Jan. 20, 1970 A. U. HAANES 3,490,757

EXTERNALLY-RETRACTED RECIPROCATORY HYDRAULIC SPRING

Filed Sept. 13, 1967

FIG. 1

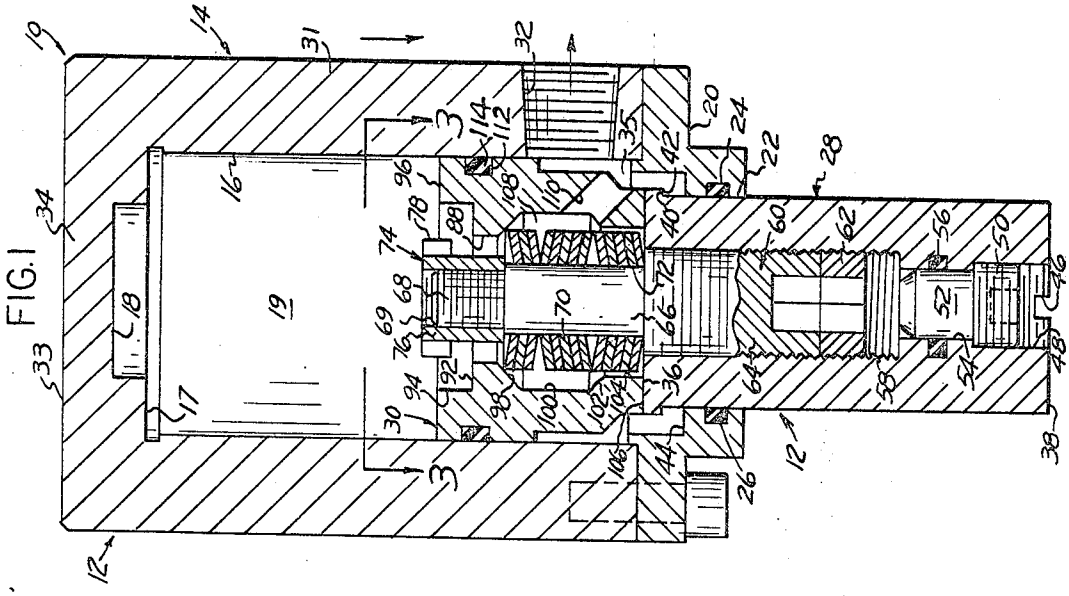


FIG. 2

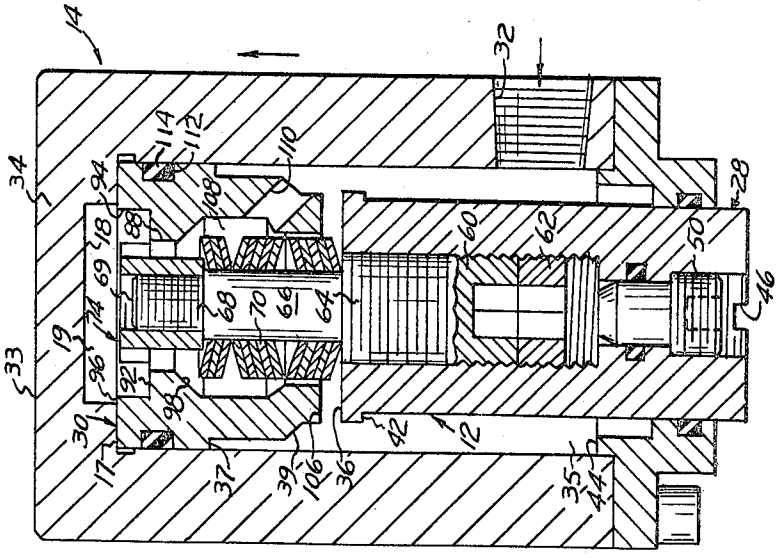
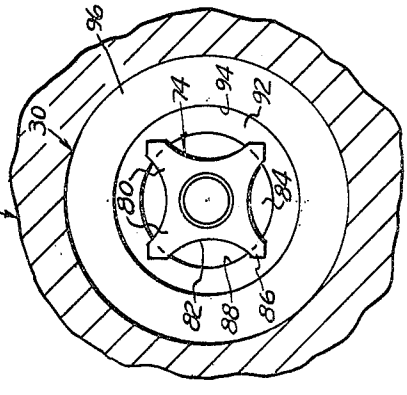


