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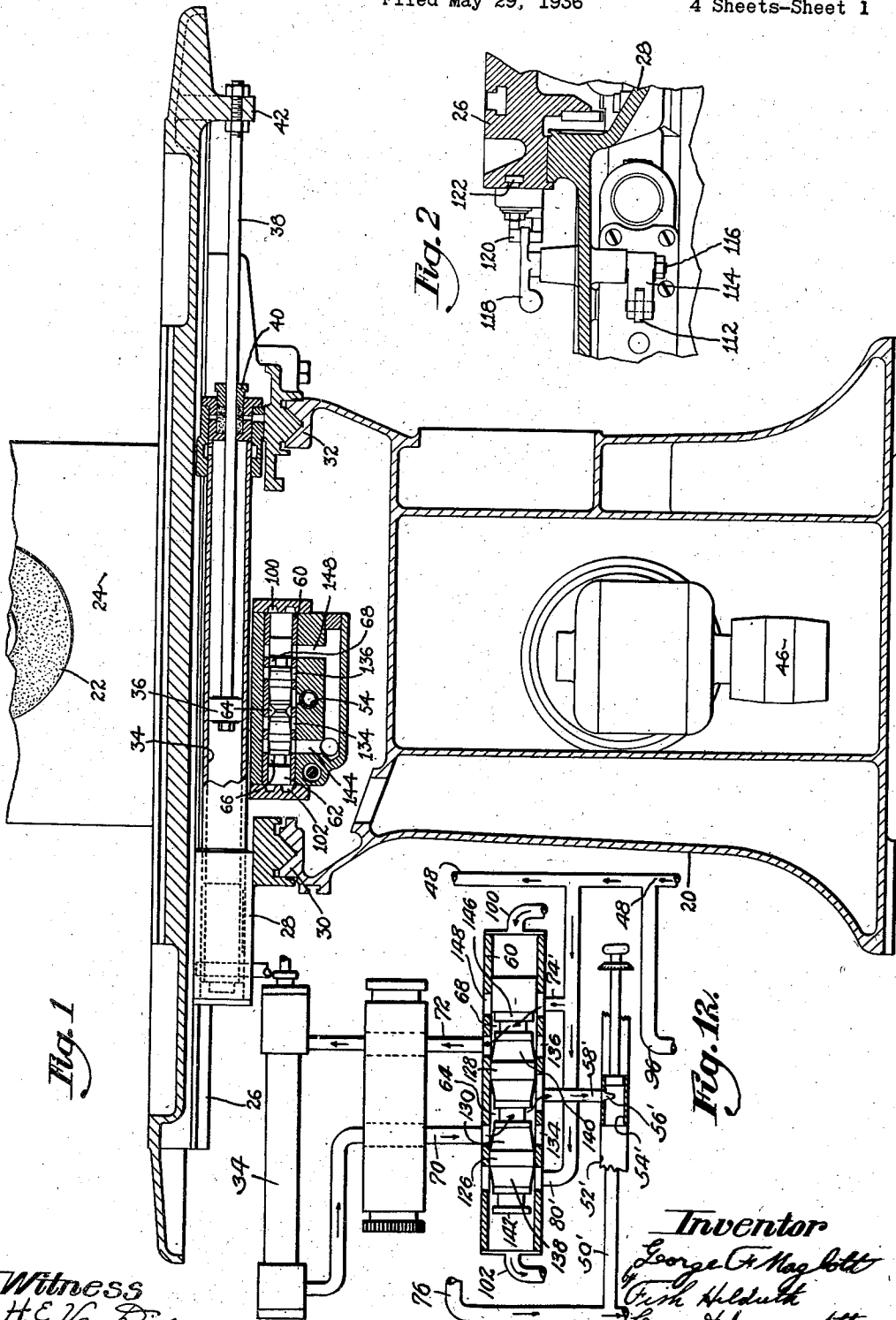
G. F. MAGLOTT

2,172,981

FLUID PRESSURE DRIVING AND REVERSING MECHANISMS

Filed May 29, 1936

4 Sheets-Sheet 1



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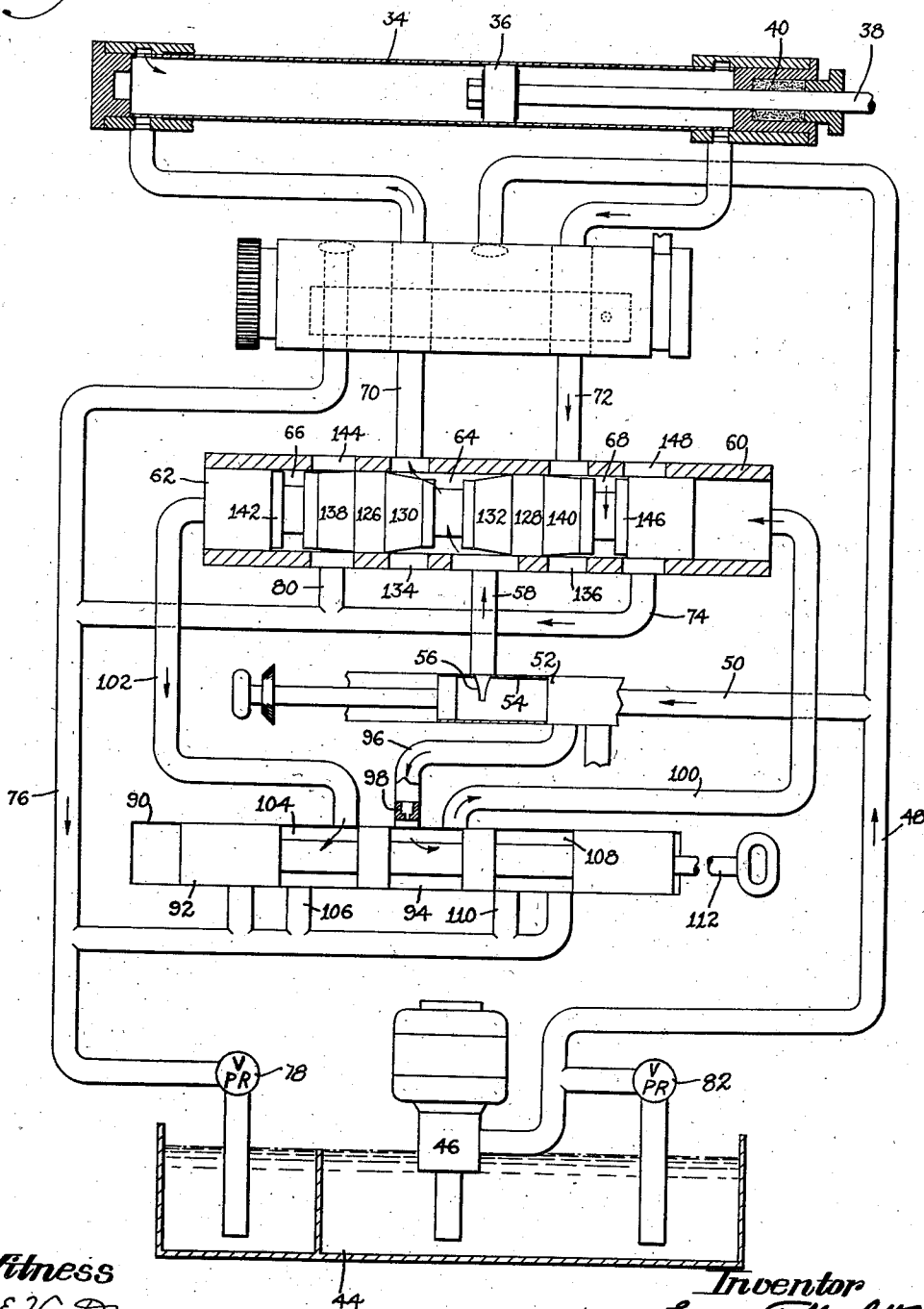
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FLUID PRESSURE DRIVING AND REVERSING MECHANISMS

