

[54]	HYDRAULIC OPERATING MECHANISM FOR A ROTARY CHUCK	3,364,823	1/1968	Benjamin	91/420
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[22] Filed: Apr. 4, 1973

[21] Appl. No.: 347,922

[52]	U.S. Cl.	91/29; 91/31; 91/420; 137/110; 279/4
[51]	Int. Cl. ²	F15B 11/08; F15B 13/042; B23B 31/30
[58]	Field of Search	91/420, 29, 28, 31; 137/110; 279/4

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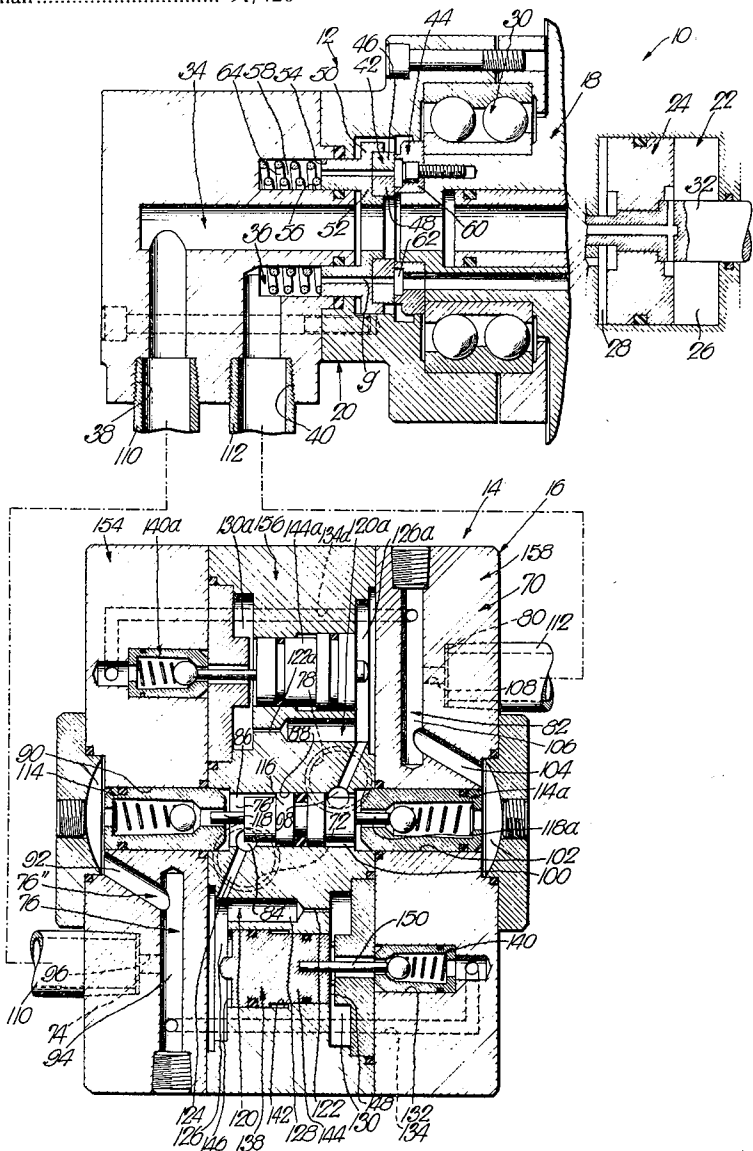
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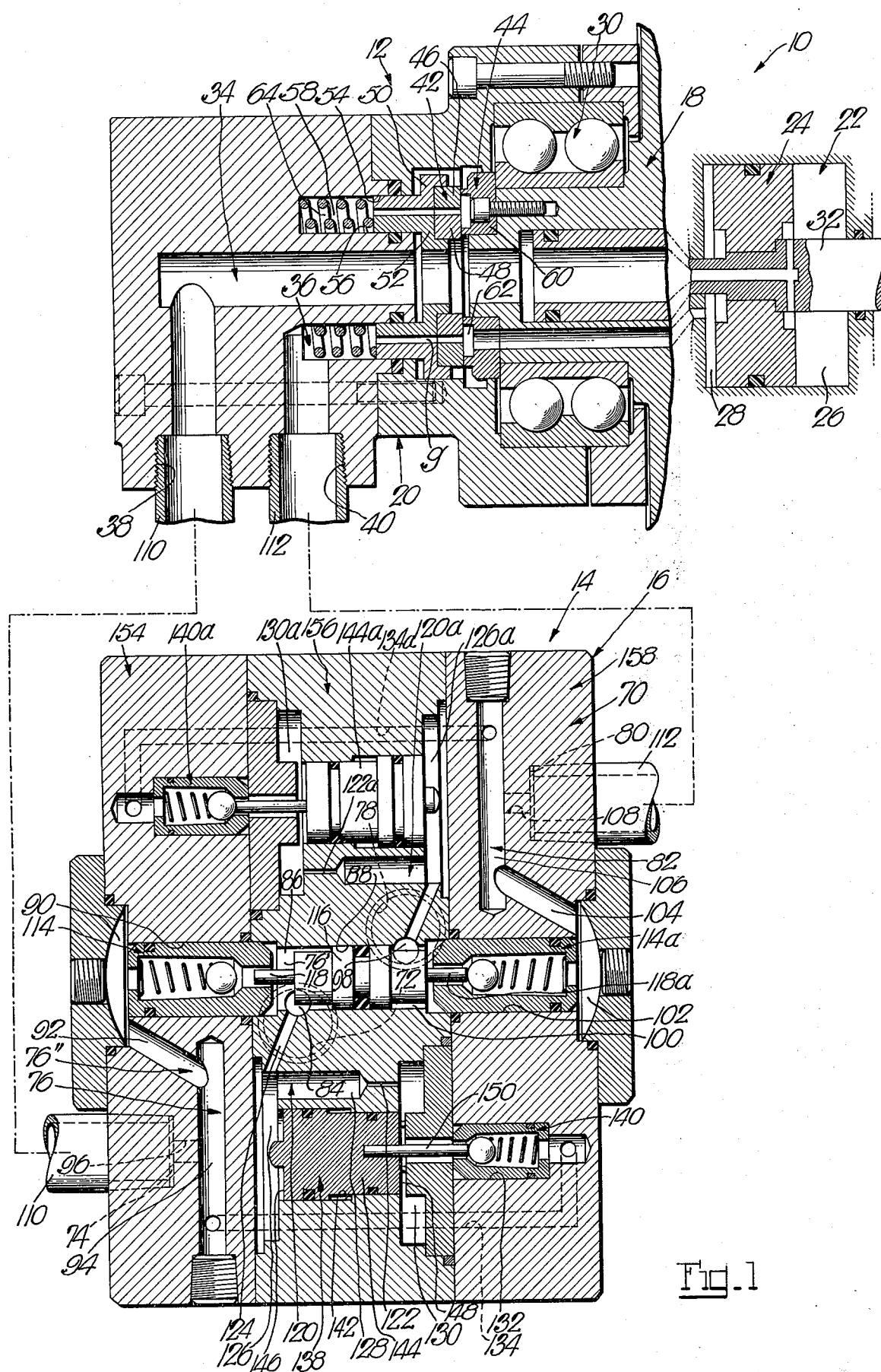
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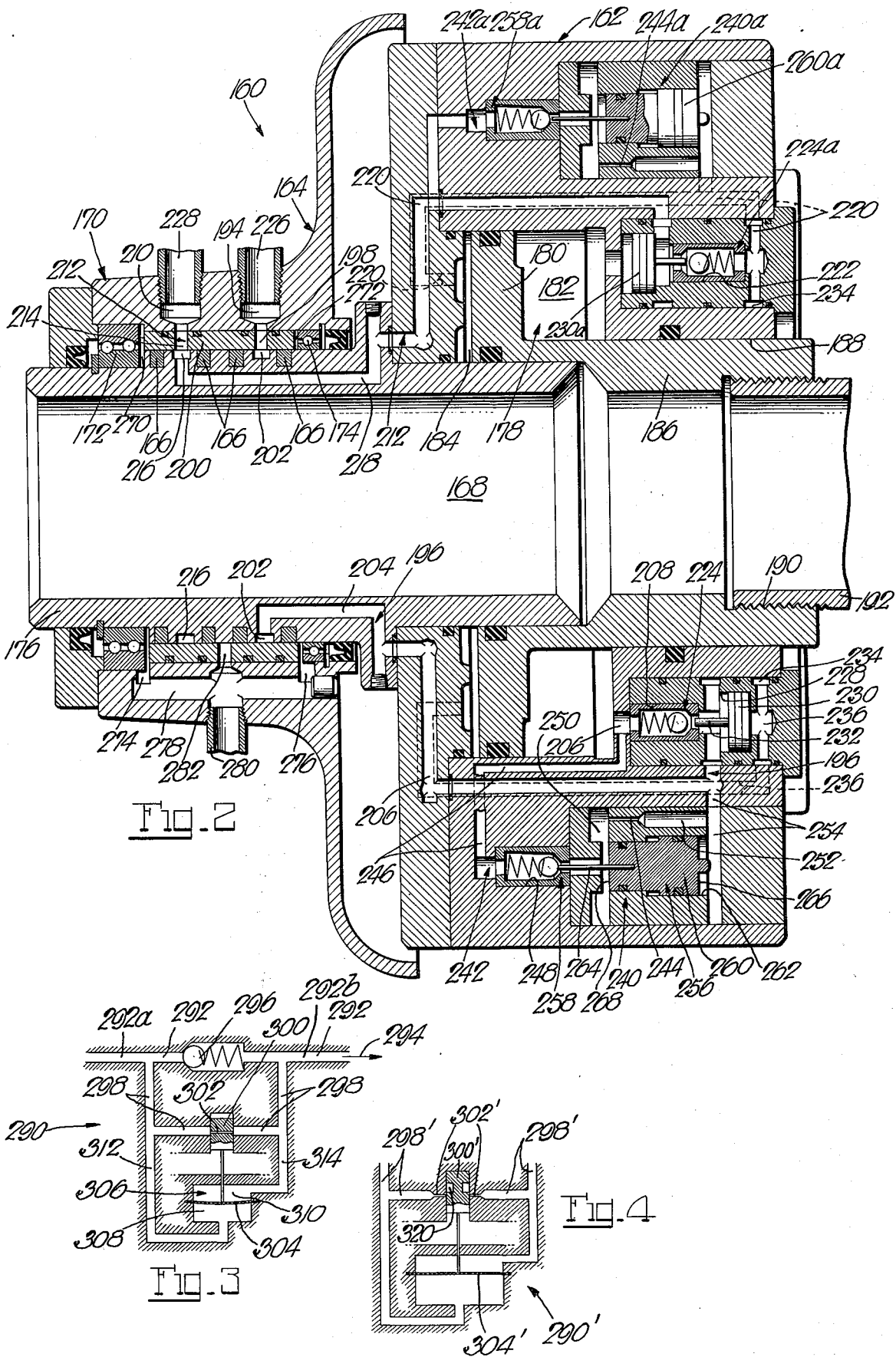
[57] ABSTRACT

