HYDRAULIC OVERLOAD SAFETY DEVICE

Filed June 11, 1962 2 Sheets-Sheet 1

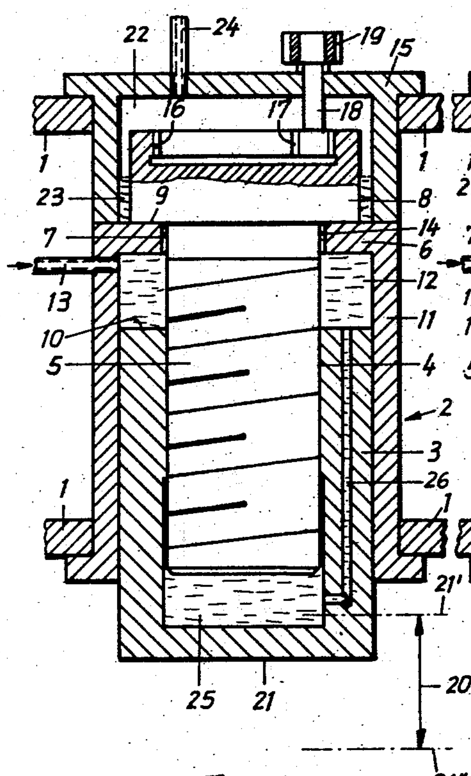

Fig. 1

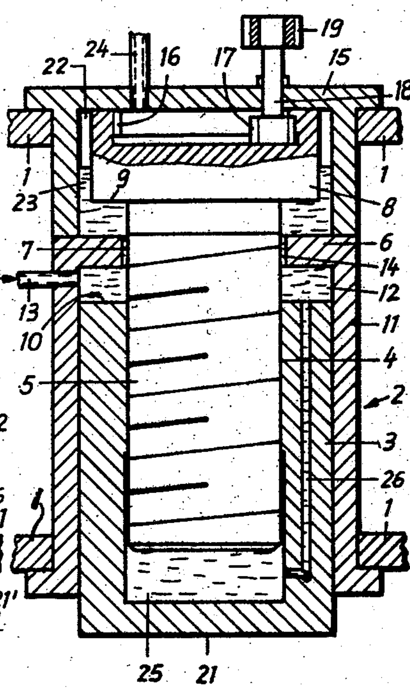

Fig. 2

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HYDRAULIC OVERLOAD SAFETY DEVICE

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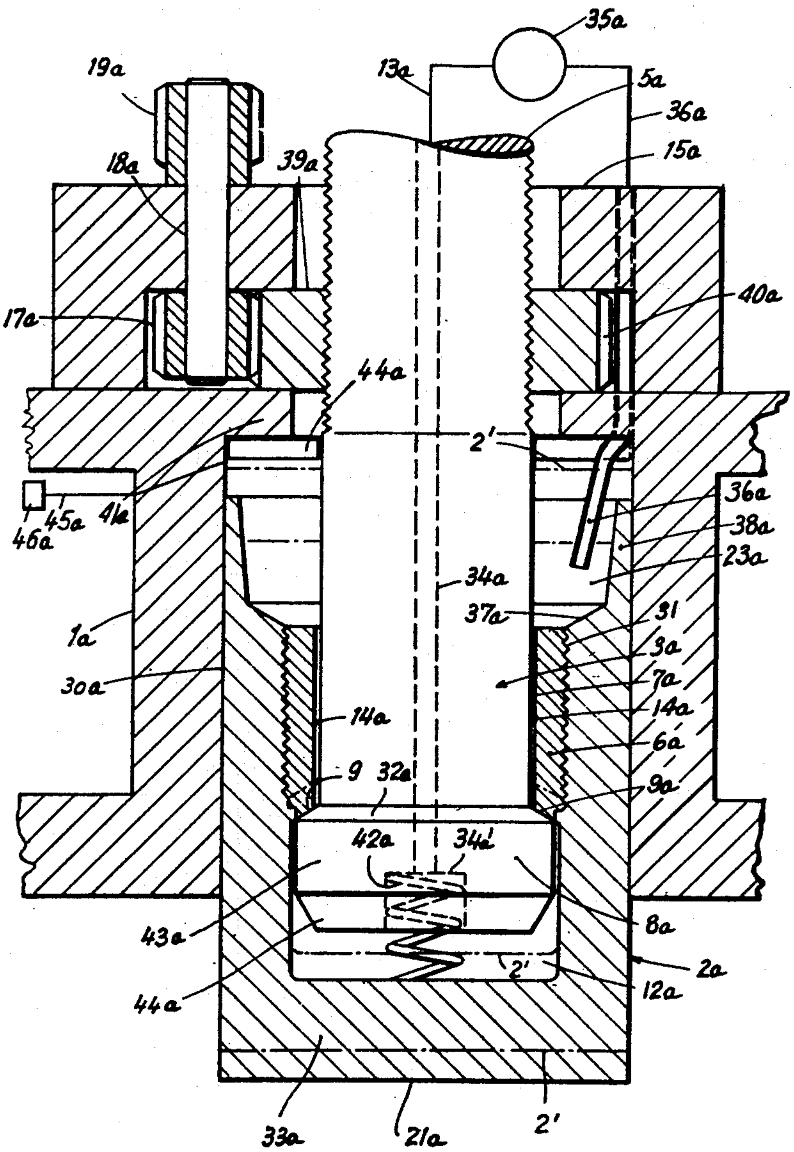