FIG. 3



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EXTERNALLY-RETRACTED RECIPROCATORY HYDRAULIC SPRING

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U.S. Cl. 267—1 10 Claims

ABSTRACT OF THE DISCLOSURE

This reciprocatory hydraulic spring for replacing metallic springs such as are used in die sets for gripping a workpiece blank during forming, as in a press, utilizes an external source of hydraulic pressure fluid to retract the plunger after a working stroke has been completed, thereby achieving a much more compact device by eliminating the space required for the metal helical spring employed in prior self-contained hydraulic springs for retraction of the plunger. The plunger has a hollow piston head with a fluid passageway therethrough, this head being slidable along a piston rod provided with concavo-convex spring washers and an adjustment screw for varying their pressure. During a working stroke, as the press platen descends, the fluid subjected to pressure in the downwardly-moving cylinder escapes through this passageway to an external accumulator which is maintained under pneumatic pressure by compressed air from the factory compressed air supply line. During the upward stroke of the press platen, retraction of the plunger is brought about by the pressure of the hydraulic fluid returning to the rearward side of the piston head in response to the pressure exerted thereon by the accumulator.

In the drawings,

FIGURE 1 is a central vertical section through an externally-retracted reciprocatory hydraulic spring, according to one form of the invention, with the moving parts in their positions occupied at the beginning of a working stroke;

FIGURE 2 is a view similar to FIGURE 1 but with the moving parts in the positions occupied at the beginning of a retraction stroke; and

FIGURE 3 is a cross-section taken along the line 3—3 in FIGURE 1, showing the retaining nut construction with its fluid passageways.

Referring to the drawing in detail, FIGURES 1 and 2 show an externally-retracted reciprocatory hydraulic spring according to the invention, generally designated **10**, as consisting generally of a plunger **12** reciprocable relatively to and mounted within a cylinder **14**. The latter is ordinarily adapted to be subjected to a pressure in response to the descent of a press platen which is engaged in closing the components of a die set operating upon a metal blank yieldingly held or supported by one or more of the hydraulic springs **10** of the present invention. The cylinder **14** is provided with a cylinder bore **16** which, with its upper end surface **17** containing a counterbored recess **18**, defines a hydraulic fluid working chamber **19**. At its lower end, an annular cylinder head **20** is bolted to the cylinder **14** and provided with a central bore **22** and annular recess **24** with packing **26** for the passage and sealing respectively of the hollow piston rod **28** of the plunger **12** carrying the hollow sliding piston head **30**.

The cylinder **14** adjacent the cylinder head **20** is provided with a threaded port **32** in the side wall **31** thereof remote from the cylinder upper end surface **33** of the end wall **34** containing the recess **18**. The port **32**, during use, is connected by piping to a conventional hydraulic accumulator (not shown) which in turn is connected to

a compressed air line of the factory. Such compressed air line ordinarily carries compressed air under pressure of approximately 80 pounds per square inch. This in turn exerts pneumatic pressure upon the hydraulic fluid, ordinarily hydraulic oil, which is forced into the accumulator during the working stroke of the press and expelled from the accumulator by the pneumatic pressure to achieve retraction of the hydraulic plunger **12** in the manner explained below. Adjacent the cylinder head **20** at the lower end of the cylinder bore **16** is a hydraulic lower or fluid retraction chamber **35** beneath the piston head **30** which has annular retraction piston areas **37**, **39** and **106** thereon, the latter being the lower end of the head.