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4 Sheets-Sheet 2

Fig. 3



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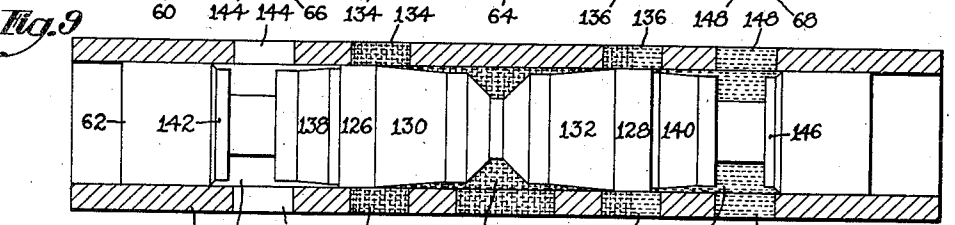
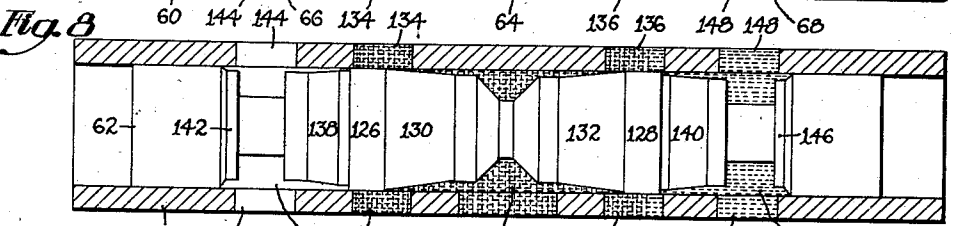
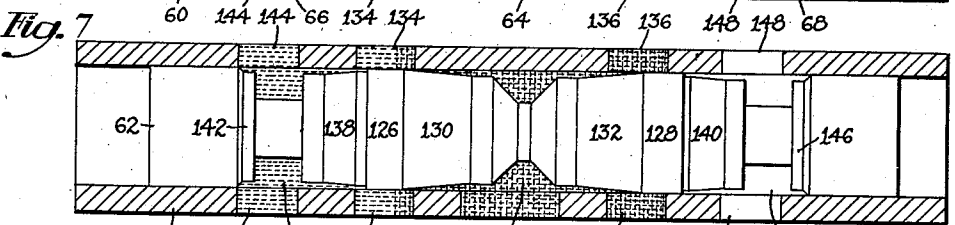
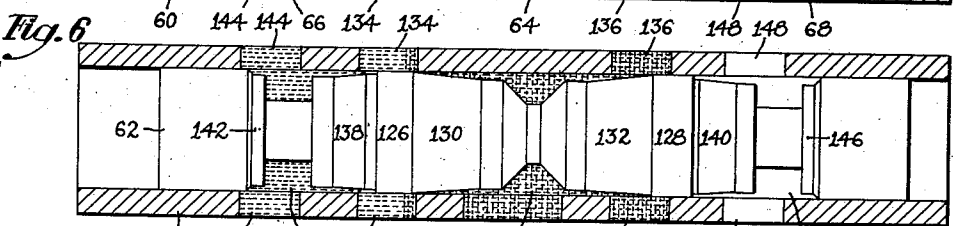
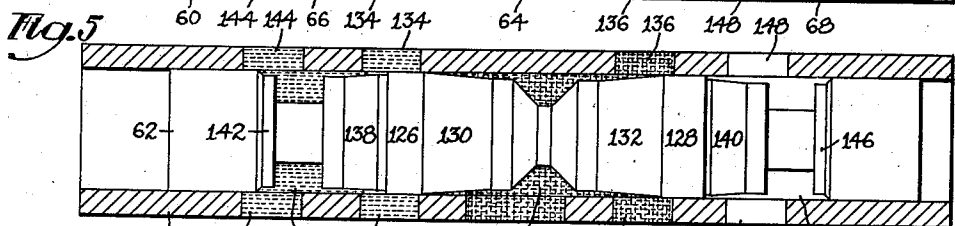
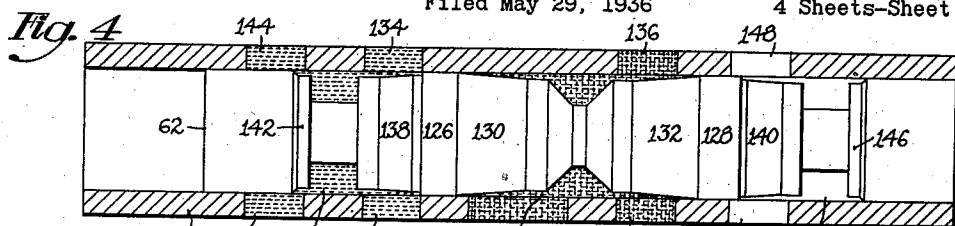
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4 Sheets-Sheet 3



