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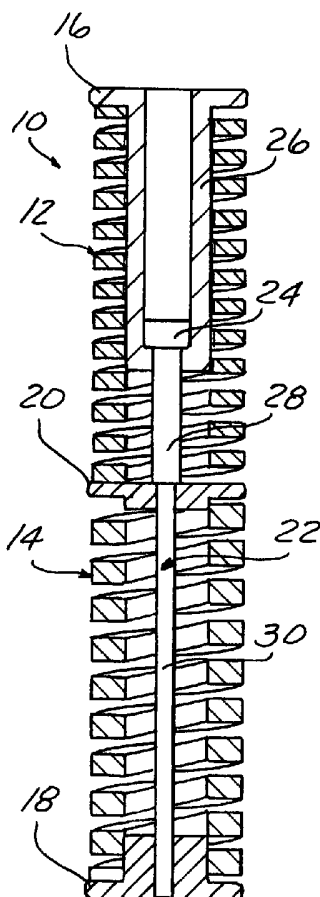
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(54) Title: LONG TRAVEL, HIGH FORCE COMBINATION SPRING



(57) Abstract: A long travel, varying spring rate combination spring includes two differing rate springs connected end-to-end in such a way that the lower rate spring is compressed until positive engagement of a plunger with an intermediate flange member occurs with the higher rate spring thereafter compressed. Each spring may be assembled separately and connected together with a coupling to create a combination spring, allowing various springs to be combined to meet the requirements of a particular application.

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1 **LONG TRAVEL, HIGH FORCE COMBINATION SPRING**

2

3 **Background of the Invention**

4 This invention concerns springs and more particularly mechanical compression
5 springs as are used to provide a return force such as in cam operated dies.

6 In cam operated tooling installed on dies in forming presses, a slide is operated
7 by the press motion to drive a tool used to form a feature on a part.

8 One or more return springs are compressed as the tool is advanced by a
9 camming action produced by the slide. When the press platens are moved apart, the
10 compressed spring or springs act to retract the slide.

11 In metal forming, it sometimes takes considerable force to withdraw a piercing
12 tool from the part, such that a high return spring force is required at the start of the return
13 motion. At the same time, a substantial slide travel is required. Very stiff coil springs have
14 limited available travel for a given space due to the thick cross section required to develop a
15 high spring rate.

16 This required combination of long travel and high peak forces has led to the
17 development and use of "nitrogen" springs in which compressed nitrogen is sealed in a chamber,
18 and further compressed by a piston having a projecting rod subjected to a load, creating a fluid
19 spring.

20 Nitrogen springs are capable of generating considerable forces while allowing
21 substantial travel, and are widely used as return springs in die cam units.

22 However, nitrogen springs have several disadvantages, including their initial
23 high cost and their need to be serviced regularly, and the fact that high cycle rates are not
24 possible due to excessive heat build up.

1 These nitrogen springs must be precharged with nitrogen under high pressure so
2 as to have an initial high spring rate.

3 This initial high spring rate creates a high shock force when the cam unit is
4 impacted by the cam driver since there is a relatively high initial resistance to cam movement
5 caused by the precharging of the nitrogen spring.

6 These disadvantages of nitrogen springs led to the development of a variable
7 force spring assembly described in U.S. Patent No. 5,390,903, assigned to the same assignee as
8 the present application.

9 The design disclosed in U.S. Patent No. 5,390,903 houses springs of different
10 stiffness in telescoped casings which are arranged to successively compress the springs, which
11 are nested together, allowing a large range of movement with low forces developed initially and
12 very high forces developed at the end of the stroke. A stack of Belleville springs is used as the
13 high rate spring.

14 The inclusion of machined casings and other components makes that device
15 relatively high in cost to manufacture, and is not easily adapted to varying applications since the
16 casings and other components must be reengineered for each application. Also, the Belleville
17 springs used are not well suited for high cycling rates, as fatigue failure commonly occurs when
18 Belleville springs are subjected to such service.

19 For this reason, there has heretofore not been any mechanical spring
20 arrangement available which has become commercially successful as a replacement for
21 nitrogen springs.