The piston rod **28** of the hydraulic plunger **12** has inner and outer end faces **36** and **38** respectively, the inner face **36** being formed on the end of a slight enlargement **40** of the piston rod **28** providing an annular abutment shoulder **42** engageable with the counterbored central inner face **44** of the cylinder head **20** as a stop. The outer end face **38** is provided with diametrally-aligned spanner notches **46** on opposite sides of a threaded central outer bore **48** containing a threaded screw closure plug **50**. The closure plug **50** has an inwardly-extending integral cylindrical nose **52** which snugly engages a reduced diameter bore **54** annular recessed to receive a conventional sealing O-ring **56**. The inner end of the nose **52** is tapered for ease of passage through the O-ring **56**. The closure plug **50** is hexagonally recessed for the reception of a conventional Allen wrench (not shown) for its insertion or removal.

The hollow piston rod **28** is provided with an inner threaded bore **58** extending from the reduced diameter bore **54** to the inner end face **36** thereof and containing a hexagonally-recessed-pressure-adjusting screw **60** which is locked in its adjusted position by a hexagonally-bored lock nut **62**, both being adjusted by means of a conventional Allen wrench. The adjusting screw **60** on the inner end of its outer threaded portion **64** is provided with a smooth cylindrical intermediate diameter portion **66** extending inward and upward from the threaded outer portion **64**. The latter in turn terminates in a reduced diameter threaded inner end portion **68** with a top surface **69**. Stacked upon the intermediate portion **66** are multiple convexo-concave spring washers **70**, the lowermost of which engages the annular shoulder **72** between the adjusting screw portions **64** and **66**. The uppermost spring washer **70** acts as a movable valve member in the manner described below, and is retained in position by a retaining nut **74** threaded upon the inner end portion **68**. The nut **74** has a tubular interally-threaded shank **76** terminating in a cross-shaped head **78** (FIGURE 3) which has arms **80** separated from one another by arcuate cutaway portions **82** providing fluid passageways **84**.

The outer ends **86** of the arms **80** of the retaining nut **74** extend radially outward beyond a central bore **88** in the hollow piston head **30** sufficiently to overhang (FIGURE 1) and during operation engage (FIGURE 2) an annular shoulder **92** between the bore **88** and a counterbore **94** (FIGURE 1) extending downward from the inner end face **96** of the hollow piston head **30**. The latter below the bore **88** has an annular beveled shoulder **98** which serves as a valve seat for the uppermost spring washer **70** and extends from the bore **88** to an enlarged bore **100**. From the lower end of the bore **100** an annular beveled shoulder **102** extends downward to a lower bore **104** which in turn extends downward to the annular lower face **106** of the piston head **30**. The bores and bevel portions **100**, **98** and **102** define an intermediate spring chamber **108** containing the spring washers **70**, the upper ends of which engage the bevel surface **98** as a valve seat and the lower ends the annular shoulder **72** on the pressure-adjusting screw **60**. The spring washers **70** during

the retraction stroke of the hydraulic plunger **12** (FIGURE 2) are loose and relaxed, whereas upon a working stroke (FIGURE 1) they are in a state of compression. The spring chamber **108** has an inclined fluid port **110** communicating with the cylinder port **32** through the side wall of the hollow piston head **30**.

In the installation of the invention, let it be assumed that one or more of the reciprocatory hydraulic springs **10** of the present invention are mounted either in the press bed or die set or in the press platen or ram itself of a metal forming press, such as in suitable vertical bores therein snugly receiving the cylinders **14** with the axes of their cylinder bores **16** parallel to the direction of travel of the platen. In a typical installation, the piston rods **28** extend downward from the cylinders **14** toward the hold-down pad, blank holder or other portion of the die set or machine element upon which pressure is to be exerted by the lower end faces **38** of the piston rods **28**. Let it also be assumed that the threaded ports **32** at the lower ends of the cylinders **14** have been connected by suitable piping (not shown) to a hydraulic accumulator which in turn is connected to a compressed air supply line for supplying the pneumatic pressure above the hydraulic fluid, such as oil, in the storage chamber of the accumulator. Let it finally be assumed that the press ram or platen is in its raised position and that each hydraulic spring **10** is in its open position shown in FIGURE 1, ready for the performance of a working stroke.

