

(19) World Intellectual Property Organization  
International Bureau



(43) International Publication Date  
30 August 2001 (30.08.2001)

PCT

(10) International Publication Number  
**WO 01/63243 A2**

- (51) International Patent Classification<sup>7</sup>: **G01N 3/36**
- (21) International Application Number: PCT/US01/05697
- (22) International Filing Date: 22 February 2001 (22.02.2001)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:  
09/510,845 23 February 2000 (23.02.2000) US
- (71) Applicant: **SATURN FASTENERS, INC.** [US/US]; 425 South Varney Street, Burbank, CA 91502 (US).
- (72) Inventor: **BARKER, Raymond** (deceased).
- (74) Agent: **MOORE, Stanley, R.**; Jenkins & Gilchrist, P.C., 1445 Ross Avenue, Suite 3200, Dallas, TX 75202-2799 (US).
- (81) Designated States (*national*): AE, AG, AL, AM, AT, AT (utility model), AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, CZ (utility model), DE, DE (utility model), DK, DK (utility model), DM, DZ, EE, EE (utility model), ES, FI, FI (utility model), GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, UZ, VN, YU, ZA, ZW.
- (84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).
- Published:**  
— *without international search report and to be republished upon receipt of that report*
- For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*



**WO 01/63243 A2**

(54) Title: FASTENER TEST ASSEMBLY

(57) Abstract: A device for tension testing specimens, such as stress durability testing of aviation fasteners, is disclosed. The test assembly is a frame of horizontal and vertical member forming vertical regions in which test rigs are disposed. A load generated by a hydraulic pump and piston against the underside of the frame is translated by rods extending upwardly from floating support plates into a tensile force on the specimens, which are suspended in the test rig. In one embodiment, a manifold assembly is provided so that multiple independent tests may be performed with a single hydraulic pump. Testing may be conducted by a single operator in a remote location.

## FASTENER TEST ASSEMBLY

### BACKGROUND OF THE INVENTION

#### Technical Field of the Invention

The present invention generally relates to the field of tension testing devices, and more particularly to stress durability testing devices used in the testing of aviation fasteners.

#### Description of Related Art

Aviation fasteners used in aircraft construction must be made to exacting standards, and each such fastener is subject to various tests prior to use to help verify its safe construction. One such test involves applying a predetermined tension load along the fastener's longitudinal axis. It should be understood that this known force, which may be applied gradually or suddenly, so long as it is not fast enough to cause an impact failure, is less than the fastener's predicted tensile strength, but is sufficient to cause failure in fasteners having hidden imperfections. The load is generally maintained for a period of hours or days, but generally not less than about 20 hours, to confirm the viability of the fastener over an extended period of time.

Typically, aviation fastener stress durability testing has been performed by suspending the fastener in a test rig, then adding weights of known mass to a hook or tray attached to a coupling threaded onto the fastener's lower end until the

desired load is reached. During the test, the pounds of force applied to the fastener is measured by a load cell mounted between the test rig and the apparatus used for securely holding the fastener therein. The load cell is connected to a visual readout device or recorder.

5 Alternately, the lower coupling attached to the fastener has an opposite threaded end that is passed through a hole in a fixed plate and secured with a torquing nut. The torquing nut is tightened until the desired test load is reached.

To increase the test rig's capacity, multiple fasteners can be tested  
10 simultaneously by connecting the lower end of a fastener to a jig for holding the upper end of a second fastener, the lower end of which will also be connected to such a jig, and so on to rig capacity, with the lowest fastener in the series being connected to the weight bearing means or torquing nut.

Even using series-testing to increase capacity, however, the prior art test  
15 rig described above has several disadvantages. To begin with, when physical weights are added by an operator, the opportunity exists for dropping the weight, adding too much, or otherwise improperly stressing the fasteners being tested. Even when done properly, the procedure is cumbersome and involves the moving and storage of relatively heavy free weights. As will be demonstrated below, the  
20 instant invention helps to reduce or eliminate these disadvantages, provides for

more efficient and accurate testing, and increases the capacity of the testing device.

### SUMMARY OF THE INVENTION

The present invention is directed to a hydraulically-loaded test assembly  
5 for use in tension testing, and particularly the stress durability testing of aviation  
fasteners. A test-assembly support frame is constructed of vertical and horizontal  
members to provide a plurality of vertical testing regions. Within each vertical  
testing region one or more aviation fastener specimens are suspended from a  
coupling. The coupling is in turn attached to a load cell secured to the test-  
10 assembly frame. The threaded lower end of the fastener is then engaged by a  
second coupling, which is itself secured to a movable test plate. Alternatively, the  
second coupling is adapted to suspend another test specimen, or series of test  
specimens, which are eventually coupled to the movable plate.