22 It is the object of the present invention to provide a mechanical spring
23 combination having a large travel, with an initial low spring rate during an initial range of

1 compression and developing a high spring force through second shorter range of compression
2 of the spring combination.

3

4 Summary of the Invention

5 The above recited object and other objects which will become apparent upon a
6 reading of the following specification and claims are achieved by combining two springs in an
7 end-to-end in series relationship, each spring having a substantially different spring rate.

8 A plunger is slidable within the lower rate spring as the lower rate spring is
9 compressed by a flange on the upper end of the plunger. The plunger in turn is slidable on a pin
10 projecting from the other end of the combination spring through the higher rate spring and into
11 the plunger. The pin has a first flange affixed thereto abutting the lower end of the high rate
12 spring and an intermediate flange above the higher rate spring is held against the other end of
13 the higher rate spring by being seated on a shoulder on the pin.

14 The plunger moves into abutment with the second flange held against the upper
15 end of the higher rate spring after a predetermined length of travel, and thereafter begins to
16 compress only the higher rate spring for the remainder of its stroke.

17 The higher spring rate spring is normally preloaded by the second flange to a
18 degree such that it is not deflected by the pressure exerted by the lower rate spring and is not
19 further compressed, until the plunger engages the intermediate flange. Alternatively, the higher
20 rate spring may be preloaded to a lesser extent such as to be allowed to be deflected at the same
21 time as the lower rate spring after the precompression level of the higher spring rate is reached
22 when a composite spring rate is affected until abutment of the plunger against the intermediate
23 flange occurs, and the only higher rate spring compressed thereafter.

1 In a second embodiment, separate spring assemblies each having a plunger,
2 connecting pin, and precompression flanges are connected together end-to-end as by a press fit
3 coupling pin mated with bores in adjacent flanges. This allows different combinations of
4 various springs to be readily provided to suit different applications.

5

6 Description of the Drawings

7 Figure 1 is a side view of a combination spring according to the present
8 invention.

9 Figure 2 is a partially sectional view of the combination spring shown in
10 Figure 1.

11 Figure 3 is a partially sectional view of the combination spring shown in Figures
12 1 and 2 with the plunger within the lower rate spring moved into abutment with the upper
13 flange to thereafter create compression of the higher rate spring by continued travel of the
14 plunger.

15 Figure 4 is a partially sectional view of the combination spring shown in Figures
16 1-3 with both springs fully compressed.

17 Figure 5 is a partially sectional view of a variation of the combination spring
18 shown in Figures 1-4.

19 Figure 6 is a partially sectional view of another variation of the combination
20 spring shown in Figures 1-4.

21 Figure 7 is a partially sectional view of a die assembly having a combination
22 spring according to the present invention installed therein.

23 Figure 8 is an exploded view in partial section of a second embodiment of a
24 combination spring according to the present invention.

1 Figure 9 is a diagram depicting the force-deflection characteristics of a typical
2 combination spring according to the present invention and for comparison a characteristic of a
3 conventional nitrogen spring.

4 Figure 10 is a diagram of another force-deflection curve for a spring
5 combination creating three stages of effective spring rates.

6

7 Detailed Description

8 In the following detailed description, certain specific terminology will be
9 employed for the sake of clarity and a particular embodiment described in accordance with the
10 requirements of 35 USC 112, but it is to be understood that the same is not intended to be
11 limiting and should not be so construed inasmuch as the invention is capable of taking many
12 forms and variations within the scope of the appended claims.

13 Referring to the drawings, and particularly Figures 1-4, a combination spring 10
14 according to the present invention is shown, including two elongated, differing rate helically
15 wound coil compression springs 12 and 14 connected together end-to-end.

16 Each spring 12, 14 is held compressed between respective end flanges 16, 18
17 and a common intermediate flange 20.

18 End flange 16 is held to the common intermediate flange 20 by a stepped
19 diameter pin 22 having a head 24 slidable within a plunger 26 connected to the associated end
20 flange 16.