A pressure control device for a swivel coupling with a cylinder in the turning coupling part and a piston therein forming a chuck-closing cylinder side, a conduit for hydraulic fluid and including a port in the coupling leading to this cylinder side and crossing the stationary and turning coupling parts, port sealing means in the coupling at the port crossing, and a check valve in the conduit normally closed to block fluid flow from the chuck-closing cylinder side, with the device featuring a bypass in the conduit around the check valve and having a constriction.

5 Claims, 4 Drawing Figures







HYDRAULIC OPERATING MECHANISM FOR A ROTARY CHUCK

This invention relates to fluid-operated chucks in general, and to hydraulic operating mechanism for rotary chucks in particular.

Conventional hydraulic or pneumatic chuck operating mechanism provides a cylinder, usually double-acting, and a piston therein, as well as a swivel coupling. The cylinder is customarily adapted for mounting on the chuck-carrying spindle of a lathe or the like so as to be turnable therewith, and the piston is adapted for operative connection with the jaw actuator of the chuck, while the swivel coupling has companion parts of which one part forms and, hence, turns with the cylinder, and the other part is connectible with two conduits and is held against rotation, with these coupling parts being suitably ported for the flow of operating fluid between the conduits and the opposite sides, respectively, of the cylinder. There is also provided a usual control valve which is connected with the conduits, and is operable to admit operating fluid under pressure from a suitable source to either the chuck-closing or chuck-opening cylinder side and simultaneously vent the other cylinder side.

The present invention is concerned with a type of chuck operating mechanism which will act to lock the operating fluid in the chuck closing cylinder side whenever the pressure of the fluid therein is above the pressure of the supply fluid. This is achieved by interposing a check valve in a part of the fluid passage which is close to and leads to the chuck-closing cylinder side, with the check valve opening to admit fluid into, but closing to block fluid flow from, this cylinder side, and providing a plunger which is subjected to fluid in the fluid passage to the chuck-opening cylinder side, and which on admission of operating fluid into this passage for work release, opens the check valve for venting the chuck-closing cylinder side. In using a check valve in this fashion, the same will even close when the pressure of the fluid in the chuck-closing cylinder side is substantially equal to that of the supply fluid. The advantage of this type of mechanism is that once work is gripped by the associated chuck and the pressure of the fluid supplying the chuck-closing cylinder side should thereafter drop suddenly from any cause whatever, such as a sudden leak in the fluid passage ahead of the check valve, for example, the chuck may nevertheless be driven and the work machined without giving rise to relaxation of the chuck's grip on the work and the hazards this would involve.

While this type of chuck operating mechanism is entirely satisfactory for pneumatic operation, it has been found totally unsuitable for hydraulic operation, in that the very lock of the operating fluid in the chuck-closing cylinder side, which is to take place on the slightest sudden pressure drop of the supply fluid, will give rise to an uncontrollable and potentially quite hazardous pressure increase of hydraulic fluid in this cylinder side at no pressure drop whatever of the hydraulic fluid ahead of the check valve. This is due to the fact that the imperative port seals in the swivel coupling between the stationary and turning parts thereof are subject to friction which increases with chuck operating speed, and which is even higher for the seal or seals that are associated with the port in the coupling leading to the chuck-closing cylinder side and, hence, are constantly subjected to the pressure load of the hydraulic fluid in

chuck operation, and the ensuing heat generated in the seals and coupling, while generally tolerable, does raise the pressure of the hydraulic fluid in the coupling. While heat-up, and ensuing increase in pressure of the hydraulic fluid in the coupling from this friction cause is of no consequence for the hydraulic fluid ahead of the check valve, it is of the gravest consequence for the hydraulic fluid in the chuck-closing cylinder side because this fluid will, under increasing pressure from this friction cause, soon close the check valve though the pressure of the supply fluid has not dropped at all, and once this check valve is closed and the hydraulic fluid in the chuck-closing cylinder side thus trapped therein, this trapped hydraulic fluid will further be heated with ensuing further increase of its pressure that soon will reach intolerable and highly hazardous proportions.