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FLUID PRESSURE DRIVING AND REVERSING MECHANISMS

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4 Sheets-Sheet 4

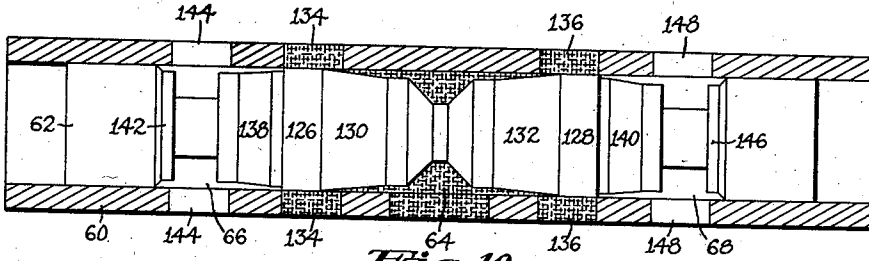
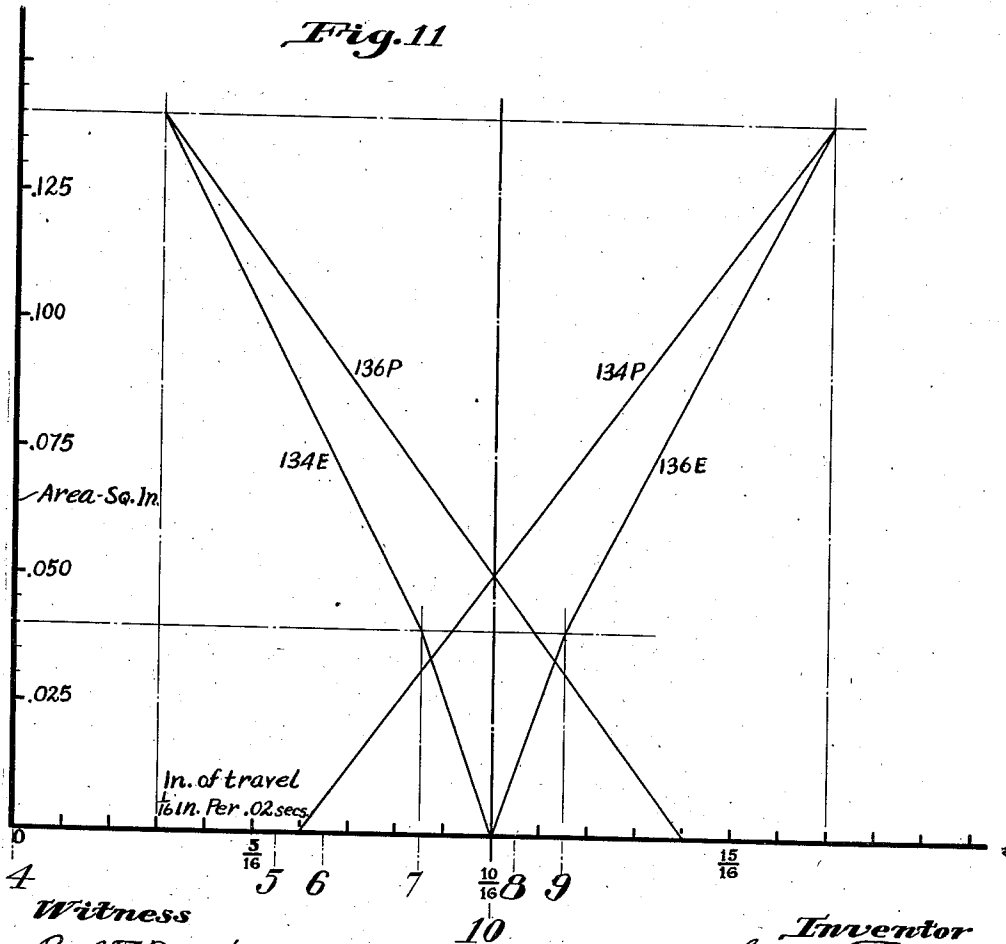


Fig. 10



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UNITED STATES PATENT OFFICE

2,172,981

FLUID PRESSURE DRIVING AND REVERS-
ING MECHANISM

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Application May 29, 1936, Serial No. 82,533

9 Claims. (Cl. 121-45)

The present invention relates to improvements in fluid pressure driving and reversing mechanisms for a reciprocable machine element, and more particularly to a driving and reversing valve mechanism which is well adapted for use in a grinding machine having a grinding wheel support and a work support, to secure a rapid and smoothly reversing reciprocatory movement of one of said supports relatively to the other.

10 The invention is herein disclosed as embodied in a preferred form in a hydraulically operated surface grinding machine comprising with a base, a vertically adjustable grinding wheel support, a longitudinally reciprocable work supporting table, 15 and a cross slide or saddle on which the table is supported for lateral positioning movements.

It is a principal object of the invention to provide a novel and improved reversing valve mechanism for controlling the supply and exhaustion of 20 liquid under pressure to opposite ends of a cylinder and cooperating piston operatively connected to reciprocate the table, which is well adapted to secure a rapid and uniform deceleration of the table and subsequent acceleration again to driving speed upon reversal with a minimum loss of time in the active operation of the machine, and without shock or jar.

It is more specifically an object of the invention to provide a valve mechanism of the general description which is well adapted for a sensitive and accurate control of the liquid pressure in each end of the table cylinder during the reversal of the table to secure an approximately uniform net retarding pressure and thus a 35 gradually decreasing differential or net operating pressure in the cylinder, and thereafter a decrease in the net retarding pressure as the table is slowed from driving to zero speed; to produce a deceleration curve of maximum smoothness and efficiency.

It is another object of the invention to provide a valve mechanism of this general description which will operate as the table stops to produce a graded increase in the differential operating 45 pressure such as to effect an approximately uniform net accelerating pressure on the piston which is substantially maintained until the table is brought up to speed in the opposite direction and is thereafter sharply reduced, to secure a similarly efficient acceleration curve of table 50 movement without shock or jar to the machine.

With these and other objects in view as may hereinafter appear, one feature of the invention consists in the provision of a reversing valve 55 mechanism as above set forth, which is arranged

to admit regulated amounts of liquid under pressure from the supply simultaneously to both ends of the table cylinder in order to secure a sensitive control of the net decelerating and accelerating pressures at each stage of the reversal and also in order to provide a yield in the operation of the reversing valve mechanism which will operate to cushion the table against excessive shock or jar.

Another feature of the invention consists in 10 the provision of operating connections in the reversing valve which are arranged to permit a throttled re-circulation of the liquid through the supply ports of the reversing valve from one end of the cylinder to the other, and thereby to produce a controlled resistance to continued table 15 movement during deceleration.