Fig. 3

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HYDRAULIC OVERLOAD SAFETY DEVICE

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24 Claims. (Cl. 74—584)

The present invention relates to a hydraulic overload safety device comprising in combination: two relatively movable components, a hydraulic cylinder connected to one of said components, a plunger slidable in said cylinder in the direction of the relative movement of said two components, said plunger and said movable components defining a chamber therebetween, a hydraulic fluid in operation filling the chamber bounded by the end of said plunger and said cylinder, said cylinder having a wall with a central aperture and said plunger having a neck portion passing with ample clearance through said aperture and a valve head on said neck portion beyond said aperture normally contacting an inner or outer end face of said cylinder wall adjacent said aperture forming a valve seat for said valve head, and an external source of hydraulic pressure in communication with said cylinder chamber, and in operation setting up a preloading pressure therein which keeps said valve head tightly on said valve seat as long as the pressure set up by the force between said two relatively movable components is below said preloading pressure, and allows said valve head to be lifted off said valve seat and to rapidly discharge said hydraulic fluid past said neck portion when said force generates a pressure exceeding said preloading pressure.

This construction not only assures a very quick and effective response of the valve, but moreover makes possible other important advantages by simple means, as will be explained in more detail hereinafter.

The invention is applicable not only to presses but also to rolling mills, where the overload safety device is arranged between two roller supports mounted movably relative to one another in a roller upright to be protected from overloading. The two components movable relative to one another may be in principle of any kind desired, and the overload safety device need not be structurally combined with any of them.

In the accompanying drawings, two embodiments of the invention are diagrammatically illustrated by way of example, in which:

FIG. 1 is a longitudinal section of a hydraulic safety device arranged on the carriage of a mechanical press, in the normal position;

FIG. 2 is a corresponding section, but after the response of the safety device, and

FIG. 3 is a longitudinal section of a modified safety device.

In FIG. 1 the partly illustrated carriage of a mechanical press is denoted. The carriage **1** is moved up and down by means of an eccentric mechanism with respect to a stationary tool support; these components of the press are not illustrated, since they are well known. In the carriage **1** a cylinder **2** is fixed, in the interior of which a hollow plunger **3** is slidable, which has an internal screw thread **4** and is screwed on an adjustment spindle **5**. The spindle **5** passes through an opening **7** provided in the end wall **6** of the cylinder, and has a head **8**, which normally contacts the outer face **9** of the cylinder end wall **6**.