In the operation of the invention, as the press platen or ram (not shown) descends to perform a working stroke and moves the cylinders **14** downward by exerting pressure on the upper end surface **33** of each cylinder **14**, the hydraulic fluid in the working chamber **19** transmits this pressure to the upper end surfaces **92** and **96** of the piston head **30**, forcing the latter downward and at the same time compresses the spring washers **70** while flexing the uppermost spring washer **70** downward away from its valve seat **98**. The piston rod **28** moves downward through the short distance represented by the gap between the surfaces **106** and **36** (FIGURE 2) until the arms **80** of the retaining nut **74** (FIGURE 3) engage the annular shoulder **92** and it is brought to a halt against the blank holder or other part upon which it is intended to exert pressure.

As the cylinder **14** continues to be pushed downward by the press ram or platen, it forces hydraulic fluid from the the chamber **19** past the cutout portions **82** of the retaining nut **74** (FIGURE 3) and through the counterbore **94** and bore **88** past the peripheries of the flexed spring washers **70** and through the spring chamber **108** and the fluid port **110** into the lower chamber **35** and thence out through the cylinder side wall port **32** to the accumulator (not shown) where the rising level of the hydraulic fluid further compresses the air above it. This action continues until the cylinder **14** has descended to its full extent so that the upper end surface **96** of the piston head **30** comes to rest against the end surface **17** of the hydraulic working chamber **19**. At the same time, the lower end **106** of the piston head **30** has remained in abutting engagement with the upper end surface **36** of the hollow piston rod **28**, as shown in FIGURE 1, with the spring washers **70** in their compressed condition.

When the press platen or ram has reached the end of its downward stroke (FIGURE 2) and the hydraulic spring **10** has reached its fully closed position, the reversal of the press and the consequent beginning or the upward stroke causes hydraulic fluid under the pressure of the compressed air in the upper part of the hydraulic accumulator (not shown) to move through the cylinder side wall port **32** into the lower end chamber or retraction chamber **35** of the cylinder bore **16** beneath the piston head **30**, where it acts against the area **36** to move the piston rod **28** downward. At the same time, the fluid also flows through the inclined port **110** and spring chamber **108**, past the space between the spring washers **70** and the valve seat **98**, through the bore **88** and counterbore **94** into the recess **18** to refill the working chamber **19** of the cylinder **14**. The frictional drag of the piston head sealing ring **114** in the piston head groove **112** causes the piston head **30** to resist downward motion until forcibly pulled downward by the piston rod **28** when the ends of the arms **80** of the retaining nut **74** move into engagement with the annular shoulder **92** (FIGURES 2 and 3). This downward or opening motion continues until the plunger **12** reaches its fully extended position shown in FIGURE 1, whereupon the hydraulic spring **10** is ready for the performance of another working stroke. In the meantime, the die set (not shown) operated by the press platen or ram (also not shown) has completed the forming operation on the workpiece blank and the formed workpiece is ready to be ejected from the die set in the usual manner, by a knock-out device or other conventional ejection device.

The pressure at which hydraulic fluid will be discharged from the working chamber **19** through the hollow piston head **30** into the retraction chamber **35** and thence through the cylinder port **32** to the hydraulic accumulator is adjusted by adjusting the pressure exerted by the convexo-concave spring washer **70**. To make such an adjustment, the sealing plug **50** is first unscrewed by means of an Allen wrench and removed from the bores **48** and **54**. The lock nut **62** is then rotated reversely by means of an Allen wrench to loosen the grip upon the pressure adjusting screw **60**, whereupon the latter is screwed inward or outward, as desired, within its threaded bore **58** to cause the annular shoulder **72** to move inward or outward relatively to the inner end surface **36** of the hollow piston rod **28** of the plunger **12**, as most clearly shown in FIGURE 2. While this is being done, the hollow piston rod **28** is held against rotation by means of a spanner inserted in the notches **46** in its outer end. When the desired adjustment has been accomplished, the lock nut **62** is retightened against the adjusting screw **60** and the closure plug **50** is then replaced and screwed into its bore **48**, sealing the bore **54** by its engagement with the O-ring **56**.