21 The plunger 26 has an opening in its lower end slidably fit to a larger diameter
22 section 28 of the pin 22, allowing the plunger 26 to slide down when the flange 16 is advanced
23 to compress the lower rate spring 12 until moving into abutment with the upper surface of the
24 intermediate flange 20.

1 The smallest diameter section 30 of the pin 22 extends through a hole in the
2 intermediate flange 20 with a slidable fit, allowing the flange 20 to move down when
3 compressing the higher rate spring 14.

4 The smallest diameter pin section 30 extends within the higher spring rate 14 to
5 the end flange 18, to which it is affixed as by a plug weld. This prevents the intermediate flange
6 20 from moving away, which allows a precompression of the higher rate spring 14. The end
7 flange 18 has a pilot plug 32 extending up into the lower end of the higher rate spring 14.

8 The combination spring 10 is mounted in an installation so that the two end
9 flanges 16, 18 are able to be compressed together.

10 Different rate springs can be readily substituted into the combination to enable
11 different spring requirements to be engineered at very low cost, and different end fittings easily
12 provided as required for a given application.

13 In the first stage of compression, the lower rate spring 14 is compressed against
14 the intermediate flange 20, held in position by the precompression of the higher spring rate
15 spring 14. When the lower end of the plunger 26 contacts the intermediate flange 20, as seen in
16 Figure 3, after a traveling a distance X, this positive abutment prevents further compression of
17 the lower rate spring 12 and compression only of the higher rate spring 14 thereafter occurs
18 with continued compression of the combination spring 10.

19 The plunger 26 pushes the intermediate flange 20 off the shoulder on the
20 stepped diameter pin 22 as seen in Figure 4 to initiate compression of the higher rate spring 14.

21 Figure 9 shows the force-deflection plot for the combination spring 10 of the
22 present invention. If the precompression of the higher rate spring 14 is high enough to be in
23 excess of the peak force existing at the point when compression of the lower rate spring 12
24 ceases, then two different segments 32A, 32B of the curve result.

1 A plot 34 of a conventional nitrogen spring is also shown for comparison.

2 In Figure 10, the initial compression of the lower rate spring 12 is plotted in
3 segment 36A.

4 If the precompression of the high rate spring 14 is set to be less than in the above
5 example such that the force in the lower rate spring 12 exceeds the higher rate spring force at
6 some point during the compression of the lower rate spring 12, deflection of the higher rate
7 spring will begin at point X as seen in Figure 10 with deflection of the lower rate spring 12
8 continuing at the same time.

9 Thus, lesser composite spring rate exists from point X to point Y depicted as
10 segment 36B. Abutment of the plunger 26 occurs at point Y.

11 Thereafter, the higher spring rate of the spring 14 alone controls, depicted by
12 segment 36C.

13 The combination spring 10 can be easily redesigned for other applications, by
14 merely changing the dimensions of the relatively simple hardware items, i.e., the plunger 26,
15 the pin 22A, and substituting different springs 12A, 14A as in the combination spring 10A
16 shown in Figure 5.

17 A different plunger travel distance X_1 can also easily be set. A slight clearance
18 to eliminate any precompression of the lower rate spring 12 may be provided, if desired.

19 Different end features can be included, as the pilot end feature 32 shown in
20 Figure 5.

21 Such a pilot feature 32 can be provided at one end and a tubular extension 34 at
22 the other end in the combination spring 10B shown in Figure 6.

23 Figure 7 shows another variation of the combination spring 10C according to
24 the invention installed in a cam unit 40 adapted to be installed in a press (not shown). Such cam

1 units 40 include a driver 42 on an upper press platen which cams a tooling body 44 slidable on
2 a plate 46 mounted on a lower press platen in the manner well known in the art.

3 The body 44 moves relative the driver 42 as the press is operated closing the
4 space 45.

5 A return stripping force is created by a combination spring 10C installed in a
6 pocket 50 formed in the tooling body 44 extending in the direction of relative movement
7 between the driver 42 and body 44 so that this relative motion will compress the combination
8 spring 10C.