The rear annular end face **10** of the plunger **3**, the spindle **5**, the cylinder end wall **6** and the cylinder wall **11** define a cylinder space **12**, which is filled with oil. The oil is supplied to the cylinder space **12** through an oil pipe **13** by means of an oil pump (not shown) similar to the pump **35** in FIGURE 3, if desired with an accumulator interposed in order to obviate a permanent running of the oil pump. The oil pump has merely to cover the leakage losses and to make sure that in the cylinder space **12** a certain pressure is maintained, the so-called "pre-loading pressure." This pre-loading pressure may amount e.g. to about 800 atmospheres gauge, but this figure should merely illustrate the order of magnitude of the pressures in question. The pump is of each character that it precludes back-flow of fluid. By the pre-loading pressure the spindle **5** is pulled downwardly by the plunger **3**, so that the head **8** of the spindle contacts firmly and tightly the outer face **9** of the cylinder end wall **6**, and accordingly no oil can emerge from the space **12** through the annular gap **14**, which exists between the cylinder bottom **6** and the spindle **5**, which in this region does not carry a screw thread.

The head **8** of the spindle is arranged within a cap **15**, which is connected with the carriage **1** and the cylinder **2** to a rigid unit in a manner not illustrated in detail. The head **8** of the spindle is provided on top with an internal toothing **16**, which meshes with a pinion **17**, mounted on a shaft **188** which is journalled in the cap **15** and passes through the same, and which carries another pinion **19** externally of the cap **15**, which may be driven in a manner not illustrated in detail in order to turn the spindle **5** and thereby to adjust the plunger **3** with respect to the cylinder **2**. The adjustment stroke of the plunger **3** is indicated by a double arrow denoted **20**, the uppermost position of the piston end face **21** being denoted **21'**, and the lowest position **21"**.

In the lower part of the cavity **22** of the cap **15** there is contained a small oil reserve **23**, on top of which a slight air excess pressure, of for example 2 atmospheres gauge, is maintained by means of a compressed air pipe **24**.

To the lower end face **21** of the plunger **3** a tool holder (not shown) for a pressing tool is attached. The opposite pressing tool is obviously arranged on the stationary tool support, towards which the carriage **1** forming the movable tool support moves during its working stroke. The cavity **25** existing in the lower portion of the hollow plunger **3** and bounded on top by the spindle **5** is in communication with the cylinder space **12** through a duct **26** provided in the plunger **3**, and is accordingly likewise filled with oil under pressure.

The device described operates as follows: When during the working stroke of the carriage **1** the force arising between the tools and the work piece to be pressed does not exceed a predetermined limit, which is proportional to the pre-loading pressure, the plunger **3** moves as a rigid unit together with the carriage **1** and the components connected therewith. The tensile force on the spindle generated by the pre-loading pressure above the plunger **3** is reduced by the amount of the pressing force but yet holds the head **8** of the spindle tightly against the outer face **9** of the cylinder end wall **6**. As soon as the pressing force exceeds the limit, the head **8** of the spindle is slightly lifted off the outer face **9** of the cylinder end wall, so that oil from the cylinder chamber **12** enters into the cavity **22** of the cap through the gap **14**. As soon as even a little oil emerges from the cylinder space **12**, the pressure in this space **12** and accordingly also the resistance to the pressing force drops very sharply, so that the head **8** of the spindle, which serves as a valve head, moves abruptly away from the face **9** serving as a valve seat, and the oil may enter into the cavity **22** of the cap without finding a throttling resistance between the head **8** of the spindle and the face **9**. The gap **14** may be made without any difficulty so wide that its throttling resistance may be neglected. FIG. 2 shows the position of the components after the response of the safety device to an excessive pressing force.

In the known hydraulic overload safety devices there is likewise a plunger slidable in a cylinder, and a pre-loading pressure is maintained in the cylinder chamber. To this cylinder space an outlet duct is connected, wherein there is a valve responsive to excess pressure. This valve, the valve head of which is loaded, e.g., by means of a spring, does not however work so abruptly as the valve **8, 9**, since its valve head is subject to the bias of the spring forcing it towards its closed position even after the response pressure has been reached. Other known valves likewise do not operate quickly enough for the present purpose. It is accordingly very difficult with the known devices to pass during a very short period of, e.g., 1/10 of a second sufficient oil from the cylinder space through the valve for preventing a further rise of the pressing force during the working stroke and thus to obviate damage to the pressing tools and/or the press itself.