It is the primary aim and object of the present invention to provide chuck operating mechanism of this type which does lend itself to hydraulic operation.

It is another object of the present invention to provide chuck operating mechanism of this type which embodies the described structure of, and functions as, the aforementioned prior chuck operating mechanism of this type, but which does not give rise to any adverse pressure increase of hydraulic operating fluid in the chuck-closing cylinder side, and for that reason is to lend itself to highly desirable hydraulic operation.

It is a further object of the present invention to provide hydraulic chuck operating mechanism of this type which embodies the structure of, and functions as, the aforementioned prior mechanism of this type and, hence, includes a check valve, now referred to as "main" check valve, in the fluid passage to the chuck-closing cylinder side, and in which any appreciable pressure increase of hydraulic fluid in the chuck-closing cylinder side is prevented by a pressure control device which, on operational closure of the main check valve in any started chuck operation, functions to bleed from the chuck-closing cylinder side enough hydraulic fluid to keep the pressure of the remaining fluid therein at a level which is entirely safe, on the one hand for the duration, no matter how long, of the started chuck operation during which the pressure of the supply fluid undergoes no sudden drop, and on the other hand until after a sudden pressure drop of the supply fluid preferred automatic controls responsive thereto have stopped the power drive of the chuck. In order to function in this manner, the pressure control device may also be of exceeding structural simplicity by providing in the fluid passage to the chuck-closing cylinder side a bypass around the main check valve, and a constriction this bypass.

Another object of the present invention is to provide chuck operating mechanism of this type in which the aforementioned pressure control device further functions to stop bleeding of excess hydraulic fluid from the chuck-closing cylinder side on a sudden pressure drop of the supplying fluid ahead of the main check valve, to thereby keep work safely gripped after sudden pressure drop for a time period during which many started chuck operations are finished, or if not finished will enable responsive automatic controls to bring the power drive of the chuck to a safe stop, without giving rise to any potentially hazardous increase in pressure of the hydraulic fluid in the chuck-closing cylinder side. To this end, the pressure control device further provides in the bypass a secondary valve which, when open, forms

part of the bypass, with the constriction being in a part of the bypass other than that between the secondary valve and the fluid passage behind the main check valve, i.e., the fluid passage from the latter to the chuck-closing cylinder side, and also provides an instrumentality which is subjected to hydraulic fluid in the fluid passage ahead of and behind the main check valve, and operative to open and close the secondary valve when the pressure of hydraulic fluid in the fluid passage behind the main check valve is within a certain range and is above this range, respectively, with the range being from a pressure at least equal to, to a pressure of predetermined excess over, the pressure of hydraulic fluid in the passage ahead of the main check valve.

A further object of the present invention is to provide chuck operating mechanism of this type, of which the aforementioned secondary valve in the bypass of the pressure control device is in its preferred form a secondary check valve of inherent automatic operation which is normally closed to block fluid flow from the fluid passage behind the main check valve to the fluid passage ahead of the main check valve, and the instrumentality of this control device preferably provides a slidable stepped plunger with larger and smaller ends exposed to hydraulic fluid in the fluid passage ahead and behind the main check valve, respectively, whereby this plunger is stepped into advance and retract positions when the total pressure of fluid on the larger plunger end changes from smaller to greater and from greater to smaller, respectively, than the total pressure of fluid on the smaller plunger end, and the plunger being arranged to act on its advance and retract steps to open the secondary check valve and permit its closure, respectively.

It is a further object of the present invention to provide chuck operating mechanism of this type, of which the bypass of the pressure control device is formed, between the constriction and the secondary check valve therein, with a reservoir, and the entire smaller plunger end is exposed to and forms part of this reservoir. With this arrangement, the constriction will on operational closure of the main check valve, on the one hand at no sudden pressure drop of the supply fluid ahead of this valve, permit bleeding from the reservoir of sufficient fluid to keep the fluid in the chuck-closing cylinder side at approximately the pressure of the supply fluid despite any operational heat-up of the fluid in this cylinder side, and on the other hand at a sudden pressure drop of the supply fluid ahead of the main check valve, permit bleeding of fluid from the reservoir at such a very low rate that the prevailing pressure of the reservoir fluid immediately after such sudden fluid pressure drop is entirely adequate forcefully to step the plunger to its retract position and, hence, permit closure of the secondary check valve before the pressure of the fluid in the chuck-closing cylinder side undergoes any appreciable drop.

Further objects and advantages will appear to those skilled in the art from the following, considered in conjunction with the accompanying drawings.

In the accompanying drawings, in which certain modes of carrying out the present invention are shown for illustrative purposes:

FIG. 1 is a fragmentary longitudinal section through hydraulic chuck operating mechanism embodying the invention;

FIG. 2 is a longitudinal section through hydraulic chuck operating mechanism embodying the invention in a modified manner; and

FIGS. 3 and 4 are fragmentary diagrammatic sections through hydraulic chuck operating mechanisms embodying further modifications of the invention.

Referring to the drawings, and more particularly to FIG. 1 thereof, the reference numeral 10 designates chuck operating mechanism which provides as its major operating components a swivel coupling 12 and a fluid pressure control device 14 which in this example is embodied in a control unit 16 separate from the swivel coupling 12.

The swivel coupling 12 comprises companion parts 18 and 20, of which the coupling part 18 provides a cylinder 22 with a piston 24 therein defining in the cylinder opposite sides 26 and 28. The coupling part 18 is adapted for mounting on the power spindle of a lathe or the like (neither shown) and, hence, is operationally turning therewith, while the other coupling part 20 is held stationary and is mounted on the turning coupling part 18 through intermediation of an antifriction bearing 30. The piston 24 is connected with a drawbar 32 which in turn is adapted for connection with a jaw actuator in a chuck carried on the power spindle of the lathe. In the present example, the jaws of the chuck are closed on work when fluid under pressure is admitted to the "chuck-closing" cylinder side 26 and the other "chuck-opening" cylinder side 2 is vented, and the jaws of the chuck are open when fluid under pressure is admitted to the chuck-opening cylinder side 28 and the chuck-closing cylinder side 26 is vented.