9 The combination spring 10C includes a boss 52 integral with the intermediate
10 flange 20C extending within the high rate spring 14C, and a boss 54 integral with the end flange
11 18 also extending within the high rate spring 14C.

12 The combination spring 10C is largely confined and supported within the bore
13 50. The protruding portion of the low rate spring 12C is internally supported by the plunger
14 26C, to eliminate any tendency to buckle.

15 A removable plug 56 is threaded into the lower end of the bore 50 and together
16 with a snap ring 58, resists the force exerted when the combination spring 10C is fully
17 compressed.

18 Other arrangements for providing a removable closure for the bore 50 are
19 described in copending application U.S. Serial No. _____, filed on _____, Attorney Docket No.
20 DNY-117.

21 Referring to Figure 8, two separate single spring assemblies 60A, 60B are
22 shown which are readily connectable together to form a combination spring according to the
23 invention. This allows a wide variety of spring combinations to be conveniently made.

1 In this arrangement, each assembly 60A, 60B holds a respective compression
2 coil spring 62A, 62B between a pair of end flanges 64A, 66A and 64B, 66B.

3 Each flange 64A, 64B, 66A, 66B has an integral boss 68A, 70A, 68B, 70B
4 projecting into the associated spring 62A or 62B.

5 A headed pin 72A, 72B is received in a bore in each boss 68A, 68B, 70A, 70B,
6 the head portion 74A, 74B slidable in the outboard boss 70A, 70B. The stem portion 76A, 76B
7 is plug welded in the opposite boss 70A, 68B. This captures the springs 62A, 62B between the
8 associated pairs of flanges 64A, 66A and 64B, 66B.

9 Thus, the outside, away flanges 64A, 64B are free to collapse to compress the
10 springs 62A, 62B respectively to the distance allowed by the spacing A, B.

11 Each spring assembly 60A, 60B is readily connectable by a coupling pin 76
12 press fit into counterbores 78A, 78B in adjacent flanges 66A, 64B.

13 Thus, various spring assemblies can be inventoried and combined in any
14 combination suited to a particular application.

15 Optional pilots 80A, 80B can be press fitted in the bases of the opposite flanges
16 64A and 66B.

17 Urethane or other compression springs can be substantial for the coil springs
18 shown, although the coil springs are preferred.

1 Claims

2

3 1. A long travel, high force combination spring comprising:
4 a first elongated spring;
5 a second elongated spring having a different spring rate from said first elongated
6 compression spring;
7 said first and second spring arranged end-to-end with an interposed intermediate
8 flange member engaging juxtaposed ends of said first and second springs;
9 a respective end flange member engaged with an opposite end of each spring;
10 said intermediate flange member and each end flange member having a driving
11 interconnection therebetween preventing further separation of said flange members from an
12 initial condition but allowing compressing relative movement of each flange member towards
13 said intermediate flange member to compress said first or second coil spring; and
14 a plunger fixed to one of said end flange members associated with one of said
15 springs and projecting within said associated spring towards said intermediate flange member,
16 said plunger contacting said intermediate flange member after a predetermined travel and
17 thereafter upon further movement compressing the other spring.

18

19 2. The combination spring according to claim 1 wherein said driving
20 interconnection includes a pin having a head slidable within a bore in said plunger and a stem
21 passing into said intermediate flange member.

22

1 3. The combination spring according to claim 2 wherein said stem extends
2 through said intermediate flange member and said other end flange member and is affixed
3 thereto.

4

5 4. The combination spring according to claim 3 wherein said pin stem
6 extends through a bore in said intermediate flange member and has a shoulder engaging said
7 intermediate flange member.

8

9 5. The combination spring according to claim 1 wherein said intermediate
10 flange member is comprised of two parts connected together, each part connected to a
11 respective end flange member to restrain separating movement between while allowing each of
12 said end flange members to move towards said intermediate flange member parts to allow said
13 springs to be compressed.

14

15 6. The combination spring according to claim 5 wherein a pin drivingly
16 interconnects each end flange member with a respective intermediate flange part.

17

18 7. The combination spring according to claim 6 wherein a coupling pin has
19 opposite ends press fit into a bore in a respective intermediate flange member parts to form said
20 combination spring.