Another feature of the invention consists in the construction and arrangement of the reversing valve which causes regulated decreasing 20 amounts of liquid to be admitted under driving pressure to the exhaust side of the cylinder and cooperating piston during the early stages of acceleration to driving speed, and thereby to secure a smooth and substantially uniform ac- 25 celeration of the table.

Another feature of the invention consists in the provision in the reversing mechanism described, of a throttle device which is rendered operative as the table reaches its desired driving 30 speed, to partially close the exhaust port from the cylinder, and thereby to prevent over-acceleration of the table.

The several features of the invention consist also in the devices, combinations and arrangement of parts, which together with the advantages obtained thereby will be readily understood by one skilled in the art from the following description taken in connection with the accompanying drawings, in which Fig. 1 is a sectional view in front elevation, of a surface grinding machine, only so much of the machine being shown as is believed necessary to illustrate the connection of the present invention therewith; Fig. 2 is a detail sectional view in right side elevation, 45 of a portion of the machine illustrating particularly the dog actuated mechanism for operating the reversing valve; Fig. 3 is a diagrammatic view illustrating particularly the hydraulic driving connections for the work supporting 50 table; Figs. 4 to 9 inclusive, are a series of sectional views illustrating successive steps in the operation of the reversing valve to reverse the direction of table movement; Fig. 10 is a view similar to Figs. 4 to 9 inclusive, illustrating the 55

valve in dead center position during reversal; Fig. 11 is a chart in which the areas of valve openings from each end of the table driving cylinder both to pressure and exhaust are plotted for each step in the movement of the reversing valve from one operating position to the other; and Fig. 12 is a diagrammatic view illustrating an alternative arrangement of the hydraulic connections shown in Fig. 3, in which a smooth table reversal is effected by re-circulation of the exhaust fluid, the pressure and exhaust connections to the reversing valve having been reversed.

Referring specifically to the drawings, the base of the surface grinder illustrated is generally indicated at 20 in Fig. 1, a grinding wheel at 22, and a vertically adjustable supporting column for the grinding wheel at 24. The machine is also provided with a longitudinally reciprocable work table 26 slidably supported on a saddle or cross slide member 28 which is in turn carried on cross ways 30 and 32 on the base 20.

Reciprocatory movements are imparted to the table by means of hydraulically operated connections which include a cylinder 34 secured to the saddle member 28 and a cooperating piston 36 which is connected to move with the table by means of a piston rod 38 extending through a packing box 40 in one end of the cylinder, and connected at one end to the piston 36 and at its other end to a downwardly extending lug 42 formed at the right hand end of the table. The construction and mode of operation of the hydraulic system employed for reciprocating the table 26, will be readily understood in connection with the somewhat diagrammatic Fig. 3 of the drawings. The pressure medium, preferably oil, is drawn from a reservoir or sump 44 in the base of the machine by means of an oil pressure pump 46, and is carried through a pressure supply line 48 and extension 50 thereof, to a table throttle valve 52 which comprises with the casing 52 a rotatable throttle valve member 54 having formed therein an irregular aperture 56 through which oil under pressure is admitted to a pipe connection 58 and the reversing valve 60. The table reversing valve comprises with the cylindrical casing 60 therefor, an axially shiftable valve member 62 having portions thereof cut away, as hereinafter more fully set forth, to form a central oil pressure supply chamber 64 and two exhaust chambers 66 and 68 upon opposite sides thereof. Two pipe connections 70 and 72 connect the reversing valve respectively with the two ends of the table cylinder 34. With the reversing valve in its running position to the extreme left as shown in Fig. 3, oil under pressure is admitted from the table throttle valve through the chamber 64 and pipe connection 70 to the left hand end of the table cylinder 34, while at the same time oil is exhausted from the right hand end of the cylinder through the pipe connection 72, the chamber 68 in the reversing valve, and an exhaust connection 74 from which the exhausted liquid passes through the exhaust line 76 of the system through a low pressure check valve 78 to the sump 44 in the base. Similarly, when the table reversing valve member 62 is moved to its running position to the extreme right, oil under pressure passes from the table throttle valve 52 through the pressure supply chamber 64 in the reversing valve and pipe connection 72 to the right hand end of the table cylinder 34, oil being exhausted at the same time from the left hand end of the cylinder 34 through

the pipe connection 70, the chamber 66 in the reversing valve 60, and an exhaust connection 80 therefrom to the exhaust line 76 and reservoir 44.

In order to maintain a substantially constant available driving pressure in the system, there is provided in the supply line 48 adjacent the pump 46, a high pressure relief valve 82. For purposes of illustration it may be assumed that the relief valve 82 is set to maintain a driving pressure of substantially 100 lbs. per square inch in the system, and that the relief valve 78 in the exhaust line is adjusted to maintain an exhaust back pressure of about 4 lbs. per square inch.

In the preferred embodiment of the invention disclosed, the movable valve member 62 of the reversing valve 60 is shifted from one to the other of its alternative operating positions through the operation of hydraulically operating means which operates to produce a positive and uniform rate of travel of the valve member 62 from one operating position to the other. The connections through which the position of the reversing valve member 62 is controlled, comprise a pilot valve 90 in the form of a cylinder having mounted therein an axially movable valve member 92. Liquid under pressure is admitted to a pressure chamber 94 formed by a central spool portion of the pilot valve member 92 by way of a throttle 98 and connections 96 from the supply line 48, and passes through a pipe connection 100 to the right hand end of the reversing valve 60, or alternatively through a pipe connection 102 to the left hand end of the reversing valve 60. With the pilot valve member 92 in the position shown in Fig. 3, liquid under pressure has been admitted through the chamber 94 and connection 100 to the right hand end of the reversing valve 60, so that the reversing valve member 62 is moved to its extreme position to the left at a rate which is determined by the size of the throttle 98. Liquid has simultaneously been exhausted from the left hand end of the reversing valve 60 through the pipe connection 102 and an exhaust chamber 104 in the pilot valve member 92, and thence through an exhaust connection 106 to the main exhaust line 76. Conversely, when the pilot valve 92 is moved to the left, the connection 102 to the left hand end of the reversing valve 60 is connected with the pressure chamber 94 and throttle opening 98, and the pipe connection 100 to the right hand end of the cylinder is connected through an exhaust chamber 108 in the pilot valve member 92 and exhaust connection 110 to the main exhaust line 76, so that the reversing valve member 62 is moved in a reverse direction to the right again at a constant rate of speed which is determined by the throttle opening 98.