The safety device described has not only the advantage that it responds very rapidly and is accordingly applicable to mechanical presses having relatively high numbers of strokes per minute, and for which the known safety devices would fail, but has the further advantage that its construction solves in an extremely simply way even other problems of importance for a mechanical press.

With the known presses it is usual to make the tool holder adjustable with respect to the carriage by means of a spindle, in order to be capable of varying the distance between the two press tools. In order to make the play in the screw thread of the spindle ineffective, it is necessary to arrange a lock nut at the upper end thereof. This lock nut, which is in a rather inaccessible position at the upper portion of the carriage, has to be loosened for any alteration in the position of the upper pressing tool, and has to be firmly tightened after the adjustment of the spindle.

With the device described this lock nut can be dispensed with, since the pressure oil takes over its function thereby that it holds the plunger **3** in the lowest position of the play in the screw thread with respect to the spindle **5**. For adjusting the plunger **3**, it is only necessary to bring the duct **13** into communication with the atmosphere so that no pressure prevails any more in the cylinder chamber **12**, whereafter the plunger **3** can be adjusted comfortably with respect to the cylinder **2** by driving the pinion **19**, e.g. by means of a small motor.

A further advantage of the device described consists in that the oil pressure prevailing in the interior **25** of the plunger tends to expand the plunger **3** and accordingly to force it against the cylinder wall **11** in the manner of a chuck. The plunger is accordingly connected very rigidly with the cylinder **2** during the operation of the press as required for an accurate working of the press. When the pressure is released for the adjustment of the plunger, the pressing of the plunger against the cylinder wall ceases so that it does not hamper the adjustment of the plunger.

It should be remarked that the duct **26** is not indispensible, since the play in the thread of the spindle **5** may constitute a sufficient communication between the chambers **12** and **25**. However, the duct **26** facilitates the passage of the oil from one chamber to the other, when the spindle **5** is driven by means of the pinion **19** for the adjustment of the plunger **3**. Moreover the duct **26** has the effect that upon response of the safety device the pressure drops very rapidly also in the interior **25** of the plunger, and accordingly also the friction between the plunger and the cylinder wall is reduced immediately. The duct **26** may naturally be provided alternatively in the spindle **5**.

The oil pressure prevailing in the interior **25** of the plunger effects a stiffening of the bottom of the plunger during the operation of the press. The air pressure prevailing on top of the oil reserve **23** serves for restoring the plunger **3** into the normal position after a response of the device, for which purpose obviously the oil pressure in the cylinder chamber **12** has to be switched off.

It is clear that the safety device described could be fitted alternatively to the stationary tool support (not shown) instead of to the movable tool support **1**. In practice however, in view of the general assembly of the press and of its operation, the solution illustrated will be preferred.

By the safety device illustrated in FIG. 3 a considerable improvement in respect of the embodiment according to FIGS. 1 and 2 is attained thereby that, instead of an outer face, an inner face of a cylinder wall is used as a valve seat, the head of the plunger then being obviously inside instead of outside the cylinder.

The following is a description of the invention shown in FIGURE 3.

The carriage (shown only partially) of a mechanical press is likewise denoted by the reference character **1**, which is movable in a known manner up and down with respect to a stationary lower tool support (not shown). The carriage has a vertical bore **30a**, wherein a cylinder **2a** is guided. A plunger, which is slidable in the cylinder **2a**, is provided with a head **8a** serving as a valve head, which is however located inside the cylinder **2a** instead of outside the same. In the cylinder **2a** a bushing **6a** having an external screw thread is screwed, which constitutes a cylinder wall having an aperture **7a**. Between the aperture **7** and the neck of the plunger **3a** there exists an annular gap **14a**. The inner face **9a** of the cylinder wall, which serves as a valve seat, is conical, and normally a complementary conical face **32a** of the head **8a** rests firmly and tightly on the same.

In contrast to the FIGS. 1 and 2, the cylinder **2a** is not open on its end opposite its wall **6a**, but is closed by a full lower end wall **3a**, and at its lower end face **21a** a tool holder (not shown) for a press tool is mounted. The other press tool is naturally mounted on the stationary tool supports, towards which the carriage **1**, which constitutes the movable tool support, moves during its working stroke.