21

22 8. The combination spring according to claim 5 wherein each pin has a
23 head slidable in a bore in an associated end flange member.

24

1 9. The combination spring according to claim 8 wherein said head of each
2 pin engages an end wall in a bore in a boss portion of a respective end flange with said
3 respective springs extended prior to compression of said combination spring.

4

5 10. The combination spring according to claim 3 wherein said head portion
6 of said pin engages an end wall of said plunger to prevent separating movement between said
7 one end flange member and said intermediate flange member prior to compression of said
8 combination spring.

9

10 11. A method of making a combination spring comprised two different rate
11 springs comprising:

12 separately assembling each spring between a set of flange members to form two
13 spring assemblies;

14 interconnecting said flange members in each spring assembly to be restrained
15 from separating but allowed to be moved together to compress said associated spring;

16 and, connecting one flange in each separate spring assembly together to create
17 a combination spring comprised of said two different springs arranged end-to-end.

18

19 12. The method according to claim 10 wherein each set of flange members
20 is interconnected by a pin having a head formed at one end slidable in a bore in a plunger
21 connected to one flange member in each flange set and a stem portion affixed to the other flange
22 member in each set.

23

1 13. The method according to claim 12 wherein said plunger is spaced from
2 the other flange member to allow travel of said one flange member to comprise a spring
3 disposed therebetween and thereafter positively engage said other flange member.

4

5 14. The method according to claim 13 wherein said connected flange
6 members are connected by press fitting each end of a coupling pin into a bore in each connected
7 flange members.