The position of the pilot valve member 92 is conveniently controlled either manually or by the operation of table dogs through connections (see Figs. 2 and 3) comprising a valve stem 112 secured to one end of the pilot valve member 92 and having a pin and slot connection with a lever arm 114 secured to the lower end of a vertically extending post 116 supported on the saddle member 28. To the upper end of the post 116 there is secured a control lever 118 which is formed to permit convenient manipulation by the operator, and is provided with a rearwardly extending projection arranged to extend into the path of actuating dogs 120 adjustably mounted

in a T-shaped slot 122 in the front side of the table 28.

In accordance with the present invention, applicant's reversing valve mechanism is constructed and arranged so that the movement of the reversing valve member 62 from one operating position to the other will operate to regulate the effective decelerating or braking pressures set up in the table cylinder 34 in accordance with the rate of deceleration and actual table speed at each successive instant during the slowing of the table from driving to zero speeds, and thereafter to secure a similarly regulated control of the net accelerating or driving pressure in the table cylinder during the acceleration of the table again from zero to driving speed in the opposite direction.

Applicant is aware that attempts have been made to secure a graduated deceleration in the speed of the moving support by diminishing in varying ratio the areas of the pressure and exhaust ports to the two ends of a driving cylinder and piston. The regulation of the decelerating pressures secured in this manner is comparatively in-elastic, and if not adjusted exactly to the rate of movement of the table at each moment during the deceleration thereof, will operate to cause objectionable bumps or shocks due to the too rapid building up of the decelerating pressure at some stage in the slowing and stopping of the relatively heavy driven support.

In accordance with a principal feature of the present invention, the reversing valve member 62 is constructed and arranged with relation to the supply and exhaust connections 70 and 72 to each end of the table cylinder 74, to admit increasing amounts of liquid under pressure from the supply line 48 and throttle valve 52 to the exhausting end of the cylinder 34 while the connection therefrom to the exhaust line 76 is gradually shut off, so that the stopping of the table is effected against an always yielding pressure, the maximum value of which is determined after the supply connection to the exhausting end of the cylinder starts to open by the areas of the throttled port openings and by the resisting pressure in the supply line 48 as determined by the setting of the relief valve 32, and is therefore to a considerable extent independent of the rate of movement of the table at any given instant during the deceleration, and the corresponding areas of the supply and exhaust ports to the table cylinder 34 at that instant. As the reversing valve approaches its central position, and both exhaust connections are closed, the pressure from the supply line 48 acting against both ends of the cylinder is gradually equalized, and a relatively free circulation of liquid is permitted from one end of the cylinder to the other, thus wholly eliminating the possibility of unevenness or shock in table reversal. In utilizing this principle of operation of the reversing valve in which deceleration and the subsequent acceleration of the table in opposite directions are controlled by the simultaneous admission of varying amounts of liquid under pressure to both ends of the table cylinder 34, it has been found possible to secure a graduated control of the net braking pressures in the table cylinder 34, in which the braking pressure is maintained at a high level as the table speed is cut down, and thereafter again decreases as the table approaches zero speed to produce a deceleration curve of maximum efficiency.

In order to secure a maximum application of

braking pressure during the middle portion of the decelerating period, gradually increasing amounts of fluid pressure medium are admitted to the exhausting side of the cylinder at the same time that the exhaust line is gradually shut off, thus producing a rapid but controlled increase in the gross retarding pressure. As shown in Fig. 7, additional liquid forced out of the exhausting side of the cylinder 34 by the pressure set up by the momentum of the table is now re-circulated to the feeding end of the cylinder through the supply chamber 64 against the supply pressure and against an additional resistance provided by the throttling of the ports from the reversing valve chamber 64 to the pipe connections 70 and 72. As the table deceleration approaches zero speed, the continued movement of the valve member 62 will have completely shut off the exhaust connection from the port 134 to the exhaust port 144 as shown in Fig. 10. At the same time, however, the port opening from the pressure chamber 64 to the port 136 is increased, allowing a comparatively free re-circulation of the exhaust fluid, caused by the pressure of table momentum, through the port 134, pressure chamber 64 and port 136 to the other side of the driving cylinder 34 and piston 36, so that the gross decelerating pressure is reduced at the exact moment when this is most desirable, that is to say, when the table approaches zero speed.

A continued movement of the valve member 62 past center position further increases the pressure valve opening through port 134, and at the same time further reduces the pressure valve opening through port 136, again restricting the re-circulation between the two ends of the driving cylinder and building up a relatively greater pressure through the port 134 to the left hand end of the driving cylinder. With this arrangement of the reversing valve, it will readily be seen that the actual stopping of the table takes place against a yielding cushion provided by the supply pressure which has a known value determined by the setting of the pressure relief valve 32. Inasmuch as liquid under pressure is still being supplied to the pressure side of the table cylinder 34, the net braking pressure at the point of actual reversal may be maintained at the constant theoretical value or is preferably even reduced to insure the gradual stopping of the table without shock or jar.

Further in accordance with the present invention, the reversing valve mechanism is arranged to produce a smooth and substantially uniform acceleration of the table from zero to driving speed in the opposite direction. To this end the supply of liquid under pressure to the now exhausting side of the table cylinder 34, is not completely shut off until after the table has begun to move in a reverse direction. The corresponding exhaust valve opens causing the gross accelerating pressure to be set at a maximum value, thus maintaining a net accelerating pressure as nearly constant as possible until the table is brought up to speed, being then sharply reduced, to produce a similarly efficient acceleration curve of table movement to exactly the desired driving speed in the opposite direction.

The construction and mode of operation of applicant's improved reversing valve for the attainment of the above-stated objects, will be readily understood from Fig. 3, and the somewhat diagrammatic views Figs. 4 to 10 inclusive. As shown in these figures, the barrel portions

126 and 128 of the valve member 62 adjacent the pressure supply chamber 64, are tapered as indicated respectively at 130 and 132 to permit a gradual throttling or opening of the cooperating ports 134 and 136 in the valve casing 68 connected respectively to the pipe lines 70 and 72. In order to permit throttling the flow of the exhausted liquid from the table cylinder 34 through the pipe connection 70 and port 134 to the exhaust chamber 66, or alternatively through the pipe connection 72 and port 136 to the exhaust chamber 68, a taper 138 is formed in the barrel portion 126 of the valve member 62 adjacent the exhaust chamber 66, and a similar taper 140 is provided in the end of the barrel portion 128 adjacent the exhaust chamber 68. There is also provided at the outer or left hand end of the exhaust chamber 66, a land 142 which is arranged as the reversing valve member 62 reaches its extreme operating position to the right, and as the table is brought up to full driving speed, to partially shut off the flow of exhaust fluid from the chamber 66 through the exhaust port 144 in the valve casing to the exhaust line 76. Similarly, there is provided at the outer or right hand end of the exhaust chamber 68, a land 146 which is arranged as the reversing valve member 62 reaches its extreme operating position to the left illustrated in Fig. 3, to partially shut off the flow of liquid from the exhaust chamber 68 through the cooperating exhaust port 148.