To pass fluid to and from the cylinder sides 26 and 28, the coupling 12 is provided with passages 34 and 36 which lead from openings 38 and 40 in the stationary coupling part 20 across the coupling parts 20, 18 to the chuck-closing and chuck-opening cylinder sides 26 and 28, respectively. To seal the fluid passages 34 and 36 at their crossings from one coupling part to the other coupling part, there are provided suitable seals which are subjected to operational friction owing to the fact that one coupling part is stationary and the other coupling part is operationally turning. In the present instance, there are provided companion seals 42 and 44 which are carried by the stationary and turning coupling parts 20 and 18, respectively. The seal 42 provides in this instance outer and inner rings 46 and 48 in outer and inner bearing rings 50 and 52 which are slidable on the outer and inner peripheral walls 54 and 56 of a ring-shaped recess 58 in the stationary coupling part 20. The other seal 44 is in the form of a ring 60 on the turning coupling part 18, with this ring 60 having a ring-shaped recess 62. The outer and inner rings 46, 48 of the seal 42 and their bearing rings 50, 52 are spaced by an annular gap *g* which leads from the recess 58 in the stationary coupling part 20 to the recess 62 in the other seal 44, with the recess 58, gap *g* and recess 62 forming part of the fluid passage 36 to the chuck-opening cylinder side 28. The outer and inner rings 46, 48 of the seal 42 are by springs 64 urged into sealing engagement with the ring seal 44.

The control unit 16 provides a casing 70 which in this instance is fixedly mounted separately from the coupling 12. The casing 70 is provided with an inlet 72, an outlet 74 and a port 76 connecting them, and is further provided with another inlet 78, another outlet 80 and a port 82 connecting the latter with the inlet 78. The

port 76 is formed in this instance by an orifice 84 leading from the inlet 72, one side 86 of a cylinder chamber 88, an annular recess 90 and successive orifices 92, 94 and 96, of which orifice 96 leads to the outlet 74. The other port 82 is formed in this instance by an orifice 98 leading from the inlet 78, the other side 100 of the cylinder chamber 88, an annular recess 102 and successive orifices 104, 106 and 108, of which orifice 108 leads to the outlet 80. The outlets 74 and 80 are connected, in this instance by conduits 110 and 112, with the opening 38 and 40, respectively, in the stationary coupling part 20, wherefore the ports 76 and 82, are through the conduits 110 and 112 and fluid passages 34 and 36 in the coupling 12, in communication with the chuck-closing and chuck-opening cylinder sides 26 and 28, respectively.

The fluid pressure control device 14 includes the ports 76 and 82 in the casing 70, and provides various control elements which in this instance are arranged in the casing 70. Among these control elements is a main check valve 114 which is interposed in the port 76, and in this instance mounted in the annular recess 90, with this check valve 114 being normally closed to block fluid flow from the outlet 74, and hence from the chuck-closing cylinder side 26, to the inlet 72, and this check valve dividing the port 76 into sections 76' and 76'', of which the port section 76'' is open to the chuck-closing cylinder side 26 and the port section 76' is open to the inlet 72. Associated with the check valve 114 is a piston 116 in the cylinder chamber 88, with this piston having a pin 118 for opening the check valve 114. The inlets 72 and 78 are, through conduits, connected with a usual control valve (not shown) which is operative to admit fluid under pressure from a suitable source to either inlet 72 or 78 and simultaneously vent the other inlet.

In operation of the mechanism 10, and assuming that work is to be gripped by an associated chuck and to be machined in the power-driven chuck, the mentioned control valve is operated to admit fluid under pressure to the inlet 72 and simultaneously vent the other inlet 78 and, hence, also the chuck-opening cylinder side 28, with the admitted fluid under pressure opening the normally-closed check valve 114 and passing to the chuck-closing cylinder side 26 to cause the chuck to grip the work. The power drive of the chuck-carrying power spindle is next started, whereupon the gripped work is machined. Once fluid under pressure from the source is admitted to the inlet 72 and passed to the chuck-closing cylinder side 26, the pressure of the fluid in the latter will quickly equal that of the source so that the check valve 114 will then close and remain closed as long as the pressure of the fluid in this cylinder side remains substantially equal to that of the source. However, if for any reason the pressure of the fluid in this cylinder side should be below that of the source, the check valve 114 will be opened until substantial fluid pressure equilibrium is established. The fluid pressure source, in the case of hydraulic operating fluid at least, is usually the output of a pump of preferred regulatable output pressure. The primary purpose of the check valve 114 is, of course, to render a chuck operation safe in the event that in the course of the latter the pressure of the supply fluid should suddenly drop from any cause, such as pump failure or a sudden leak in the fluid line from the pump to the check valve 114. In the event of such a sudden pressure drop, the check valve 114,

if not then closed, will immediately close and thus trap in the chuck-closing cylinder end the fluid therein which will be at an entirely safe operating pressure for the remainder of the started chuck operation. After the chuck operation is then concluded, the mentioned control valve is actuated to admit fluid under pressure to the inlet 78 and, hence, to the chuck-opening cylinder side 28, and simultaneously vent the inlet 72. The moment the admitted fluid under pressure reaches the port 82 in the casing 70, and more particularly the side 100 of the cylinder chamber 88, the fluid therein will shift the piston 116 to the left into a position in which its pin 118 opens the check valve 114 for venting the chuck-closing cylinder side 26.

Safe conclusion, by virtue of the check valve 114, of any started chuck operation on any sudden pressure drop of the supply fluid, is certain when the mechanism is operated pneumatically and the operating fluid is air as usual. However, the present mechanism as described so far, and including the check valve 114, does not lend itself to safe chuck operation at any time if the mechanism is operated hydraulically, with oil being then the usual operating fluid. This is due to the fact that when the chuck, and hence also the turning coupling part 18, are power-driven, the seals 42 and 44 undergo operational friction, whereby there is generated in these seals heat which is transmitted to the coupling 12 and, hence also to the operating fluid in the chuck-closing cylinder side 26, with this operating fluid, when hydraulic and, hence, non-compressible, undergoing increasing pressure with increasing heat. Thus, with operational heat-up, from this friction cause, of the hydraulic fluid in the chuck-closing cylinder side 26 and back to the check valve 114 being progressive in the course of a chuck operation, its correspondingly progressively increasing pressure will soon close the check valve 114, if the same is not already closed, even at no pressure drop whatever of the hydraulic supply fluid in the line up to this check valve. Progressive increase in pressure of the hydraulic fluid thus trapped in the chuck-closing cylinder side in the course of a chuck operation is thus inevitable and the pressure of this trapped hydraulic fluid will soon reach hazardous proportions before many started chuck operations would be concluded.

In accordance with the invention, provisions are made whereby chuck operation is rendered entirely safe when the operating fluid for the mechanism 10 is hydraulic fluid. To this end there is provided in the fluid passage from the pressure source to the chuck-closing cylinder side a bypass 120 around the check valve 114, with this bypass having a constriction 122. In the exemplary chuck operating mechanism 10, the bypass 120 with the constriction 122 is provided in the port 76 in the casing 70 around the check valve 114 therein, and the bypass 120 is formed in this instance by an orifice 124, a chamber 126, an orifice 128, the constriction 122, a chamber 130, an annular recess 132, and an orifice 134.