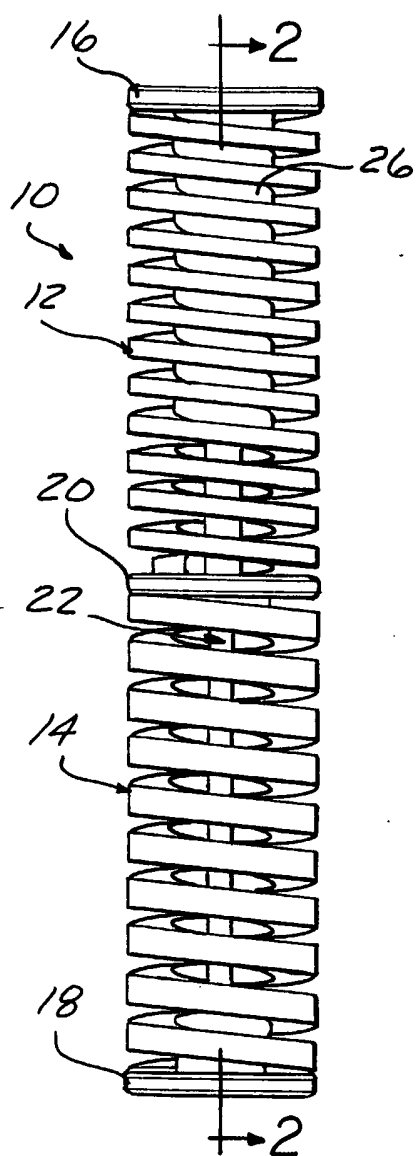


FIG. 1

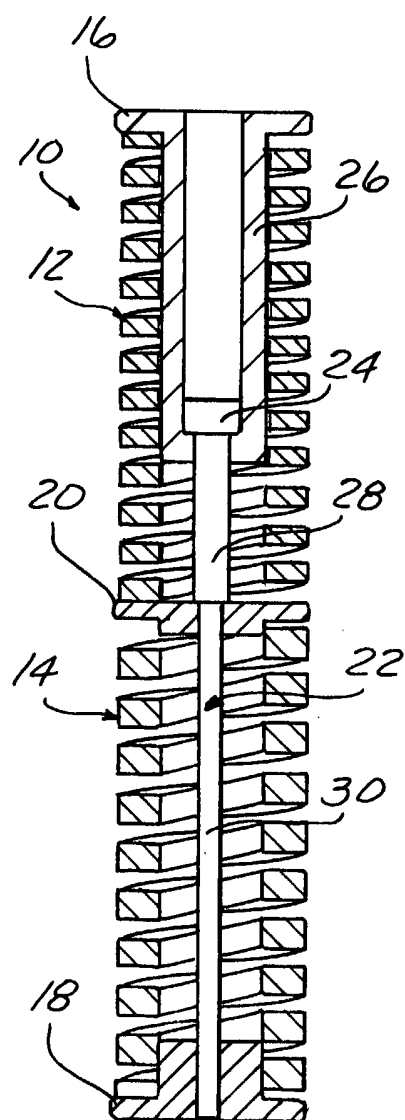


FIG. 2

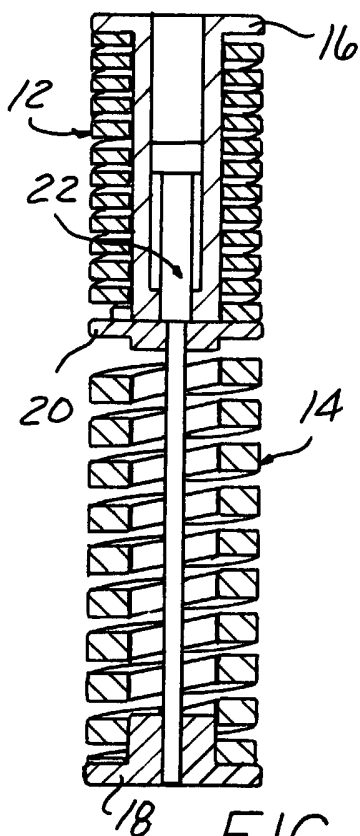


FIG. 3