The operation of the reversing valve to reverse the direction of travel of the table, will be readily understood from the somewhat diagrammatic views Figs. 4 to 10 inclusive, taken in connection with Fig. 11, which illustrates in chart form the variations in the effective port areas through which liquid is admitted under pressure from the pressure chamber 64 to each end of the cylinder 34 through the ports 134 and 136, and similarly the effective areas of the openings through which liquid is exhausted from each end of the cylinder 34 through ports 134 and 136 to the exhaust chambers 66 and 68 during the movement of the reversing valve member 62 from one operating position to the other. For purposes of illustration it may be assumed that the valve member 62 moves at a uniform rate through a total distance of 20/16 of an inch to effect the reversal of the table.

This distance is represented by the horizontal divisions of the chart. The vertical divisions represent area of valve opening. Lines 134P and 136P represent the variations in the areas of the valve openings to the ports 134 and 136 through which liquid under pressure is admitted to each end of the cylinder 34 at different stages in the movement of the reversing valve member 62 from one to the other of its alternate driving positions. Similarly, the lines 134E and 136E represent the variations in area of the exhaust valve openings from ports 134 and 136 through which liquid is exhausted from each end of the cylinder 34 to the exhaust chambers 66 and 68 of the reversing valve during the movement of the reversing valve member 62 from one position to the other.

Fig. 4 of the drawings illustrates the valve in its position to the extreme right, or opposite to that shown in Fig. 3, in which liquid under pressure is being supplied freely to the right hand end of the table cylinder 34 through the port 136 and supply line 72, and liquid is being exhausted from the left hand end of the cylinder 34 through the pipe connection 70 and port 134 to the exhaust chamber 66 from which it passes through

the exhaust port 144 and connection 80 to the exhaust line 76. This position corresponds to that indicated at 4 in Fig. 11. Assuming that the table pilot valve 90 is now rendered operative to move the reversing valve member 62 to the left to reverse the direction of movement of the table, it will be seen from an inspection of the chart in Fig. 11, that the valve will move slightly more than $\frac{1}{4}$ of an inch before any appreciable retard of the table begins. Fig. 5 of the drawings shows this condition, in which the area of the port opening 136P from the pressure chamber 64 has been slightly reduced, a somewhat greater reduction having taken place in the port opening 134E to the exhaust chamber 66, thus producing a relatively small retarding force, and slightly reducing the rate of movement of the table. When the valve 62 has been moved to the station illustrated by Fig. 6, it will be seen that liquid has begun to flow from the pressure chamber 64 through the port 134, thus admitting a small amount of liquid under pressure to the exhausting end of the cylinder 34. The area of the passageway 136P from the pressure chamber 64 to the port 136 has been still further decreased, and a still further reduction has taken place in the area of the exhaust opening from the port 134 to the exhaust chamber 66. These changes in the valve openings have had the effect of considerably increasing the retarding pressures in the table cylinder 34, and thus increasing the rate of deceleration of the table. Continued movement of the valve member 62 to the position shown in Fig. 7, and as illustrated by the chart Fig. 11, causes the area of the valve opening 136P from the pressure chamber 64 through the port 136 to be still further reduced, the exhaust opening 134E to the exhaust chamber 66 through the port 134 to be reduced even more drastically somewhat less than one-third of its original size, while at the same time the area of the opening 134P from the pressure chamber 64 through the port 134 to the left hand end of the table cylinder 34 has been increased, so that the retarding effect is now to a considerable extent due to the resistance set up by the reduction in the driving pressure due to the admission of liquid under pressure to the exhausting or left hand side of the table cylinder 34 through the port 134P. The area 134E is, however, still considerably greater than the area 134P, so that most of the return liquid goes to exhaust.

During the time when the valve member 62 passes through positions illustrated by Figs. 10 and 8 respectively, a new stage in the operation of retarding the table movement is introduced, the exhaust connection 134E has closed off entirely, and the pressure throttle connections 136P and 134P to the pressure chamber 64 of the reversing valve are nearly equal. Also, as the reversing valve member 62 passes the exact center position shown in Fig. 10, the exhaust connection designated as 136E starts to open. At this time practically all the liquid flowing to and from the table cylinder 34 is being re-circulated through the central portion of the reversing valve comprising the pressure chamber 64 and the throttle pressure ports 134P and 136P. The retarding effect at this time is produced principally by the resistance to the passage of the liquid from one end of the table cylinder to the other through the throttle ports 134P and 136P. The table has now slowed to nearly zero speed, and the net retarding pressure has at the same

time dropped, thus preventing any possibility of shock or jar as the table reaches stop position.

At some point in the position of the valve between that illustrated in Fig. 8 and the next position illustrated in Fig. 9, the table will have reversed. By this time the throttle opening designated as 134P has opened to a considerable extent, and the opening to the exhaust from the right hand side of the cylinder represented as 136E has increased. It will be noted that the next accelerating pressure provided by the opening of the pressure port 134P and exhaust port 136E is controlled by the still open throttle at 136P which operates to prevent any sudden urge in the building up of the accelerating pressure, with a consequent shock or jar to the machine. As the pressure port 136P is completely shut off and the pressure port 134P and exhaust port 136E continue to open, the accelerating pressure of the table is maintained at a maximum until the full speed operation of the table is attained. In order to avoid over-acceleration as the table reaches its full operating speed to the right and after port 134P has reached its full opening, the land 146 operates to partially close or throttle the exhaust port 148 from the exhaust chamber 68, thus introducing a secondary resistance in the exhaust side of the cylinder 34 and bringing to an abrupt stop further acceleration of the table which now continues to move at a uniform rate of speed under the full control of the main throttle 52 of the machine.