The term "externally-retracted" as used herein will be understood to mean that the source of pressure which effects return of the plunger **12** and cylinder **14** from their closed position of FIGURE 2 to their open position of FIGURE 1 is located externally of the hydraulic spring **10**. This is in contradistinction to the use of mechanical springs located internally of the cylinder itself for effecting such retraction, as in the hydraulic spring disclosed and claimed in my co-pending application Ser. No. 499,442 filed Oct. 21, 1965 for Self-Contained Reciprocatory Hydraulic Spring, now U.S. Patent No. 3,350,087 issued Oct. 31, 1967.

I claim:

1. An externally-retracted reciprocatory hydraulic spring, comprising:

a cylinder having a hydraulic working chamber adjacent one end thereof and a hydraulic retraction chamber adjacent the opposite end thereof with a cylinder port near said opposite end adapted to be connected to an external pressurized hydraulic fluid accumulator, and

a plunger reciprocably mounted in said cylinder and having a piston rod extending through said opposite end of said cylinder to the exterior thereof and a hollow piston head movably mounted on said piston rod for sliding motion relatively thereto,

said hollow piston head having a fluid passageway therethrough leading from said working chamber to said retraction chamber,

said plunger having spring-pressed valve means normally closing said piston head passageway and responsive to the attainment of a predetermined pressure in said working chamber for opening communication therethrough from said working chamber through said retraction chamber to said cylinder port whereby to discharge

hydraulic fluid from said working chamber through said cylinder port.

2. An externally-retracted reciprocatory hydraulic spring, according to claim 1, wherein said hollow piston head has a valve seat communicating with said passageway, and wherein said valve means includes a spring washer movable into and out of fluid flow impeding engagement with said valve seat.

3. An externally-retracted reciprocatory hydraulic spring, according to claim 2, wherein said washer is a concavo-convex spring washer adapted to flex into and out of engagement with said valve seat.

4. An externally-retracted reciprocatory hydraulic spring, according to claim 1, wherein said piston rod has a bore therethrough threaded along at least part of its length, wherein a correspondingly-threaded spring-pressure adjusting screw threadedly engages the threaded portion of said bore and has an enlargement on the inner end thereof, and wherein said spring-pressed valve means includes a spring assembly mounted on said adjusting screw between said enlargement and said piston rod whereby relative rotation between said adjusting screw and said piston rod varies the compressing force of said washer.

5. An externally-retracted reciprocatory hydraulic spring, according to claim 4, wherein said enlargement includes a threaded member threaded into the inner end of said adjusting screw.

6. An externally-retracted reciprocatory hydraulic spring, according to claim 5, wherein said threaded member comprises an internally-threaded nut having a head provided with a fluid flow opening therepast.

7. An externally-retracted reciprocatory hydraulic spring, according to claim 4, wherein said spring assembly includes a spring-pressed valve member yieldingly engaging said valve seat.

8. An externally-retracted reciprocatory hydraulic spring, according to claim 7, wherein said spring assembly also includes a plurality of convexo-concave spring washers disposed in stacked relationship on said adjusting screw.

9. An externally-retracted reciprocatory hydraulic spring, according to claim 1, wherein said fluid passageway includes a fluid port in said hollow piston head communicating with said retraction chamber.

10. An externally-retracted reciprocatory hydraulic spring, according to claim 4, wherein said enlargement extends laterally into overhanging relationship with said piston head, and wherein said piston head is movable into and out of engagement with said enlargement.

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