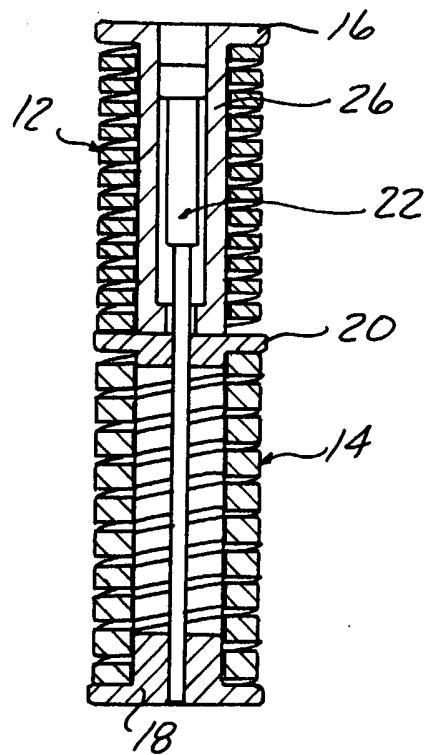


FIG. 4

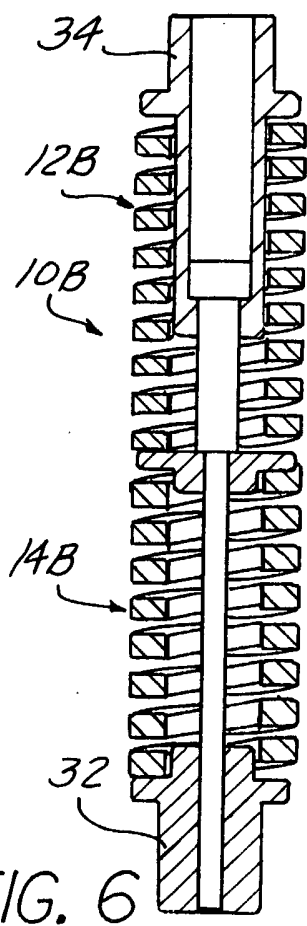


FIG. 6

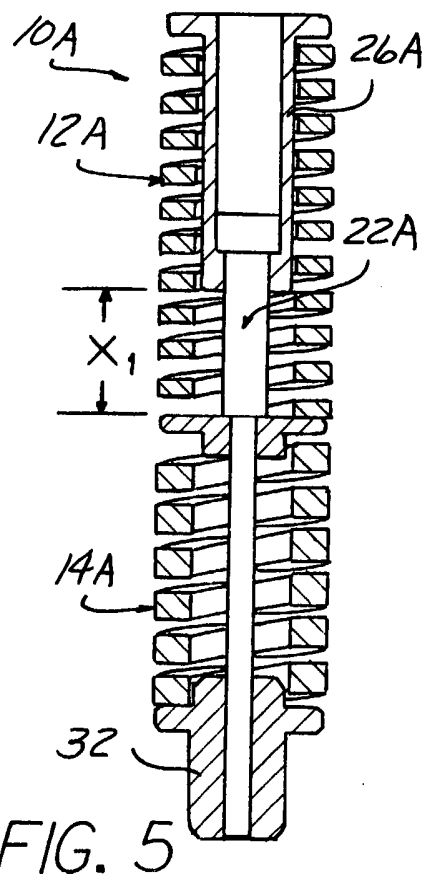
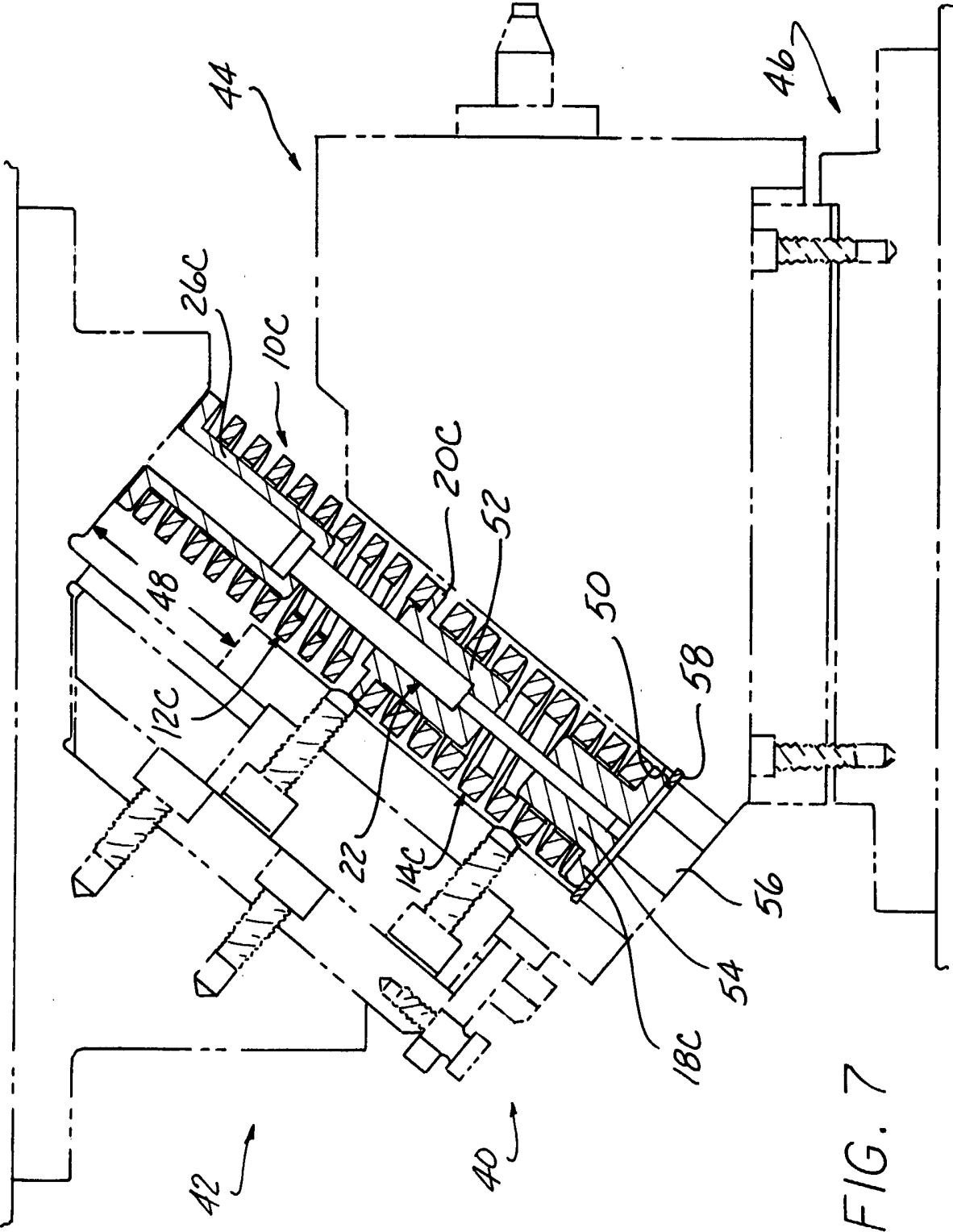