While the valve mechanism constructed and arranged to operate as above set forth, constitutes a preferred embodiment of the invention, it will be understood that certain features of the invention are applicable more broadly to other types and constructions of reversing valve mechanisms within the scope and spirit of the appended claims. The value of the connections illustrated for producing the re-circulation of the pressure medium between the two ends of the driving cylinder and ram, is not limited to the specific embodiment illustrated, since a similarly effective control in the stopping and reversing of the table can be obtained by a throttled re-circulation of the exhaust fluid which is independent of the pressure line connections. Such a construction, for example, might comprise an arrangement in which the pipe line 58 is connected to exhaust and the lines 74 and 80 to pressure, so that the effect is produced by the re-circulation of the exhaust rather than the pressure fluid. This arrangement is specifically illustrated in Fig. 12 of the drawings, in which the conduits 74' and 80' are connected to the pressure supply line 48, so that fluid under pressure is supplied to each of the valve ports 142 and 144, and the pipe connection 58' to the central portion of the reversing valve 60, together with the throttle valve 54' and conduit 50' are connected directly with the exhaust line 76. The mechanical construction shown in this figure, is otherwise identical with that shown in Fig. 3. With the modified construction shown in Fig. 12, a re-circulation of the exhausting fluid under pressure caused by the table momentum, is allowed to take place through the chamber 64 between the two ends of the cylinder 34 for a restricted central portion of movement of the reversing valve member, the tapered portions 130 and 132 providing a throttled passageway of increasing and thereafter decreasing area for the controlled re-circulation of the fluid medium.

The operation of the reversing valve having the modified connections shown in Fig. 12, may be briefly set forth in connection with Figs. 4 to 8 inclusive, showing successive positions of the valve member. Referring to Figures 4, 5 and 6, it will be seen that successive throttling of the pressure liquid occurs at port 134, co-acting with tapered portion 138, and that it occurs earlier than in the former case where pressure was in chamber 64; but without the application of pressure on the reverse port 136. Figures 6 and 7 show the rapid reduction of pressure in 134 by by-passing it into chamber 66. Somewhere between positions shown in Figures 7 and 8, re-circulation from the two ends of the cylinders takes place via the heavily throttled ports 134E and 136E, with practically no driving force in throttled port 134P. Up to this point, it will be noticed that retard is accomplished more by reducing the driving force than by increasing the force on the reverse side of the piston (via port 136E); the net or differential pressure effect being much the same as formerly.

In Fig. 8, however, pressure is actively brought to bear on port 136, thus increasing the retarding force. Note that ports 136 and 134 are still by-passed and re-circulating, with only exhaust pressure on port 134, giving something less than this value on the driving face of the piston, by virtue of the resistance at port 134.

At, or slightly after the position shown in Fig. 9, reversal takes place, with pressure building up markedly in port 136, and only exhaust through port 134. Reversal will occur slightly later than in the former case, the action being quite shockless or soft; acceleration, correspondingly, will be more rapid. The result, however, is quite an acceptable reversal, accomplished without undue waste of time.

The invention having been described, what is claimed is:

1. In a fluid pressure actuated driving and reversing mechanism for a reciprocable support, the combination with a cylinder and piston operatively connected to drive the support, and a source from which a fluid medium is supplied at a predetermined pressure, of a reversing valve having a port connected to each end of the cylinder and having a valve member movable between alternative operative positions for controlling admission and exhaust of the pressure medium to and from each end of the cylinder through said ports, said valve member having fluid exhaust chambers including throttle connections cooperating with said ports during movement of the valve member from one operating position to the other to gradually shut off the exhaust connection to one of said ports and thereafter to gradually open the exhaust connection to the other of said ports, and a fluid pressure supply chamber in said valve member including throttle connections to each of said ports arranged during movement of the valve member from one operating position to the other gradually to close one throttle opening, and at the same time to gradually open the other throttle opening and thereby to permit a controlled re-circulation of fluid through said supply chamber from one end of the cylinder to the other.

2. In a fluid pressure actuated driving and reversing mechanism for a reciprocable support, the combination with a cylinder and piston operatively connected to drive the support, and a source from which a fluid medium is supplied at

a predetermined pressure, of a reversing valve having a port connected to each end of the cylinder and having a valve member movable between alternative operative positions for controlling admission and exhaust of the pressure medium to and from each end of the cylinder through said ports, said valve member having fluid exhaust chambers including throttle connections cooperating with said ports during movement of the valve member from one operating position to the other to gradually shut off the exhaust connection to one of said ports and thereafter to gradually open the exhaust connection to the other of said ports, a fluid pressure supply chamber in said valve member including throttle connections to each of said ports arranged during movement of the valve member from one operating position to the other gradually to close one throttle opening, and at the same time to gradually open the other throttle opening and hereby to permit a controlled recirculation of fluid through said supply chamber from one end of the cylinder to the other, and means for moving said valve member from one to the other of said positions at a predetermined uniform rate.

3. In a fluid pressure driving and reversing mechanism for a reciprocable support, the combination with a cylinder and piston operatively connected to drive the support, and a source from which a fluid pressure medium is supplied under pressure, of a valve device including a movable valve member for controlling admission and exhaust of the fluid pressure medium to and from the ends of the cylinder, said valve device having throttle connections operable upon movement of the valve member from one operating position to the other to gradually reduce the exhaust of pressure medium from one end of the cylinder to substantially zero for an intermediate position of said valve member, and thereafter gradually to open the other end of said cylinder to exhaust, and additional throttle connections operative during the movement of said valve member from one operative position to the other to gradually shut off the flow of fluid pressure medium to the latter end of the cylinder, and while fluid pressure medium is still being supplied to said latter end of the cylinder, to admit slowly increasing amounts of said pressure medium to the first-mentioned end of said cylinder, a connection between said latter throttle connections to permit a controlled re-circulation of the fluid pressure medium as the valve member passes through its intermediate position, and means for moving said valve member from one to the other of said positions at a predetermined uniform rate, the variations in area of said throttle connections being related to the distance travelled by said valve member to maintain a substantially uniform net retarding pressure to slow the support, then to effect a rapid reduction of the net retarding pressure as the support approaches zero speed so that reversal takes place after the valve member passes middle position, and thereafter to maintain a substantially uniform net accelerating pressure to accelerate the support.