In operation of the mechanism 10 with hydraulic fluid now as the operating fluid, and assuming that hydraulic fluid under the source pressure has just been admitted to the chuck-closing cylinder side 26, the check valve 114 will close when substantial pressure equilibrium prevails in the port sections 76' and 76'' on opposite sides of the check valve 114. On then starting the power drive of the chuck, the pressure of the hydraulic fluid in the chuck-closing cylinder side 26 will,

during closure of the check valve 114, soon start to increase due to heat-up emanating from inevitable heat-up of the seals 42 and 44 from operational friction, with any pressure increase of the hydraulic fluid from this cause spreading throughout the trapped fluid from the check valve 114 to and including the chuck-closing cylinder side. However, even the slightest increase in pressure of this trapped hydraulic fluid will force or bleed from the latter through the constriction 122 sufficient fluid to keep the pressure of the trapped fluid substantially at the normally constant pressure of the supply fluid in the port section 76' for any duration of a chuck operation and regardless of the extent of operational heat-up of the trapped fluid. The chuck operating mechanism 10 is thus entirely safe for any and all chuck operations, except in the event that the supply pressure of the hydraulic fluid should suddenly drop from any cause whatever, such as pump failure or a sudden leak in the fluid supply line from the pump to the check valve 114. However, the chuck operating mechanism 10 is, nevertheless easily rendered safe for any and all chuck operations by providing known automatic control which senses the pressure of the hydraulic supply fluid, as that in the port section 76' for example, and which is presettable to a still safe work-gripping pressure below normal operating pressure, and operates when the sensed pressure is equal to the preset pressure to stop the power drive of the chuck. Thus, even in the event of a sudden pressure drop of the hydraulic supply fluid during a chuck operation, the work will remain safely gripped until the chuck comes to a safe stop very soon after this control goes into action.

In accordance with a further aspect of the invention, further provisions are made to stop bleeding through the constriction 122 of hydraulic fluid from the trapped fluid between the chuck-closing cylinder side 26 and the check valve 114 on a sudden pressure drop of the hydraulic supply fluid. To this end there is provided an instrumentality 138, and there is, in the part of the bypass 120 between the constriction 122 and the port section 76'', a valve 140 which in this instance is a "secondary" check valve in distinction from the described and appropriately termed "main" check valve 114, with this secondary check valve 140 being in this instance mounted in the annular recess part 132 of the bypass 120, and normally closed to block fluid flow from the port section 76'' to the port section 76'. The instrumentality 138 provides in this instance a stepped cylinder aperture 142 with its larger and smaller ends open to the chamber parts 126 and 130, respectively, of the bypass 120, and a stepped plunger 144 with larger and smaller ends 146 and 148 in the cylinder aperture 142, with the smaller plunger end 148 being provided with a pin 150 in line and operatively associated with the secondary check valve 140. With this arrangement, and while hydraulic fluid under pressure is admitted to the chuck-closing cylinder side 26 and the hydraulic supply fluid remains substantially at its pressure, the pressure of the fluid in the chamber parts 126 and 130 of the bypass 120 is the same, meaning that the total pressure of fluid on the larger plunger end 146 is greater than the total pressure of fluid on the smaller plunger end 148, whereby the plunger is then held in the right end position shown in which its pin 150 holds the secondary check valve 140 open to thereby permit such of the trapped hydraulic fluid which would due to operational heat-up increase the pressure of the latter

appreciably beyond the prevailing normal pressure of the hydraulic supply fluid, to reach the constriction 122 and bleed therethrough. On the other hand, if on a sudden pressure drop of the hydraulic supply fluid its effect on the larger plunger end 146 is a sudden drop of the total fluid pressure on the latter anywhere below the total fluid pressure on the smaller plunger end 148, the plunger 144 will quickly be stepped to the left from the position shown and permit equally quick closure of the secondary check valve 140 to thereby block any of the trapped hydraulic fluid from reaching the constriction 122. A sudden pressure drop of the hydraulic supply fluid, while immediately effective on the larger plunger end 146, is not effectively transmitted to the hydraulic fluid in the chamber part 130 of the bypass 120 and, hence, to the smaller plunger end 148, before the plunger 144 responds to the then greater total fluid pressure on its smaller end 148 in stepping to the left and thereby permitting quick closure of the secondary check valve 140. This is due to the fact that on a sudden pressure drop of the hydraulic supply fluid the volumetric escape rate of hydraulic fluid from the chamber part 130 of the bypass 120 through the constriction 122 is so very small that at the time the sudden pressure drop is effective on the larger plunger end 146, the pressure of the hydraulic fluid in this chamber part 130 is sufficiently high forcefully to step the plunger 144 to the left from its shown valve-opening position. Of course, the relative areas of the larger and smaller plunger ends 146 and 148 are selected so that the plunger will, on a sudden pressure drop of the hydraulic supply fluid, be stepped from its valve-opening position at a stage of the sudden pressure drop at which on closure of the secondary check valve 140 the pressure of the hydraulic fluid ahead of the main check valve 114 and including that in the chuck-closing cylinder side 26 is sufficiently high to keep the work safely gripped in the chuck. With this arrangement, a chuck operation, in the course of which the pressure of the hydraulic supply fluid should suddenly drop, may in many instances be safely concluded before the increasing pressure, due to heat-up, of the hydraulic fluid in the chuck-closing cylinder side could reach hazardous proportions after the sudden pressure drop. However, for safe chuck operation in any event, there is preferably also provided the beforementioned automatic control which senses the pressure of the hydraulic supply fluid and on a preset drop of the same acts to bring the power drive of the chuck to a stop at least within a period from the preset pressure drop of the supply fluid during which the increasing pressure of the hydraulic fluid in the chuck-closing cylinder side will safely remain below a hazardous pressure and many started chuck operations will be concluded.

While in the described chuck operating mechanism 10 the cylinder sides 26 and 28 have been designated as the chuck-closing and chuck-opening cylinder sides, respectively, the exemplary mechanism may be used with either cylinder side 26 or 28 being the chuck-closing side and the other cylinder side being the chuck-opening side since hydraulic fluid under pressure is admissible to either cylinder side and the other cylinder side simultaneously vented. In order to operate the present chuck operating mechanism at the featured safety also when the cylinder side 28 is the chuck-closing side and the other cylinder side 26 is the chuck-opening cylinder side, there is interposed in the port 82

a second main check valve 114a which functions in exactly the same manner as the other main check valve 114, i.e., the second valve 114a closes and, hence, traps the hydraulic operating fluid in the chuck-closing cylinder side 128 when the pressure of the hydraulic supply fluid should suddenly drop. The piston which is associated with the second main check valve 114a is in this instance the same piston which is associated with the other main check valve 114, i.e., the piston 116 which, for its association with valve 114a is provided with another pin 118a. Thus, when hydraulic fluid under pressure is admitted to the chuck-closing cylinder side 28 and the other cylinder side 26 is vented, hydraulic fluid under pressure in the port 82 will force the piston 116 into, and hold it in, a position to the left of that shown so that its pin 118a will permit closure of the second main check valve 114a.

For safe operation of the mechanisms 10 when the cylinder side 28 is the chuck-closing side, the mechanism further provides for bleeding from the chuck-closing cylinder side such of the hydraulic operating fluid therein which, if not bled off, would progressively increase the pressure of this fluid due to operational heat-up of the latter as long as the pressure of the hydraulic supply fluid remains at its normal pressure, and also provides for blocking bleed-off of hydraulic fluid from the chuck-closing cylinder side 28 when the pressure of the hydraulic supply fluid should suddenly drop. To these ends, the mechanism 10 provides the same elements which are provided and described for safe operation in these respects of the mechanism 10 when the cylinder side 26 is the chuck-closing cylinder side, with the major elements associated with the cylinder side 28 being denoted by the same reference numerals as their counter elements associated with the cylinder side 26, except that the suffix *a* is added to them. Safe operation in these respects of the mechanism 10 is believed to be readily understood and requires no further description, in view of the described safe operation in the same respects of the mechanism 10 when the cylinder side 26 is the chuck-closing side.