FIG. 5



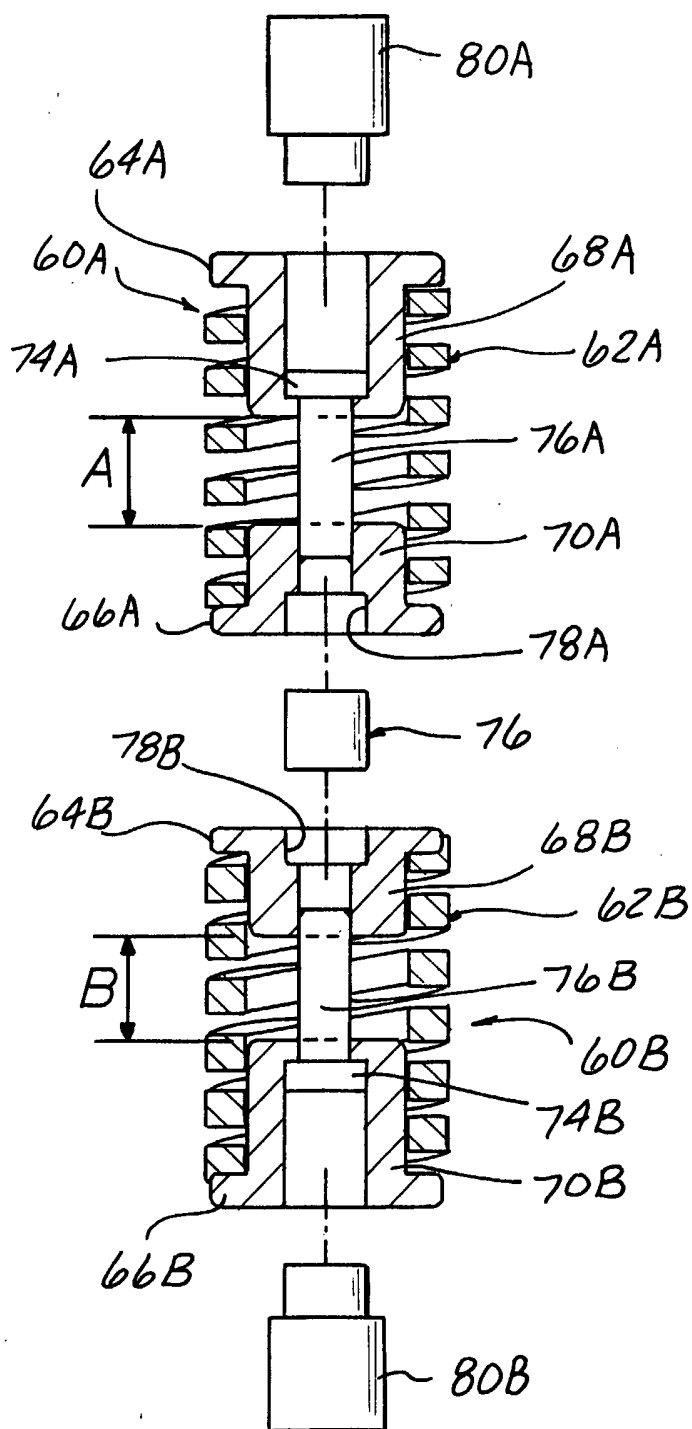


FIG. 8