Positioned below each test-assembly support-frame vertical testing region  
15 is a hydraulic cylinder capable of generating the desired load. Each cylinder is  
mounted securely to a support plate. Each support plate corresponds to one of the  
movable plates that are, in effect, suspended from the test specimens. A number  
of load transfer rods extending between the support plates and the movable plates  
transfer the load created when the hydraulic cylinders are actuated pushing each  
20 support plate away from the horizontal support frame member below which it is  
suspended. In an alternate embodiment, the hydraulic cylinders are not

individually actuated, but are operated via a manifold system connected to a single hydraulic pump.

A more complete appreciation of the present invention and the scope thereof can be obtained from the accompanying drawings which are briefly summarized below, the following detailed description of the presently-preferred  
5 embodiments of the invention, and the appended claims.

#### BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a front elevation view of a preferred embodiment of the  
10 present invention;

FIGURE 2 is a side elevation view of a preferred embodiment of the present invention, taken from section 2-2;

FIGURE 3A is a cutaway view illustrating a fastener specimen mounted for testing in accordance with an embodiment of the present invention;

15 FIGURE 3B is a cutaway view illustrating the mounting of two fastener specimens in accordance with an embodiment of the present invention;

FIGURE 3C is an elevation view illustrating how a series of fasteners are mounted in the test assembly of the preferred embodiment;

20 FIGURE 4 is an illustration of the test jig in accordance with an embodiment of the present invention;

FIGURE 5 is a schematic of the test assembly monitoring electronics of the test assembly of the preferred embodiment; and

FIGURE 6 is a schematic diagram illustrating the manifold distribution system for a test assembly according to one embodiment of the present invention.

5

#### DETAILED DESCRIPTION OF THE PRESENT INVENTION

The present invention will now be described more fully hereinafter with reference to the accompanying drawings, in which preferred embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art.

10

FIGURE 1 illustrates the present invention from a front elevation view.

15

The test assembly 100 is constructed of a front frame 110a and a back frame 110b (shown in FIGURE 2). Front frame 110a has a top beam 120a and a bottom beam 125a. Extending between top beam 120a and bottom beam 125a are a plurality of vertical risers 130a, 131a, 132a, 133a, 134a, and 135a. Back frame 110b (shown in FIGURE 2) is constructed of risers and beams in like fashion.

20

Preferably, the vertical risers of front frame 110a and back frame 110b are welded at each end to the corresponding top and bottom beam to create a rigid or semi-

rigid frame. The vertical risers 130a, 131a, 132a, 133a, 134a, and 135a are spaced sufficiently distant from each other to create vertical regions 140a, 141a, 142a, 143a, and 144a, in which the fastener test rigs, e.g. 204a, described below can operate. (Identical test rigs 200a, 200b, 201a, 201b, 202a, 202b, 203a, and 203b are not shown. Test rig 204b is shown in FIGURE 2.)

Likewise, front frame 110a and back frame 110b of test assembly 100 are preferably aligned and spaced sufficiently apart to permit operation of the test rigs. Front frame 110a and back frame 110b are held in proper juxtaposition by cross-braces 170 and 171, which are preferably welded to the upper surface of top beams 120a and 120b at or near each end. Cross-braces 170 and 171 are shown as channels, but any shape of sufficient strength can be used. Likewise, the cross-braces can be installed in alternate locations, although they should be positioned to permit operation of and access to the test rigs. Additional cross-braces may also be necessary to ensure that front frame 110a and back frame 110b are maintained in proper relation to each other during the test procedure.

Supporting front frame 110a and back frame 110b and extending between them is support assembly 180. Support assembly 180 has two cross-support plates 174 and 175 that are preferably welded to bottom beams 125a and 125b at or near each end. Cross-support plates 174 and 175 are preferably formed of a single plate bent to form an upper and lower flange, as shown, but can be constructed in other ways. Cross-support plate 174 and cross-support plate 175 are themselves

supported by mounts 172a, 172b, 173a, and 173b. Preferably, one or more of these mounts provides a means for leveling the test assembly. Mounts 172a, 172b, 173a, and 173b can alternately be replaced by or used in conjunction with wheels or casters (not shown) to facilitate relocation of the test assembly 100.

5 Lateral braces 176a and 176b extend between and are bolted or otherwise connected to the lower flanges at cross-support plates 174 and 175 to provide additional stability to support assembly 180.

Test rigs, such as 204a shown in FIGURE 1, are mounted and operate within an open vertical region, such as 144a, formed by vertical risers 134a and 10 135a. Turning now also to FIGURE 2, which shows a side elevation of the test assembly 100 (as viewed from section 2-2 shown in FIGURE 1), it can be seen that aligned vertical spaces 144a and 144b contain test rigs 204a and 204b, respectively. In this embodiment, test rigs 204a and 204b are each capable of testing one or more specimens independently of the other, as more fully described 15 below. Preferably, all of the test rigs in test assembly 100 are similarly constructed, and for simplicity, the components of only two such assemblies are described. It is anticipated, however, that modifications to one or more of the test rigs may be made, for example, to accommodate specimens of differing sizes and shapes, without departing from the spirit of the invention.