The casing 70, in which all the elements for safe chuck operation are provided in this instance, is preferably made in suitably joined sections 154, 156 and 158 for ready machining of the individual sections and ready assembly therewith of the additional elements before joining these sections.

In the exemplary chuck-operating mechanism 10 the elements making for the described safe chuck operation are provided in a stationary part of the mechanism which in this instance is the casing 70 that is separate and apart from the stationary coupling part 20 as described, but could obviously also be formed as part of the stationary coupling part 20. This mechanism 10 is entirely satisfactory for safe chuck operation as long as there is no leakage of hydraulic fluid between either main check valve and the associated chuck-closing cylinder side. Such leakage is indeed quite remote, except leakage at the fluid seals in the swivel coupling that may be difficult to avoid, or cannot be avoided at all, with particular fluid seals, including fluid seals of larger sizes which are subject to more severe heat-up from operational friction. Thus, if such a leak, at the fluid seals should develop in the described mechanism 10, safe chuck operation would be impossible because on a sudden pressure drop of the hydraulic supply liquid, the main check valve and also the associated secondary

check valve would immediately close and thus trap the fluid between these check valves and the chuck-closing cylinder side, and any leak, even the slightest one, of this trapped fluid would quickly reduce the pressure of the latter below a safe work-gripping level, for it takes comparatively little leakage of this non-compressible hydraulic fluid to do just that. Accordingly, in order to render chuck operation safe where a leak in the hydraulic fluid line to the chuck-operating cylinder may occur, and is certain to occur where the fluid seals in the swivel coupling permit leakage, and even the slightest leakage, of hydraulic fluid, it is clearly indicated to locate the elements for safe chuck operation as closely as possible to the chuck-closing cylinder side, and in particular in the operationally turning part of the swivel coupling between the fluid seals in this coupling and the chuck-closing cylinder side.

Reference is now had to FIG. 2, which shows modified chuck operating mechanism 160 in which the elements for safe chuck operation are located in the operationally turning part 162 of the swivel coupling 164 between the chuck-closing cylinder side and the fluid seals 166 in this coupling. The swivel coupling 164 is in this instance provided with a center aperture 168 to clear work that may extend rearwardly from the associated chuck in which the work is gripped for machining, with the structure of the coupling being built around this center aperture and, hence, being of considerable diametric dimensions which requires the fluid seals 166 to be of considerable diameters that may readily give rise to fluid leakage thereat in operation of the mechanism. The turning coupling part 162 is mounted on the power spindle of a lathe or the like which also carries the associated chuck for operational drive of both, the chuck and turning coupling part.

The swivel coupling 164 has also a stationary part 170 which through antifriction bearings 172 and 174 is mounted on a hollow axial shank of, and in this instance on a separate sleeve 176 on, the turning coupling part 162. The turning coupling part 162 provides a cylinder 178 with a piston 180 defining therein chuck-closing and chuck-opening cylinder sides 182 and 184, respectively, with the piston 180 having in this instance a hollow shank 186 slidable on the sleeve 176 on the turning coupling part 162 and in a cylindrical opening 188 in the latter, with this shank 186 thus also forming part of the chuck-closing cylinder side 182. The hollow shank 186 of the piston 180 is at 190 connected with a hollow draw bar 192 for operating the jaw actuator of an associated chuck.

The stationary coupling part 170 is provided with an opening 194 which through a port 196 is in communication with the chuck-closing cylinder side 182, with this port 196 providing an orifice 198 leading from the opening 194 into and through a liner 200 in the coupling part 170 to a peripheral groove 202 in the sleeve 176 on the turning coupling part 162, a continuing orifice 204 in the sleeve 176, and a continuing orifice 206 in the turning coupling part that leads to the chuck-closing cylinder side 182 and is formed with an annular recess 208.

The stationary coupling part 170 is also provided with another opening 210 which through a port 212 is in communication with the chuck-opening cylinder side 184, with this port providing an orifice 214 leading from the opening 210 into and through the liner 200 in the coupling part 170 to a peripheral groove 216 in

the sleeve 176 on the turning coupling part 162, the peripheral groove 216 and a continuing orifice 218 in the sleeve 176, and a continuing orifice 220 in the turning coupling part 162 that leads to the chuck-opening cylinder side 184 and is formed with an annular recess 222.

Interposed in the port 196 within the turning coupling part 162, and mounted in the recess part 208 of this port 196, is a main check valve 224 which is associated with the chuck-closing cylinder side 182, and is normally closed to block fluid flow from the latter.

The openings 194 and 210 in the stationary coupling part 170 are through conduits 226 and 228 connected with a control valve (not shown) which is operative to admit hydraulic fluid under pressure from a suitable source to either opening 194 or 210 and simultaneously vent the other opening. In operation of the mechanism 160, and assuming that an associated chuck is to grip work for subsequently machining the latter in the power-driven chuck, the mentioned control valve is operated to admit hydraulic fluid under pressure from the source to the opening 194 in the stationary coupling part 170, and simultaneously vent the other opening 210 and, hence, the chuck-opening cylinder side 184. Hydraulic fluid under pressure thus admitted to the opening 194 in the coupling 164 will immediately pass through the port 196 to the chuck-closing cylinder side 182 and shift the piston 180 to the position shown in which the work will be gripped by the chuck, with the hydraulic fluid in the port 196 opening the main check valve 224 until the pressure of the fluid in the chuck-closing cylinder side 182 is substantially equal to that of the hydraulic supply fluid. The main check valve 224 will act, i.e., close, when there should be a sudden drop in pressure of the hydraulic supply fluid, unless this check valve is then closed, thereby trapping the hydraulic operating fluid in the chuck-closing cylinder side, as now readily understood.

In order to release the gripped work from the chuck, the mentioned control valve is operated to admit hydraulic fluid under pressure from the source or supply to the opening 210 in the coupling 164 and, hence, to the chuck-opening cylinder side 184, and simultaneously vent the other opening 194. However, with the main check valve 224 then immediately closing, if not then closed, and the hydraulic fluid in the chuck-closing cylinder side 182 being thus trapped therein, the piston 180 will not respond to the hydraulic fluid in the chuck-opening cylinder side 184 until the other cylinder side 182 is vented. To the latter end, there is slidable in an annular recess 228 in the turning coupling part 162 a secondary piston 230 with a pin 232, with one end of this piston 230 being exposed to hydraulic fluid in the port 196, and its other end being exposed to hydraulic fluid in the other port 212 through a branch thereof including an annular groove 234 in the turning coupling part 162 and a continuing orifice 236 leading also to the chuck-opening cylinder side 184. Thus, with the opening 194 in the coupling vented and hydraulic fluid under pressure admitted to the other opening 210, for work release from the chuck, the secondary piston 222 will, by the pressure of hydraulic fluid in the port 212, be shifted to a position to the left of that shown and thereby open with its pin 232 the check valve 224 to permit venting of the chuck-closing cylinder side 182 and, hence, actuation of the "main" piston 180 for work-release from the chuck.