The cylinder space **12a** is filled with oil, which is supplied to it through a central bore **34a** of the plunger **3a**. The bore **34a** is fed through a pressure oil pipe **13a** from a high pressure pump **35a** for e.g. 1000 atmospheres gauge the suction pipe **36a** of which is connected to an oil reservoir **23a**. The pump **35a** is of such a character that it precludes back-flow of fluid. The oil reservoir **23a** is bounded by the bushing **6a**, a conical end face **37a** of the cylinder **2a** and a skirt **38a** projecting upwardly from the same.

The plunger **3a** has an upper portion **5a** on which is mounted a nut **39a**, which has a toothing **40a**. The nut **39** bears on an inner flange **41a** of the carriage **1**, on which a cap **15a** is attached in a manner not shown in detail. The toothing **40a** of the nut **39a** meshes with a pinion **17a**, which is mounted on a shaft **18** passing through the cap **15a** and carrying another pinion **19a** externally of the cap **15a**, which may be driven in order to turn the nut **39a** and thereby to adjust the plunger **3a** together with the cylinder **2a** in the vertical direction for the purpose of adjusting the level of the lower end face **21a**, of the cylinder to the level of the press tools.

Adjacent the lower end face of the head **8a** of the plunger the central bore **34a** of the plunger **3a** has an annular shoulder **34a'**, on which bears the upper end of a comparatively weak spring **42a** which abuts below the bottom **33a** of the cylinder. The head **8a** of the plunger has a cylindrical main portion **43a**, the diameter of which is smaller than the inner diameter of the cylinder **2a**. This main portion is followed on top by a conically convergent portion with the conical sealing face **32a**, and below by a portion **44a** converging conically downwardly.

The device described operates as follows:

When during the working stroke **1** the force arising between the tools and the work piece to be pressed does not exceed a pre-determined pre-loading pressure of e.g. 1000 atmospheres gauge prevailing in the cylinder space **12**, the cylinder **2** with the carriage **1** moves downwardly, the pressing force being transmitted to the cylinder **2***a* from the carriage **1** through the cap **15***a*, the nut **39***a*, the plunger **3***a* and the pressure oil contained in the cylinder space **12***a*. As soon as the pressing force exceeds the limit, the cylinder **2***a* slides slightly upward with respect to the piston **3***a*, so that the valve **8***a*, **9***a* opens, and oil flows from the cylinder chamber **12***a*, through the annular gap **14***a* into the oil reservoir **23***a*. Consequently the pressure drops in the cylinder chamber **12**, so that the cylinder **2***a* moves abruptly upwardly into the position **2'** indicated in chain-dotted lines, almost the whole of the oil contained in the cylinder chamber **12***a* flowing extremely rapidly into the oil reservoir **23***a*.

When the pressure on the end face **21***a* of the cylinder **2***a* diminishes, the spring **42***a* biases the cylinder **2***a* away from the head **8***a* of the plunger, so that the oil flows back through the open valve **8***a*, **9***a* into the cylinder chamber **12***a*, and after the closing of the valve **8***a*, **9***a*, the high-pressure pump **35***a* restores the pre-loading pressure desired.

In order that the pump **35***a* need not operate continuously, an accumulator may be provided, which may for example be constructed as a pressure multiplier. As compared with the embodiment according to FIGS. 1 and 2, the present embodiment has the advantage, that no seal has to be provided in order to prevent a leakage of the pressure oil from the cylinder chamber **12***a*. In the embodiment according to the FIGS. 1 and 2, the plunger has a sliding surface guided on the inner wall surface of the cylinder, and along this sliding surface leakage of the pressure oil from the cylinder would be possible, or such a leakage has to be prevented by special measures, e.g. by providing piston rings, which owing to the high oil pressure is a delicate task.

A further advantage of the present device is that for the same limit of the pressing force, the cylinder **2***a* can be kept smaller than that of the device according to the FIGS. 1 and 2.

It is clear that the safety device according to FIG. 3 is likewise applicable not only to presses but also to other machines, e.g. rolling mills.

