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Serial No. 289,910

Filing Date 31 August 1994

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1 Navy Case No. 74997

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3 BIAXIAL COMPRESSION TESTING DEVICE

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5 STATEMENT OF GOVERNMENT INTEREST

6 The invention described herein may be manufactured and used
7 by or for the Government of the United States of America for
8 Governmental purposes without the payment of any royalties
9 thereon or therefor.

10
11 BACKGROUND OF THE INVENTION

12 (1) Technical Field of the Invention

13 The invention relates generally to compression testing
14 machines and more particularly to machines applying biaxial
15 compression loads.

16 (2) Description of the Prior Art

17 There are many types of biaxial compression testing devices
18 available in the prior art. Typically, these devices use two
19 force actuators for applying a biaxial load to a test specimen.

20 Actuators used include hydraulic pistons and jacks,
21 mechanically and electrically operated screws and the like. In
22 order to produce accurate loading of a test specimen in two
23 directions, relatively complicated testing machines are required.
24 In particular, it is necessary to avoid tangential and torsional
25 loads on the test sample while simultaneously applying specific
26 loads to the test sample in two directions. When it is desired

1 to apply a specific ratio between forces in the two applied
2 directions over a range of load forces, complex hydraulic
3 pressure control or piston sizing is required in testing machines
4 having dual actuators. Likewise, in the jack or screw type
5 machines, the use of dual actuators requires a relatively
6 complicated means of controlling the differential action
7 necessary to produce a specific ratio between the biaxial loads.
8

9 SUMMARY OF THE INVENTION

10 It is an object of the present invention to provide a
11 compression testing device adapted to apply biaxial compressive
12 loads to a test specimen using a single input force.

13 It is another object of the invention to provide a biaxial
14 compression testing device having an adjustment means whereby the
15 ratio of forces applied along axes can be varied.

16 It is yet another object of the invention to provide a
17 biaxial compression testing device having a means to prevent the
18 transmission of torsional loads to a test specimen.

19 In accordance with these and other objects, a biaxial
20 compression testing device formed with two modified beams is
21 provided. The beams are joined together to form an X shape and
22 are modified to remove support structure such as the webs and
23 upper flanges in the region of the X intersection, thereby
24 leaving a rectangular opening. The rectangular opening has
25 dimensions slightly greater than the widths of the beams and is
26 open from the upper surface downward to the lower surface. The

1 lower surfaces are joined together, thereby providing a fixed X-
2 configuration having a flexing characteristic in a direction
3 perpendicular to the plane formed by the joined beams. A
4 specimen support plate is welded to the underside of one of the
5 upper surfaces and is free to slide under the opposing upper
6 surface. The entire X structure formed by the beams is supported
7 on four lower roller pins, one pin under each end of the beams.
8 Four upper roller bearings are placed at the cut-off ends of the
9 upper flange and rest on the specimen support plate. These upper
10 roller bearings eliminate any bending or torsional loads on the
11 test specimen. The test specimen is placed between the upper
12 roller bearings and a single load device is used to apply a
13 downward force on the upper flanges of the X-configured beams.
14 The test fixture formed by the beams lower surface flexes under
15 the download to cause a biaxial compression at the beam
16 intersection. Relocation of the lower roller pins change the
17 ratio of the biaxial loads applied to the test specimen.

18 19 BRIEF DESCRIPTION OF THE DRAWINGS

20 The foregoing objects and other advantages of the present
21 invention will be more fully understood from the following
22 detailed description and reference to the appended drawings
23 wherein:

24 FIG. 1 is a perspective view of the biaxial testing device
25 with the anvil removed;

1 FIG. 2 is a sectional view of the compression section taken
2 along section line 2-2 of FIG. 1 showing a test sample;

3 FIG. 3 is a sectional view of the complete assembly of the
4 biaxial testing device taken along section 3-3 of FIG. 1;

5 FIG. 4 is a bottom view showing the lower flange welds;

6 FIG. 5 is a side view of the hydraulic actuator assembly;

7 FIG. 6 is a side view of the screw jack actuator assembly;

8 FIG. 7 is a perspective view of an alternate embodiment of
9 the biaxial testing device with the anvil removed; and

10 FIG. 8 is a perspective view of an alternate embodiment of
11 the biaxial testing device constructed with box girders.