20 Test rig 204a is preferably assembled using a load cell 210a, such as Model # 60001-20K, available from SENSORTRONIC. Load cell 210a is

mounted below top beam 120a by a bolt extending through an opening formed therein. Data is transmitted from load cell 210a to the monitoring system 400 (shown in FIGURE 5) via cable 211a. Load cell 210a should be fixed in the vertical direction, but allowed to swivel about its vertical axis. Upper coupling  
5 212a is rotatably mounted under load cell 210a. As shown in FIGURES 1 and 2, coupling 212a and 212b are constructed of a slotted cylinder and an eye-bolt held in the slot by a pin passing through the bolt and the cylinder walls. This construction is not required, although the coupling of the illustrated embodiment will allow the adapter 213a and rod 214a to swing freely to facilitate specimen  
10 mounting but, of course, constrains movement in the vertical direction.

Illustrated in FIGURE 3A is a preferred embodiment of the invention for testing a single specimen. A test jig 302 is connected to rod 214a. Jig 302 preferably has a threaded opening 305 in its upper end for engaging rod 214, but in an alternative embodiment, rod 214 and jig 302 can be integrally formed. Jig  
15 302 also has an opening 306 formed in its lower end for receiving the test specimen. The upper end of the specimen is positioned in opening 306 of jig 302. The lower end is securely threaded into a lower adaptor 301. In a preferred embodiment, illustrated in FIGURE 3A, the specimen does not directly contact the jig 302, but is instead received into a washer/heat adaptor 310, which is itself  
20 positioned in opening 306.

FIGURE 3B illustrates another embodiment of the present invention, in which multiple specimens can be tested simultaneously in test rig 204. To implement this embodiment, the first, or upper specimen, is mounted as described in relation to FIGURE 3A above. The lower threaded opening of adaptor 301, however, receives a second test specimen. The second specimen will now extend downwardly from adaptor 301, and its head is held by an inverted jig 320. Inverted jig 320 is preferably similar in construction to jig 302, and can have a threaded opening for connecting to rod 254, or alternately can have a second opening for engaging the head of another test specimen. In this manner, numerous specimens can be tested simultaneously as shown in FIGURE 3C.

Turning now to FIGURE 4, the test jig 302 is shown in perspective cut-away view to illustrate the preferred construction.

Returning to FIGURE 2, lower coupling 252a is preferably similar in construction to upper coupling 212a, and coupled to rod 254a by adaptor 253a. At its lower end, lower coupling 256a is connected to movable plate 256a by lower coupling rod 255a, which is threaded and secured with nuts so that it will move with, but not relative to, movable plate 256a. Force generated by the hydraulic cylinders 260a and 260b is applied to movable plate 256 through transfer rods 261a and 262a. In operation, once the specimens are mounted, the hydraulic cylinder 260a is actuated. Hydraulic cylinder 260a is mounted on a support plate 265a. Support plate 265a is connected to transfer rods 261a and

261b such that as the hydraulic cylinder 260a pushes downward from bottom beam 125a, the force generated is applied to the specimens via the plates and rods described hereinabove. Although the embodiment of the present invention depicted in FIGURES 1 and 2 illustrates a pair transfer rods 261a, 262a  
5 connecting the support plate 260a to the movable plate 256a, it is understood that any combination of one or more transfer rods may be used as long the configuration is stable under load conditions.

When the load cell detects that a sufficient tension force has been generated, the apparatus maintains a loaded condition until a predetermined test  
10 period has expired. In a preferred embodiment, transfer rods 261a and 262a pass through openings formed in bottom beam 125a through limit springs 266a, 266b and 267a, as shown in FIGURES 1 and 2. The limit springs support the movable plate 256a when no specimens are loaded and prevent its sudden impact with bottom beam 125a should failure occur.

15 As can be seen from FIGURE 2, test rig 204b is similar in construction to test rig 204a, although such similarity is not required. In addition, plates 256a and 256b, or plates 265a and 265b, can be constructed as one plate, which would be operated by a single hydraulic cylinder.

As illustrated schematically in FIGURE 5, the test assembly 100 operator  
20 can monitor the load on each load cell 210, and therefore on the specimen or specimens suspended below it, from an operating console which is generally

denoted by the number 400. In short, each load cell 210 within the test assembly 100 is connected by wires or cables 405 to a channel selector 410, such as Model # 20050, available from SENSORTRONIC. The channel selector 410 is connected to a display 420 which allows the operator to load and observe each set of test specimens within the test assembly 100 independently. The operator may switch from monitoring one set of specimens to another by means of, for example, a control knob 415 or a push button array (not shown). The electronic readout or display 420 may be configured to convert the deflection or strain on the load cell 210 into pounds force or pounds to relate the actual load placed on the test specimens to the operator in a useful form.

Based on the input received and displayed by the operating console 400, the operator can make periodic adjustment as required to maintain proper testing conditions.