In FIG. 3 a modification is indicated, according to which the oil reservoir **23***a* is closed on top by an annular cover plate **44***a* indicated in chain-dotted lines, which is sealed against the plunger **3***a* by means of a seal (not shown) for example inserted into an annular groove, and by a further seal (likewise not shown) against the internal flange **41***a*. A pipe **45***a* indicated by a single chain-dotted line issues immediately below the cover plate **44** into the oil reservoir **23***a*, which includes in this case moreover a small space existing above the skirt **38***a* in the interior of the carriage **1**. The pipe **45***a* may be supplied from a source **46***a* with a fluid, for example air or oil under a comparatively low pressure, of i.e. 5–10 atmospheres gauge. Thereby the necessity is obviated of providing the spring **42***a*, which—as explained herein above—effects a closure of the valve **8***a*, **9***a* after a response of the device to an overload, oil flowing from the reservoir into the cylinder chamber **12***a*. The return flow of the oil and the closure of the valve is here effected by the compressed air or by the oil supplied under low pressure e.g. by an oil pump having an output which is large as compared with that of the high-pressure pump **35***a*. After the closure of the valve **8***a*, **9***a*, the high-pressure pump **35***a* restores the required high pressure of e.g. 1000 atmospheres gauge in the cylinder chamber **12***a*. Instead of by a low pressure pump of comparatively large output, the source **46***a* may be constituted by a low-pressure oil accumulator, i.e. of a closed container, in which there is contained partly oil and partly air of e.g. 5–10 atmospheres gauge, the low-pressure oil pump feeding oil continuously into the container until the prescribed pressure is attained therein, whereafter the pump is switched off or is made to work idly over a by-pass valve.

If desired, an observation glass may be provided for indicating the oil level in the oil reservoir **23***a*.

While we have herein described and illustrated in the accompanying drawing what may be considered typical and particularly useful embodiments of our said invention we wish it to be understood that we do not wish to limit ourselves to the particular details and dimensions described and illustrated; for obvious modifications will occur to a person skilled in the art.

What we claim as our invention and desire to secure by Letters Patent is:

1. A hydraulic overload safety device comprising in combination: two relatively movable cylinder components, a hydraulic chamber in one of said components, a plunger carried by one of said components and movable in said chamber in the direction of the relative movement of said two components, said chamber being defined by said plunger and said movable components, a hydraulic pressure fluid from an external source of hydraulic pressure in operation filling the space in said chamber, said chamber having a wall provided with a central aperture and said plunger having a neck portion passing with ample clearance through said aperture, a valve head on said neck portion beyond said aperture, said central aperture in said wall forming a valve seat for said valve head, means for subjecting said movable cylinder components to external forces, and an external source of hydraulic pressure in communication with said chamber and in operation setting up a preloading pressure therein which keeps said valve head tightly on said valve seat as long as the pressure set up by the external forces between said relatively movable cylinder components is below said preloading pressure, and allows said valve head to be lifted off said valve seat and to rapidly discharge said hydraulic fluid in said chamber past said neck portion when external forces generates a pressure exceeding a predetermined pressure limit of said preloading pressure.

2. A device as claimed in claim **1**, wherein said component, with said hydraulic chamber, is a movable tool support, and the other said component is a fixed tool support.

3. A device as claimed in claim **1**, wherein one of said components has a hollow portion with an internal screw thread, and comprising a threaded plunger screwed into said internal screw thread and forming said neck portion carrying said valve head, said valve head contacting an outer face of said cylinder wall serving as said valve seat.

4. A device as claimed in claim **3**, wherein said chamber contains a duct connecting the space between said chamber and the end of said threaded plunger with the space adjacent said apertured cylinder wall.

5. A device as claimed in claim **3**, comprising a cap fixedly connected to a cylinder forming said chamber outside said apertured chamber wall, said valve head being located between said cap and said chamber wall, and the space between said cap and said chamber wall containing pressure loaded hydraulic fluid.

6. A device as claimed in claim **5**, comprising an external source of compressed air in communication with said space between said cap and said cylinder wall.

7. A device as claimed in claim **5**, comprising a toothed gearing in driving connection with said threaded plunger, and capable of adjusting the axial position of said plunger relative to said chamber by turning said threaded spindle in said internal screw thread of said plunger.

