that the invention may be incorporated into a record card punching machine to effect selective punching at a rapid rate.

While the invention has been particularly shown and described with reference to preferred embodiments thereof, it will be understood by those skilled in the art that the foregoing and other changes in form and details may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. A hydraulic actuator selectively operable in response to cyclically applied fluid impulses comprising: a cylinder having an inlet for receiving cyclically applied fluid impulses, a fluid displaceable member disposed within said cylinder, said displaceable member being displaceable from a first position where said member blocks said inlet to prevent the entry of fluid impulses to a second position unblocking said inlet whereby fluid impulses are able to enter said cylinder through said inlet to act upon and further displace said member; starting means for urging said member from said first position to said second position to permit said fluid impulses to enter said cylinder, and magnetic means selectively operable to overcome the urging of said starting means to hold said member in said first position to prevent fluid impulses from entering said cylinder.

2. A hydraulic actuator selectively operable in response to cyclically applied fluid impulses comprising a cylinder having an inlet for receiving cyclically applied fluid impulses; an operating member slidably disposed within said cylinder; said operating member being displaceable from a first position where said operating member blocks said inlet to a second position unblocking said inlet whereby said fluid impulses are able to enter said cylinder through said inlet to further displace said member; a control magnet; a work member having one portion adapted to engage said operating member and another portion under control of said magnet whereby, when said magnet is operated, said work member is held in a position to hold said operating member in said first position to prevent fluid impulses from entering said cylinder; and a starting member operably controlled by said magnet to act upon said operating member to displace the same to said second position to permit fluid impulses to enter said cylinder.

3. A hydraulic actuator according to claim 2 wherein said starting member comprises a spring having a force controllable by said magnet.

4. A hydraulic actuator according to claim 2, said starting member comprising: a piston of reduced diameter, and a cylinder for slidably containing said piston and receiving said fluid impulses whereby a starting force controllable by said magnet is developed.

5. A hydraulic actuator according to claim 2 wherein said starting member comprises a piston; and a cylinder for slidably containing said piston to permit the same to act upon said operating member, said cylinder having an inlet for receiving fluid under pressure to develop a starting force controllable by said magnet.

6. A hydraulic actuator selectively operable in response to cyclically applied fluid inmpulses, a cylinder having an inlet for receiving cyclically applied fluid impulses, an operating member slidably disposed in said cylinder to be moved relative thereto by said fluid impulses, cyclically operable restoring means for moving said operating member to a first position to block said inlet and thereby prevent fluid impulses from entering said

cylinder, magnetic means selectively operable to hold said operating member in said first position to block said inlet to prevent fluid impulses from entering said cylinder, and a starting means normally urging said operating member to a second position to permit fluid impulses to enter said cylinder.

7. A hydraulic actuator according to claim 6 wherein said restoring means includes means for decelerating said operating member after the same is displaced by fluid impulses.

8. A hydraulic actuator according to claim 7 further comprising: means for decelerating said operating member as the same is being restored by said restoring means.

9. A hydraulic actuator according to claim 8 wherein said magnet limits the movement of said operating member as the same is being moved by said restoring means.

10. In a punching machine, a slidably disposed punch element movable from a starting position to a punching position and therefrom to a restored position; actuating means for moving said punch element from said starting position to said punching position and back to said restored position, said actuating means being prevented from acting upon said punch element with the same in said restored position; control means selectively operable to hold said punch element in said restored position, whereby said actuating means is prevented from moving said punch element; and starting means operable under control of said control means for moving said punch element from said restored position to said starting position.

11. In a punching machine, a slidably disposed member carrying an armature element on one end and a punch element at the other end thereof with an arm fixed to project outwardly therefrom intermediate the ends thereof; a first bored housing, including a first slidable operating member, having one end normally abutting one side of said arm and the other end adapted to engage one end of a first decelerating member having its other end in engagement with a starting member, a starting biasing means for urging said starting member to move said first decelerating member and, in turn, the first operating member, and a separating biasing means normally urging said first decelerating member away from said starting member, said starting biasing means having a force overcoming said separating biasing means; a second bored housing, including a second slidable operating member, having one end normally abutting the other side of said arm and the other end thereof adapted to engage one end of a second decelerating member, and means for biasing said second decelerating member into engagement with said other end of the second operating member; means for cyclically applying fluid impulses alternately to said first and second housings so as to displace the operating members disposed therein if the same are in position to be acted upon at the time said fluid impulses are applied; and a magnet selectively energized to hold said armature against movement when the same has been positioned in proximity of said magnet, whereby said arm is holding said first operating member of said first bored housing in position to prevent the fluid impulses applied thereto from acting upon said first operating member disposed therewithin.

12. In a punching machine, a bored housing including a slidable operating member disposed therein adapted to be displaced so as to project from said housing by fluid impulses applied to said housing, said operating member being positionable to a latched position to prevent said fluid impulses from acting thereupon; a work member slidably disposed relative to said bored housing and carrying an armature element at one end and a punch element at the other end thereof with an arm fixed to project outwardly therefrom intermediate the ends thereof, said arm normally abutting said operating member; restoring means cyclically operable to move said arm so as to carry said operating member to said latched position; starting means for urging said operating member from said latched position to a position whereby said fluid impulses can act to displace said operating member so as to displace said work member; and magnetic means selectively operable to hold said armature against movement when the same is positioned in proximity of said magnet by said restoring means.

13. In a punching machine according to claim 12, wherein said restoring means includes decelerating means for decelerating said work member as the same is displaced by said operating member.

14. In a punching machine according to claim 13, further comprising: means for decelerating said operating member as the same is moved to the latched position by said restoring means.

15. Hydraulically operated apparatus comprising: a bored housing including a slidable operating member adapted to be displaced so as to project from said housing by fluid impulses applied to said housing, said operating member being positionable to a latched position to prevent said fluid impulses from acting thereupon; means cyclically operable to move said operating member to the latched position; starting means for urging said operating member from said latched position to a position whereby said fluid impulses can act to displace said operating member so as to project from said housing; and magnetic means selectively operable for overcoming said starting means to prevent said operating member from being moved to said position whereby said fluid impulses can act to displace said operating member.

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