In another preferred embodiment, hydraulic cylinders 260a and 260b are replaced by, or alternately simply act as, hydraulically driven pistons. Rather than actuate each hydraulic cylinder individually, the hydraulic pressure to actuate all of the pistons is generated by a single pump 501 and distributed by a manifold 505 via a series of conduits 502, as shown in FIGURE 6. In this embodiment, the operating console 400, as shown in FIGURE 5, also includes a manifold control (not shown) so that the operator can set and maintain the desired load for each set of specimens.

With reference now to FIGURE 6, a schematic diagram of the manifold distribution system for a test assembly according to one embodiment of the present invention is shown. The system includes a pump 501, a manifold 505, and a reservoir 550 connected together by suitable conduits 502, as known in the art.

5 The manifold 505 may be broken down into an intake 510, a return 520, and several pairs of intake and return valves which are denoted as 515 and 525 respectively. For simplicity, FIGURE 6 shows only one pair of valves 515, 525, but it is understood that there is one pair provided for each cylinder 260. So, for example, if there were ten vertical regions, e.g. 144a, for sample testing then the  
10 distribution system would include ten cylinders 260 and ten pairs of valves 515, 525. The intake valves 515 and return valves 525 may be adjusted to ensure the proper amount of hydraulic pressure in each cylinder 260. As noted earlier, these valves 515, 525 may be remotely operated from an operating console 400; however, manual operation is also contemplated.

15 In operation, hydraulic fluid is drawn by the pump 501 from the reservoir 550 and supplied to the intake 510 portion of the manifold 505. The fluid then passes through the intake valve 515 and to cylinder 260. It is then passed through the return valve 525 to the return 520 portion of the manifold 505 and back to the reservoir 550. Note also that the manifold distribution system is also  
20 provided with several check valves 530 to prevent reverse flow from occurring in the conduits 502. Also, the distribution system may include an automatic pressure

regulator 540 which is electrically connected to the pump 501. The pressure regulator 540 monitors the pressure in the conduit 502 between the pump 501 and the manifold 505 and serves to switch or cycle the pump 501 on and off to regulate the pressure at which the hydraulic fluid is supplied.

5           It is thus believed that the operation and construction of the present invention will be apparent from the foregoing description of a preferred embodiment. While the device shown is described as being preferred, it will be obvious to a person of ordinary skill in the art that various changes and modifications may be made therein without departing from the spirit and the scope  
10 of the invention, as defined in the following claims. Therefore, the spirit and scope of the appended claims should not be limited to the description of the preferred embodiments contained herein.

WHAT IS CLAIMED IS:

1. An assembly for testing the stress durability of a specimen, comprising:
  - a frame having a top and a bottom, and forming at least one test region therein;
  - 5 a first coupling for suspending the test specimen from said top of said frame and within said test region;
  - a second coupling for engaging the lower end of the suspended test specimen;
  - a first plate coupled to said second coupling;
  - 10 at least one transfer rod for moving said first plate and said second coupling away from said first coupling, thereby placing a tensile load on the specimen;
  - a hydraulically actuated piston which is attached under said bottom of said frame; and
  - 15 a second plate attached to said hydraulically actuated piston that when said hydraulically actuated piston is activated a force on said second plate is created and translated to said first plate through said at least one transfer rod.

2. The assembly of claim 1 further comprising a load cell for measuring the test load being translated to the specimen, wherein said load cell is interposed between said frame and the specimen.

5 3. The assembly of claim 2, wherein said load cell is mounted under said top of said frame and is interposed between said first coupling and said frame.

10 4. The assembly of claim 1, further comprising a hydraulic cylinder disposed on said second plate for actuating said hydraulically actuated piston.

5. The assembly of claim 1, further comprising a hydraulic pump connected to said hydraulically activated piston by a conduit.

15 6. The assembly of claim 5, further comprising at least one valve in said conduit for regulating the amount of hydraulic pressure transferred from said hydraulic pump to said hydraulically activated piston.

20 7. The assembly of claim 2, further comprising an operating console having a display for communicating load data from said load cell to an operator.

8. The assembly of claim 6, further comprising an operating console having a display for communicating load data from said load cell to an operator and manifold control means for remotely operating said at least one valve.

5 9. An assembly for testing the stress durability of a specimen, comprising:

a frame having a top and a bottom, and forming at least one test region therein;

10 a first coupling for attaching the a first end of the test specimen to said frame and within said test region;

a second coupling for engaging a second end of the test specimen;

a first plate coupled to said second coupling;

15 at least one transfer rod for moving said first plate and said second coupling away from said first coupling, thereby placing a tensile load on the specimen;

a hydraulically actuated piston which is attached to said frame; and

a second plate attached to said hydraulically actuated piston that when said hydraulically actuated piston is activated a force on said second plate is created and translated to said first plate through said at least one transfer rod.