The chuck operating mechanism 160 also has a pressure control device 240 which provides in the port 196 within the turning coupling part 162 a bypass 242 around the check valve 244, on a constriction 244 in this bypass. The bypass 242 is in this instance formed by an orifice 246 which leads from the port 196 between the check valve 224 and the chuck-closing cylinder side 182, an annular recess 248, a chamber or reservoir 250, the constriction 244, and orifices 252 and 254, of which orifice 254 leads to the port 196 between its crossing at the coupling parts and the check valve 224. The pressure control device 240 further provides a fluid-responsive instrumentality 256, and a valve 258 which is interposed in the bypass 242. The valve 258 is in this instance a secondary check valve which is mounted in the recess part 248 of the bypass 242, and is normally closed to block fluid flow from the chuck-closing cylinder side 182. The instrumentality 256 provides in this instance a stepped plunger 260 in a cylinder opening 262 in the turning coupling part 162, with the plunger 260 carrying a pin 264 associated with the secondary check valve 258, and the larger and smaller ends 266 and 268 of this plunger being exposed to the orifice and reservoir parts 254 and 250, respectively, of the bypass 242.

It has already been mentioned that in this exemplary chuck operating mechanism 160 hydraulic operating fluid may well leak past the sealing rings 166 in the coupling 164 in operation of the mechanism. To avoid messy spillage of any leaking hydraulic fluid on the floor, the stationary coupling part 170 is provided at the opposite ends of the liner 200, and hence beyond the opposite ends of the grouped sealing rings 166, with annular escape passages 270 and 272 which at 274 and 276 are open to a sump 278 in the bottom of the stationary coupling part 170, with the sump 278 being by a conduit 280 connected with a tank (not shown) that holds a supply of hydraulic fluid from which fluid is drawn by a pump the output of which constitutes in this instance the source of hydraulic fluid under pressure. The liner 200 is in this instance provided with a further escape passage 282 that leads to the sump 278.

In operation of the mechanism 160, and assuming that hydraulic fluid under operating pressure is admitted to the opening 194 in the coupling 164, and hence also to the chuck-closing cylinder side 182 through the main check valve 224, the check valve 224 will close when the pressure of the hydraulic fluid in the chuck-closing cylinder side 182 is approximately equal to the pressure of the hydraulic supply fluid. On operational heat-up, and ensuing increase in pressure, of the trapped hydraulic fluid in the chuck-closing cylinder side due to operational friction in the coupling 164 and particularly at the sealing rings 166, the main check valve 224 will remain closed, but the secondary check valve 258 is then held open by the stepped plunger 260 to permit bleeding through the constriction 244 in the bypass 242 of sufficient hydraulic fluid from the chuck-closing cylinder side 182 to maintain the pressure of the fluid in the latter at an entirely safe level for the duration, no matter how long, of any chuck operation. However, in the rare event of a sudden pressure drop of the hydraulic supply fluid, due to pump failure or a sudden leak in the supply line to the main check valve 224, for example, the stepped plunger 260 will quickly retract and permit equally quick closure of the secondary check valve 258 also, to trap the hydraulic fluid

under operating pressure in the chuck-closing cylinder side 182. The pressure of the hydraulic fluid thus trapped in the chuck-closing cylinder side will, due to further heat-up, increase to a level which is still entirely safe for the remaining duration of many started chuck operations, and certainly until a previously mentioned automatic control responding to a sudden pressure drop of the hydraulic supply fluid acts to bring the power drive of the turning coupling part 162 and associated chuck to a safe stop.

The present chuck operating mechanism thus affords entirely safe chuck operation even if hydraulic fluid should, in normal operation of the mechanism, leak from the supply line into the sump 278 in the stationary coupling part 170, for in that case the constantly available hydraulic supply fluid under pressure will, despite such leakage, keep the pressure in the supply line up to the main chuck valve 224 at full operating pressure. On the other hand, if the pressure of the supply fluid in the turning coupling part 162 should drop suddenly from any cause whatever, such as pump failure or a sudden leak in the supply line, the pressure control device 240 will act to keep the pressure of the hydraulic fluid in the chuck-closing cylinder side 182 at a safe level either for the remaining duration of a started chuck operation, but certainly until after such a sudden pressure drop of the hydraulic supply fluid the power drive of the turning coupling part 162 and associated chuck has automatically been brought to a safe stop.

While in the description so far of the chuck operating mechanism 160 the cylinder side 182 has been referred to as the chuck-closing cylinder side, the mechanism is readily suited for safe chuck operation with either cylinder side 182 or 184 being the chuck-closing cylinder side and the other cylinder side being the chuck-opening cylinder side. To the latter end, there is interposed in the port 212 in the turning coupling part 162 another main check valve 224a which is associated with the cylinder side 184, and there is further provided in the turning coupling part another secondary piston 230a associated with the main check valve 224a and operative to open the latter for operational venting of the cylinder side 184. Still to the same end, the chuck operating mechanism 160 provides another pressure control device 240a which in its structure and operation is quite similar to the described pressure control device 240 and, hence, requires no further description, with prominent elements of the pressure control device 240a being in FIG. 2 denoted by the same reference numerals as their counter elements of the pressure control device 240, except that the suffix *a* has been added to them.

While in FIG. 2 the pressure control devices 240 and 240a are, for simplicity of illustration, shown spaced radially outwardly from the respective associated main check valves 224 and 224a, it is entirely feasible, and much preferred, to arrange the pressure control devices 240 and 240a on one side or the other of the respective main check valves 224 and 224a, for example, to thereby keep the turning coupling part 162 at a considerably smaller outer diameter.

Reference is now had to FIG. 3 which shows diagrammatically a further modified pressure control device 290. Thus, the reference numeral 292 denotes a port through which to admit hydraulic fluid under supply pressure to the chuck-closing cylinder side of the mechanism, with the hydraulic fluid passing in the di-

rection of the arrow 294. Interposed in the port 292 is a main check valve 296 which is normally closed to block fluid flow from the chuck-closing cylinder side. Provided in the port 292 is a bypass 298 around the main check valve 296, and interposed in this bypass 298 is a secondary valve 300 which, when open as shown, forms part of the bypass 298. In this form of the pressure control device 290, the constriction in the bypass is formed by a constricted passage 302 in the secondary valve 300, and the fluid-responsive instrumentality is in the form of a flexible diaphragm 304 in a chamber 306, with the diaphragm 304 dividing the chamber 306 into sections 308 and 310. The chamber section 308 is, through a conduit 312 and a continuing part of the bypass 298 on one side of the secondary valve 300, in communication with the section 292a of the port 292 between the hydraulic fluid pressure source and the main check valve 296, and the other chamber section 310 is, through a conduit 314 and a continuing part of the bypass 298 on the other side of the secondary valve 300, in communication with the section 292b of the port 292 between the check valve 296 and the chuck-closing cylinder side. In operation of the pressure control device 290, and assuming that hydraulic fluid under the supply pressure has just been admitted to the chuck-closing cylinder side through the port 292 and interposed main check valve 296, the latter will close when substantial pressure equilibrium prevails in both port sections 292a and 292b, with the secondary valve 300 being then open, i.e., its constricted passage 302 forming part of the bypass 298. On operational heat-up of the hydraulic fluid in the chuck-closing cylinder side in the course of a chuck operation, and with the main check valve 296 then remaining closed, the ensuing increase in pressure of this hydraulic fluid is also effective in the chamber part 310 on one side of the diaphragm 304, and any responsive flexure of this diaphragm, such as the exemplary flexure shown, will keep the secondary valve 300 with its constricted passage 302 in communication with the bypass 298 to permit bleeding therethrough of such of the hydraulic fluid in the chuck-closing cylinder side which, if not bled off, would cause further increase in pressure of the hydraulic fluid in the chuck-closing cylinder side. However, in the rare event of a sudden pressure drop of the hydraulic supply fluid in the line up to the main check valve 296, this sudden pressure drop is immediately effective in the chamber section 308, and the diaphragm 304 will immediately respond to the hydraulic fluid under the higher pressure in the other chamber section 310 in flexing sufficiently to retract the secondary valve 300 into a closed position in which its constricted passage 302 is out of communication with the bypass 298 and, hence, permits no longer bleeding of any hydraulic fluid from the chuck-closing cylinder side.