4. In a fluid pressure actuated driving and reversing mechanism for a reciprocable support, the combination with a cylinder and piston operatively connected to drive the support, and a source from which a fluid pressure medium is supplied at a predetermined pressure, of a valve device including a movable valve member for controlling admission and exhaust of the fluid pres-

sure medium to and from the ends of the cylinder, said valve device having means operable during movement of the valve member from one operating position to the other to gradually shut off the exhaust from one end of the cylinder and thereafter to gradually open the exhaust to the other end of the cylinder, and additional means operative during the movement of said member from one operating position to the other to gradually shut off the flow of fluid pressure medium to the latter end of the cylinder and at the same time to admit gradually increasing amounts of fluid pressure medium from the source to the first-mentioned end of the cylinder, and means rendered operative as the support is brought up to speed, in an opposite direction, to again partially close the exhaust from said latter end of the cylinder.

5. In a fluid pressure actuated driving and reversing mechanism for a reciprocable support, the combination with a cylinder and piston operatively connected to drive the support, and a source from which a fluid pressure medium is supplied at a predetermined pressure, of a valve device including a movable valve member for controlling admission and exhaust of the fluid pressure medium to and from the ends of the cylinder, said valve device having means operable during movement of the valve member from one operating position to the other to gradually shut off the exhaust from one end of the cylinder and thereafter to gradually open the exhaust to the other end of the cylinder, and additional means operative during the movement of said member from one operating position to the other to gradually shut off the flow of fluid pressure medium to the latter end of the cylinder and at the same time to admit gradually increasing amounts of fluid pressure medium from the source to the first-mentioned end of the cylinder, means rendered operative as the support is brought up to speed, in an opposite direction, to again partially close the exhaust from said latter end of the cylinder, and means for moving said valve member from one to the other of said positions at a predetermined uniform rate.

6. In a fluid pressure driving and reversing mechanism including a cooperating driving cylinder and piston through which a fluid medium under pressure is supplied for reciprocating a support, a reversing valve comprising a body having an inner cylindrical surface, a fluid pressure supply port and spaced at each side thereof, outlet ports connecting respectively with opposite ends of the driving cylinder, and beyond these, additional ports through which the respective ends of the driving cylinder are connected to exhaust, and a valve member movable between alternative limiting positions within said body having a central reduced or spool portion to provide a pressure supply chamber connecting with said supply port, and at each side of said supply chamber additional spool portions to provide exhaust chambers for connecting each end of said driving cylinder to exhaust, and barrel portions interposed between the supply and exhaust chambers tapered toward the supply chamber to provide throttle connections respectively with the outlet ports shaped to provide an outlet for the fluid pressure medium through each of said ports for an intermediate position of the valve member and to fully close off one or the other of said ports only upon movement of said valve member a substantial distance beyond said central position, said barrel portions further being tapered toward the ad-

5 jacent exhaust chambers to provide throttle connections respectively with said outlet ports shaped to fully shut off each of said connections to exhaust upon movement of said valve member to said central position.

10 7. In a fluid pressure driving and reversing mechanism including a cooperating driving cylinder and piston through which a fluid medium under pressure is supplied for reciprocating a support, a reversing valve comprising a body having an inner cylindrical surface, a fluid pressure supply port, and, spaced at each side thereof, outlet ports connecting respectively with opposite ends of the driving cylinder, and beyond these, additional ports through which the respective ends of the driving cylinder are connected to exhaust and a valve member movable between alternative limiting positions within said body having a central reduced or spool portion to provide 15 a pressure supply chamber connecting with said supply port, at each side of said supply chamber additional spool portions to provide exhaust chambers for connecting each end of said driving cylinder to exhaust, and barrel portions interposed between said chambers having the ends thereof tapered to provide throttle connections from each of said outlet ports respectively to the pressure supply chamber and the adjoining exhaust chamber, and additional barrel portions 20 at each end of the valve member having formed thereon lands arranged upon movement of the valve member in either direction to its limiting position to reduce the effective area of the corresponding open exhaust port.

5 8. A reversing valve for a fluid pressure driving and reversing mechanism including a cooperating driving cylinder and piston through which a fluid medium under pressure is supplied for reciprocating a support, comprising a body having an inner cylindrical surface, two outlet ports spaced lengthwise of said valve body and connecting respectively with opposite ends of said driving cylinder, a port intermediate said outlet ports connected to exhaust, and a pair of ports spaced beyond said outlet ports towards opposite ends of the valve body connected to supply, and a valve member movable between alternative limiting positions within said body having a central spool portion and at each side thereof additional spool portions separated by barrel portions tapered toward the central spool portion to provide a throttled inter-connection between said outlet ports and the intermediate port for a restricted central portion of movement of the valve member whereby a controlled re-circulation of the fluid medium from one end of the cylinder to the other is permitted under the pressure caused by support momentum, said barrel portions being

5 tapered also toward the other spool portions to provide a throttle connection respectively between said outlet ports and the adjacent port of said pair arranged with the valve body in a central portion to substantially shut off both of said pair of ports from the adjacent outlet ports, and means for moving said valve member from one to the other of said limiting positions at a predetermined uniform rate, the variations in area of the throttle connections provided by said tapered portions being related to the distance travelled by the valve member to maintain a substantially uniform net retarding pressure to slow the support, then to effect a rapid reduction of the net retarding pressure as the support approaches zero speed so that reversal takes place after the valve member passes middle position, and thereafter to maintain a substantially uniform net accelerating pressure to accelerate the support. 10 15

9. In a fluid pressure driving and reversing mechanism for a reciprocable support, the combination with a cylinder and piston operatively connected to drive the support and a source from which a pressure medium is supplied, of a valve device including a valve member movable between alternative operating positions for controlling admission and exhaust of the fluid pressure medium to and from each end of said cylinder, said valve device having throttle connections operable during movement of the valve member from one operating position to the other for gradually shutting off the pressure connection to one end of the cylinder and for opening the pressure connection to the other end of the cylinder, and similarly for shutting off, and for opening the exhaust connections to opposite ends of said cylinder, the variations in area of said throttle connections being related to the distance travelled by said valve member to maintain a substantially uniform net retarding pressure to slow the support, and thereafter a substantially uniform net accelerating pressure to accelerate the support, a connection between the throttle connections to opposite ends of the cylinder operable as the valve member approaches a central position, to provide a throttled connection of increasing area, and as the valve member leaves said central position, of decreasing area for the re-circulation of the fluid medium under pressure caused by the support momentum directly between the ends of the cylinder for effecting a rapid reduction of the net retarding pressure as the support approaches zero speed that reversal takes place after the valve member passes middle position, and means for moving said valve member from one to the other of said operating positions at a predetermined uniform rate. 20 25 30 35 40 45 50 55

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