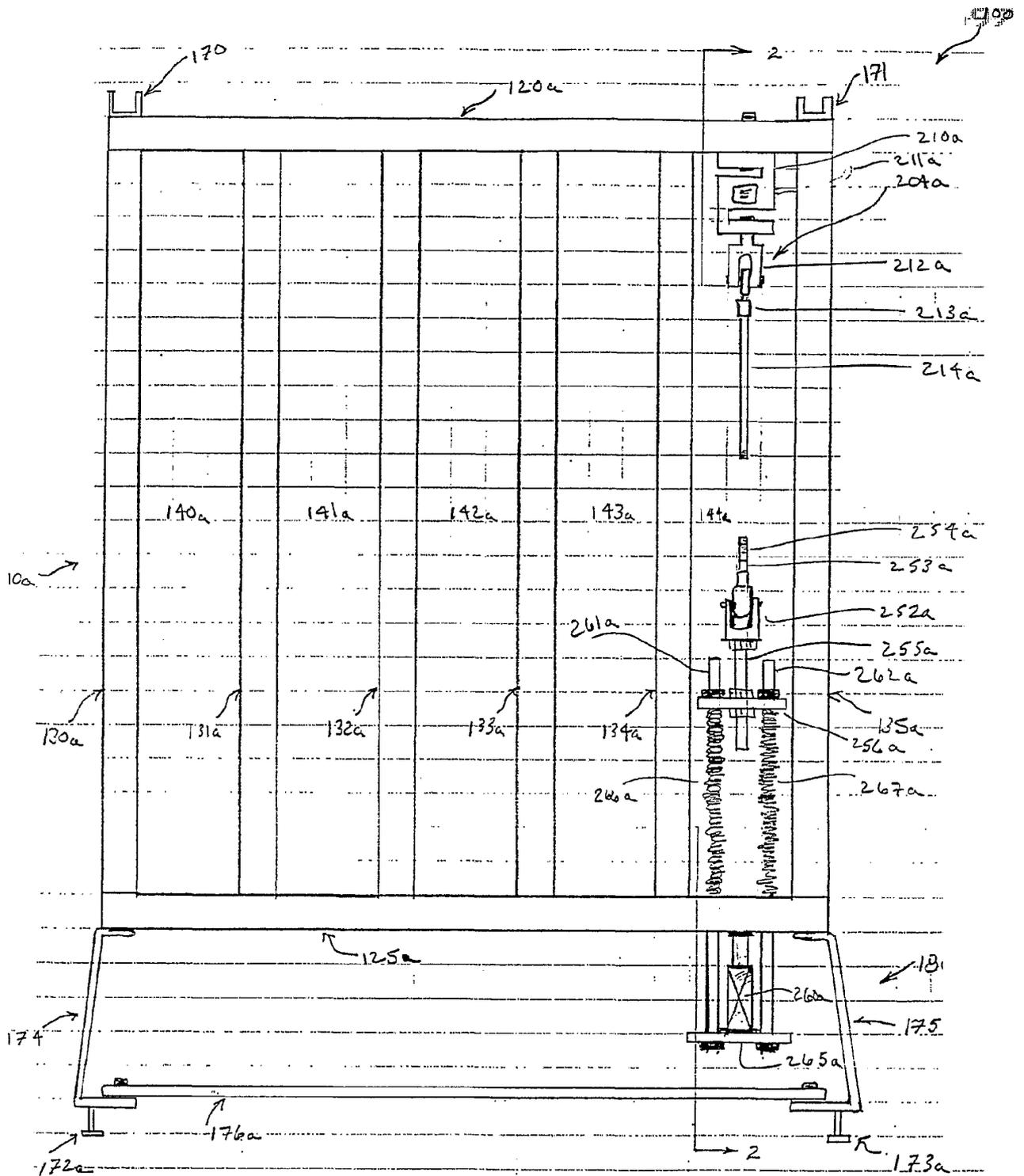


FIG. 1

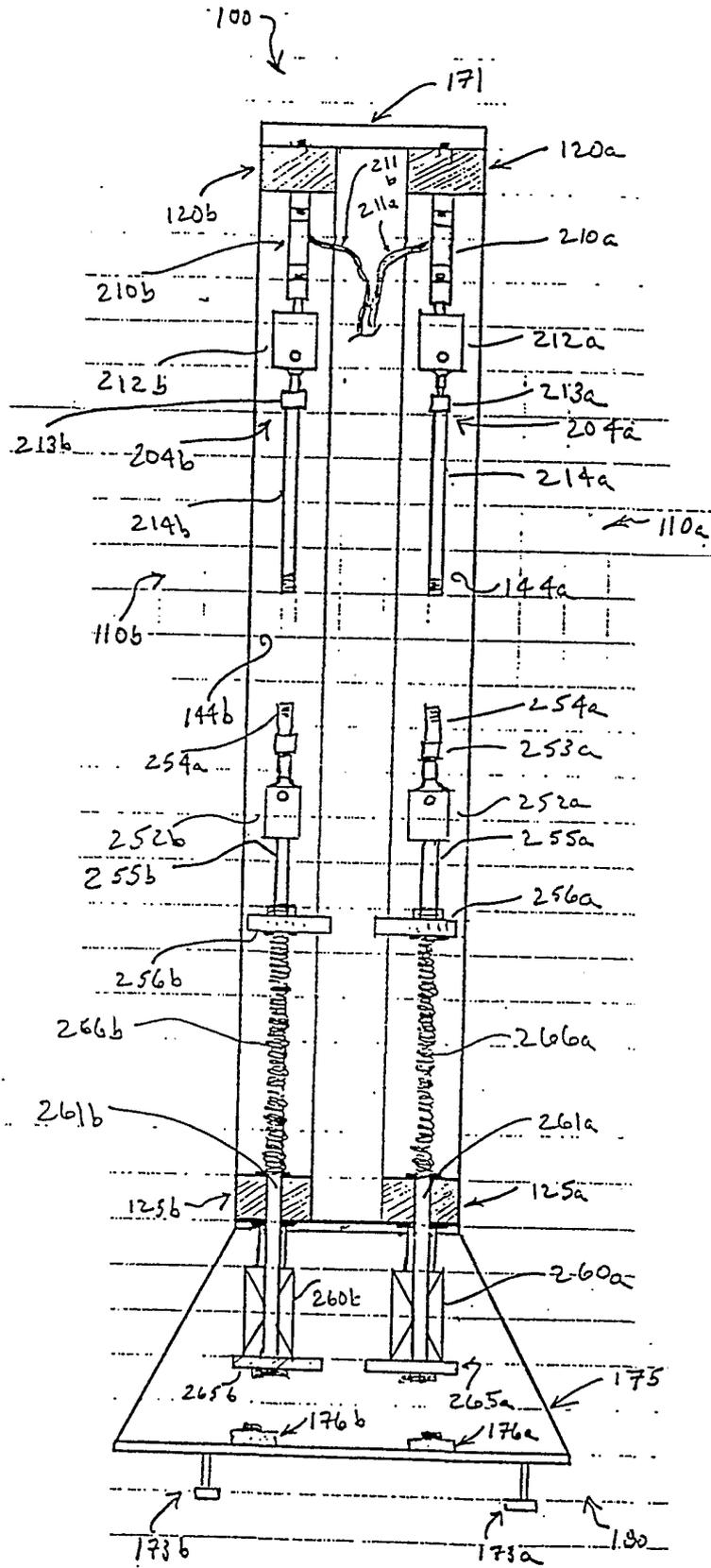