Reference is finally had to FIG. 4 which shows diagrammatically a still further modified pressure control device 290' which may in all respects be like the pressure control device 290 of FIG. 3, except that the constriction 302' is provided, not in the secondary valve 300', but directly in the bypass 298' on either or both sides of the secondary valve 300', and the secondary valve 300' is provided in this instance with a peripheral groove 320 which in normal chuck operation is in communication with the bypass 298' to permit bleeding of excess hydraulic fluid from the chuck-closing cylinder

side through the constriction 302', with the secondary valve 300' being, on a sudden pressure drop of the supply fluid, shifted by responding flexure of the diaphragm 304' into a closed position in which its peripheral groove 320 is out of communication with the bypass 298' and more particularly with its constriction 302'. The present pressure control device is further modified in that in non-flexed condition of the diaphragm 304', i.e., when there is substantial fluid pressure equilibrium in the fluid line sections ahead of and behind the main check valve, the secondary valve 300' is also closed, as shown. However, once hydraulic fluid under the supply pressure is admitted to the chuck-closing cylinder side and the main check valve is closed, the pressure of the hydraulic fluid in the chuck-closing cylinder side will, due to operational heat-up of this fluid in chuck-operation, increase, and it is only on such increase of the pressure of this fluid that the diaphragm 304' will respond to shift the secondary valve 300' to open position in which its peripheral groove 320 is just in communication with the constriction 302' in the bypass 298' to permit bleeding therethrough of excess hydraulic fluid from the chuck-closing cylinder side.

What is claimed is:

1. In hydraulic chuck operating mechanism, the combination of a swivel coupling with stationary and operationally turning companion parts, of which the turning part provides a cylinder with a piston defining therein a chuck-closing cylinder side; a conduit, including a port in said coupling leading to said cylinder side, for passing hydraulic fluid under pressure to said cylinder side, with said port crossing said coupling parts; port sealing means in said coupling at the port crossing; a check valve in said conduit dividing the same into first and second conduit sections of which said second section extends from said valve to said cylinder side, with said valve being normally closed to block fluid flow from said cylinder side, and being opened by fluid in said first conduit section under a pressure in excess of that of fluid in said cylinder side to introduce fluid into said cylinder side and opened by piston means to release fluid from said cylinder side; and a fluid pressure control for said cylinder side, providing a bypass in said conduit around said check valve, a second valve in said bypass forming part of the latter when open, a constriction in said bypass, and fluid pressure responsive means operatively associated with said second valve and having opposite faces exposed to fluid in said bypass on opposite sides, respectively, of said constriction to open and close said second valve when the pressure of hydraulic fluid in said second conduit section is within a certain range and is above said range, respectively, with said range being from a pressure at least equal to, to a pressure of predetermined excess over, the pressure of hydraulic fluid in said first conduit section.

2. The combination in hydraulic chuck operating mechanism as in claim 1, in which said second valve is a secondary check valve in said bypass between said constriction and second conduit section and being normally spring-closed to block fluid flow from said cylinder side, and said fluid pressure responsive means is a slidable stepped plunger with larger and smaller ends exposed to hydraulic fluid in said bypass between said first conduit section and constriction and between said constriction and second check valve, respectively, with said plunger being moved into advance and retract po-

sitions when the total pressure of fluid on said larger plunger end is greater and smaller, respectively, than the total pressure of fluid on said smaller plunger end, and said plunger in its advance and retract positions opening said secondary check valve and permitting its closure, respectively.

3. The combination in hydraulic chuck operating mechanism as in claim 2, in which there is further provided a reservoir in said bypass between said constriction and said secondary check valve, and said smaller plunger end is exposed to and forms part of said reservoir.

4. In hydraulic chuck operating mechanism, the combination of a swivel coupling with stationary and operationally turning companion parts, of which the turning part provides a cylinder with a piston defining therein first and second cylinder sides; first and second conduits, including first and second ports, respectively, in said coupling, with said first and second ports leading to said first and second cylinder sides, respectively, and crossing said coupling parts, and said conduits being adapted for connection with a valve to admit hydraulic fluid under pressure to either conduit and simultaneously vent the other conduit; port sealing means in said coupling at the port crossings; a first check valve in said first conduit normally closed to block fluid flow from said first cylinder side, and dividing said first conduit into first and second conduit sections of which said second section extends from said check valve to said first cylinder side, with said first check valve being opened by fluid in said first conduit section under a pressure in excess of that of fluid in said second conduit section; a second slidable piston with opposite ends exposed to hydraulic fluid in said first conduit section and in said second conduit, respectively, with said second piston being by hydraulic fluid under pressure in said first conduit section and in said second conduit moved into first and second positions, respectively, in which to permit closure of said check valve and to open the same, respectively; and a fluid pressure control for said first cylinder side, providing a bypass in said first conduit around said check valve, a second valve in said bypass forming part of the latter when open, a constriction in said bypass, and fluid pressure responsive means operatively associated with said second valve and having opposite faces exposed to fluid in said bypass on opposite sides, respectively, of said constriction to open and close said second valve when the pressure of hydraulic fluid in said second conduit section is within a certain range and is above said range, respectively, with said range being from a pressure at least equal to, to a pressure of predetermined excess over, the pressure of hydraulic fluid in said first conduit section.

5. The combination in hydraulic chuck operating mechanism as in claim 4, in which there is further provided a second check valve in said second conduit normally closed to block fluid flow from said second cylinder side and dividing said second conduit into third and fourth conduit sections of which said fourth section extends from said second check valve to said second cylinder side, with said second check valve being opened by fluid in said third conduit section under a pressure in excess of that of fluid in said fourth conduit section, and a third slidable piston with opposite ends exposed to hydraulic fluid in said first conduit and in said third conduit section, respectively, with said third piston being by hydraulic fluid under pressure in said third

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conduit section and in said first conduit moved into first and second positions, respectively, in which to permit closure of said second check valve and to open the same, respectively; and another fluid pressure control for said second cylinder side, providing a second bypass in said second conduit around said second check valve, a third valve in said second bypass forming part of the latter when open, a second constriction in said second bypass, and fluid pressure responsive means operatively associated with said third valve and having oppo-

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site faces exposed to fluid in said second bypass on opposite sides, respectively, of said second constriction to open and close said third valve when the pressure of hydraulic fluid in said fourth conduit section is within a certain range and is above said range, respectively, with said range being from a pressure at least equal to, to a pressure of a predetermined excess over, the pressure of hydraulic fluid in said third conduit section.

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