8. A device as claimed in claim **7**, wherein said toothed gearing is arranged partly outside said cap.

9. A hydraulic overload safety device comprising in combination: two relatively movable cylinder components, a hydraulic chamber in one of said components, a plunger slidable in said chamber and movable in the direction of relative movement of said two component, said chamber being defined by said movable components and said plunger, a pressure loaded hydraulic fluid filling the space in said chamber, said chamber having a first wall with a central aperture and said plunger having a neck portion passing with ample clearance through said aperture, a valve head on said neck portion beyond said aperture, an inner face of said chamber wall forming a valve seat for said valve head, means for subjecting said movable components to external forces, and in external source of hydraulic pressure in communication with said chamber and in operation setting up a preloading pressure therein which keeps said valve head tightly on said valve seat as long as the pressure set up by the external forces between said relatively movable cylinder components is below said preloading pressure, and allows said valve head to be lifted off said valve seat and to rapidly discharge said hydraulic fluid past said neck portion when said external forces generates a pressure further compressing the pressure loaded hydraulic fluid until said external forces exceed a predetermined pressure limit.

10. A device as claimed in claim 9, in which the cylinder component is provided with an end wall having an outer end face in operation serving for the attachment of an external tool holder.

11. A device as claimed in claim 9, comprising a bushing screwed into said cylinder component, an end face of movable said bushing forming said apertured chamber bottom.

12. A device as claimed in claim 9, wherein said plunger has a longitudinal bore in communication with said external source of hydraulic pressure and with the cylinder space bounded between said valve head and said second, full, cylinder bottom.

13. A device as claimed in claim 9, wherein said plunger has an externally screw-threaded portion, and comprising a nut screwed on said screw-threaded portion serving for adjusting said plunger relative to said component to which is it attached.

14. A device as claimed in claim 9, comprising a compression spring arranged between said second, full, chamber bottom and said valve head.

15. A device as claimed in claim 9, comprising a fluid reservoir arranged outside adjacent said first, apertured, chamber bottom.

16. A device as claimed in claim 15, comprising a fluid level indicator in communication with said fluid reservoir.

17. A device as claimed in claim 15, comprising an external high-pressure fluid pump having a suction pipe dipping into said fluid reservoir, and a pressure pipe in communication with said chamber space bounded between said valve head and said cylinder bottom.

18. A device as claimed in claim 17, comprising a skirt arranged on said cylinder and circumferentially bounding said fluid reservoir.

19. A device as claimed in claim 18, wherein said fluid reservoir is sealed outwardly, and comprising an external source of a fluid pressure lower than said pre-loading pressure in communication with said sealed fluid reservoir.

20. A device as claimed in claim 19, wherein said source of lower fluid pressure supplies air.

21. A device as claimed in claim 19, wherein said source of lower fluid pressure supplies the same sort of fluid as said fluid contained in said hydraulic chamber.

22. A device as claimed in claim 21, wherein said source of lower fluid pressure comprises an oil pump.

23. A device as claimed in claim 21, wherein said source of lower fluid pressure comprises an oil pressure accumulator.

24. A hydraulic overload safety device comprising inner and outer relatively movable cylinder components, a restricted wall portion formed in one of said components, a plunger adjustably mounted in the other of said cylinder components projecting through an aperture in said wall portion, a chamber defined by said movable cylinder components and plunger, an enlarged head on said plunger movable in said chamber on one side of said wall portion, said chamber being pressure loaded with a hydraulic fluid filling the space in said chamber, external pressure means for supplying said hydraulic fluid to said chamber, the aperture in said wall portion being of a diameter slightly greater than said plunger to provide a clearance space through the aperture in said wall, means for subjecting said movable cylinder components to external forces, said enlarged head and said wall surrounding said aperture forming a valve structure in a normally closed position which is opened when the external forces between said cylinder components for further compressing the pressure loaded hydraulic fluid until said external forces exceeds a predetermined pressure limit, whereby the hydraulic fluid in said chamber will escape through the aperture in said wall and permit relative movement between the plunger and movable cylinder component.

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