FIG 2

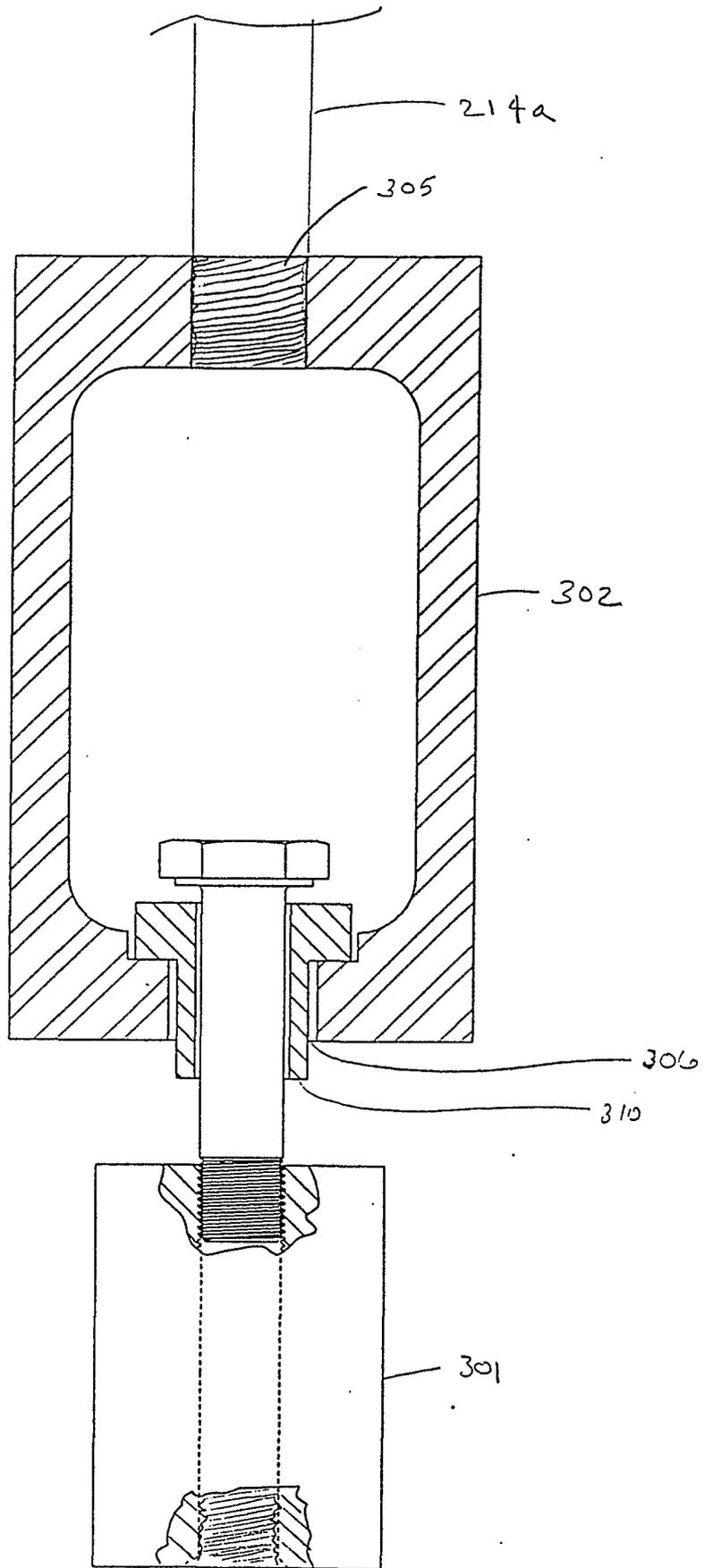


FIG 3A

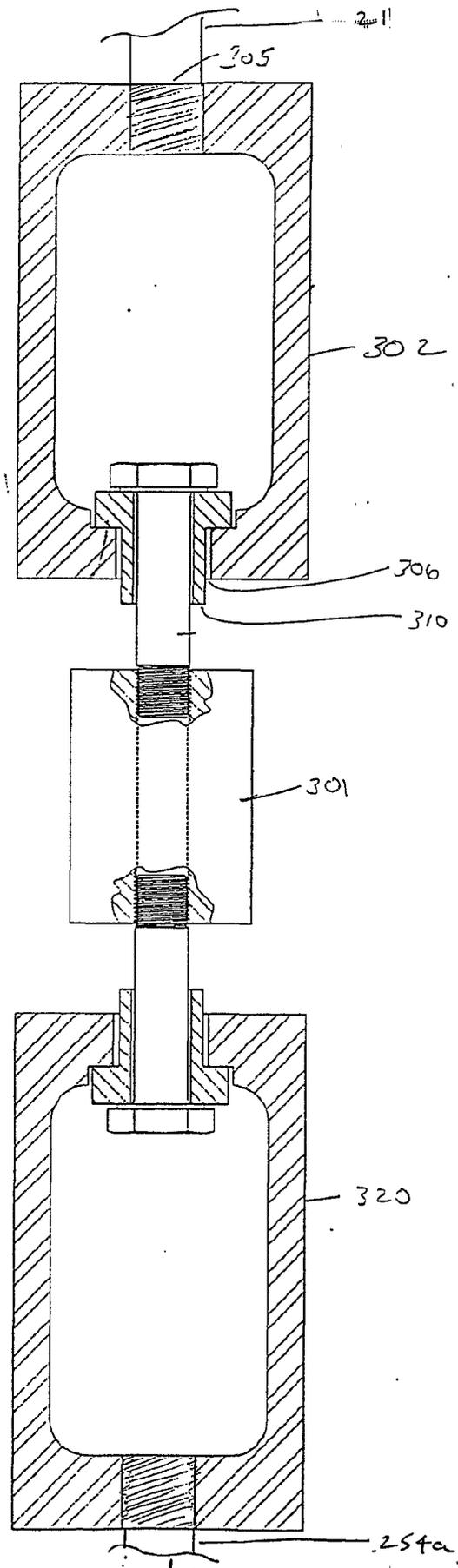
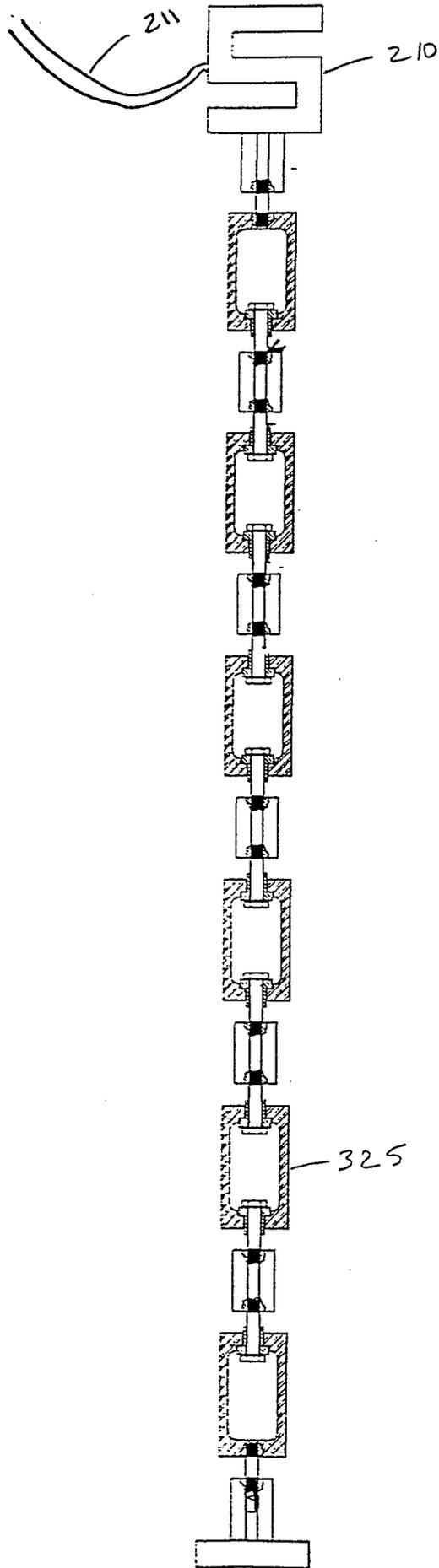


FIG. 3B



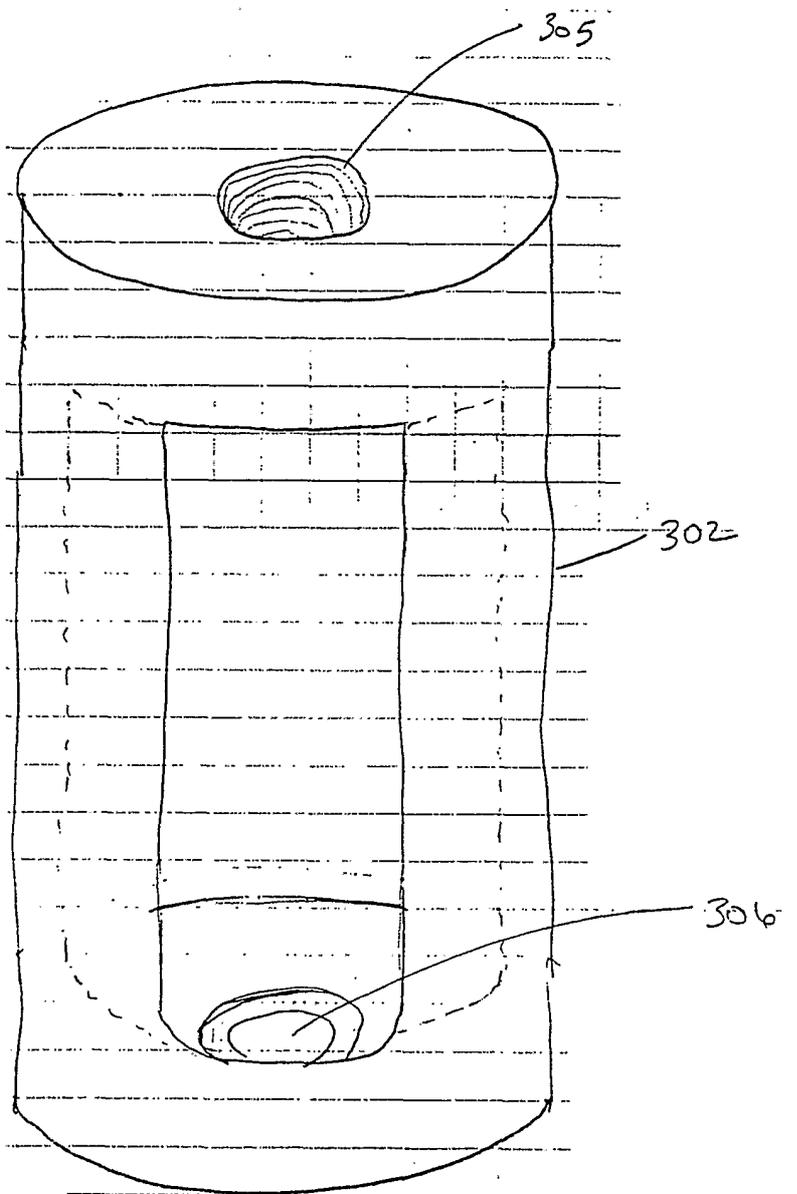


FIG 4.

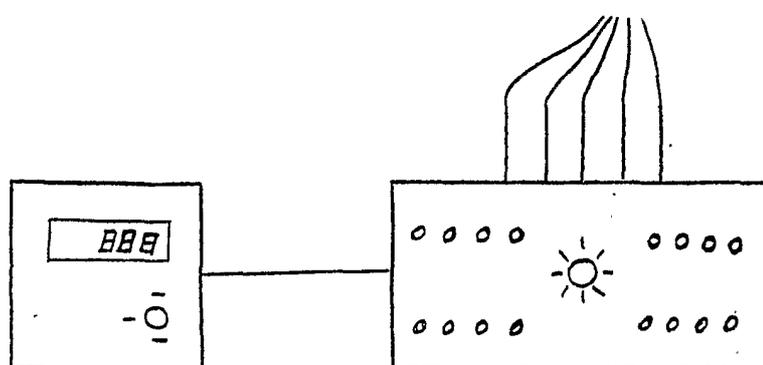


FIG 5