12 13 DESCRIPTION OF THE PREFERRED EMBODIMENTS

14 Referring now to FIG. 1, the biaxial compression testing
15 device, designated generally by the reference numeral 10, is
16 shown with its major components. The device (shown without the
17 anvil, for clarity) comprises first and second beams, 11
18 and 12, welded together at the intermediate region thereof at
19 right angles to form a X-configured test fixture having four
20 rigid beam segments. The lower flanges 34 are supported by lower
21 roller pins 33. The upper flange 14 and web 15 are removed from
22 each beam at the frame intersection. Beams 11 and 12 can be any
23 substantially rigid beams such as I-beams (shown), box girders,
24 or solid stock having flat upper and lower surfaces. A plate 17,
25 to provide support for a specimen 30 is welded (weld 18) under a
26 first upper flange 19 but is free to slide under the opposing

1 flange 23. Likewise, the flanges 24 on either side of the
2 specimen support plate 17 slide over the plate 17 during testing.
3 This sliding action allows compression movement of the flange
4 ends during the loading process with no axial restraint caused by
5 the specimen support plate 17. Specimen 30 is placed in the
6 opening between the upper flanges 19, 23 and 24 and is held in
7 position by specimen support plate 17. Upper roller bearings 21
8 are positioned between the flange ends and specimen 30 to prevent
9 the transmission of bending loads to specimen 30 while allowing
10 axial (linear) loads to be applied to the specimen. Roller
11 bearings 21 are equal in diameter to the thickness of
12 specimen 30 and are made of hardened steel. These bearings 21
13 are placed next to the upper flanges as shown. Sections 2-2 and
14 3-3 show the orientation of the sectional views provided in FIGs.
15 2 and 3, respectively.

16 Additional details of the load application to the
17 specimen 30 can be seen in FIG. 2. The specimen 30 is supported
18 by specimen support plate 17. The support plate is welded,
19 depicted by weld 18, to one of the cut-off upper
20 flanges. The opposite end 16 of support plate 17 is not attached
21 to the adjacent upper flange 23 and is free to slide in and out
22 as a load is applied. Upper roller bearings 21 are located
23 adjacent to the cut-off inner ends of the upper flanges, flange
24 19 having the weld, flange 23 opposite the welded flange, and the
25 flanges 24 on the sides. A load plate 22 is placed between force
26 application bearings 21, preferably roller bearings, and each end

1 of the test specimen 30. These load plates 22, which are
2 slightly larger than the specimen 30 are placed in contact with
3 the specimen 30. Shims 25 can also be installed so that the
4 assembly is snug within the upper flanges 19, 23, and 24 of the
5 test fixture. An anvil 27 is used to apply a load to the test
6 fixture with the points of load application 28 being applied
7 approximately over the location of each cut-off web 15.
8 Anvil 27 thus has four points of load application 28, positioned
9 on each upper flange approximately over its web 15.

10 Referring now to FIG. 3, the entire assembly is placed under
11 the load application device 31 on an appropriate loading table
12 32. Lower roller pins 33 support the test fixture above load
13 table 32. The loading device 31 exerts a single force on anvil
14 27. As the beams of the test fixture flex to an upwardly concave
15 configuration, the single downward load is converted in two
16 distinct biaxial horizontal loads. Two lower roller
17 pins 33 are shown in this figure, however as may be noted in FIG.
18 1, each leg of the test fixture is supported by a single lower
19 roller pin 33. The distance between roller pins 33 under the
20 bottom flanges 34 can be varied from one leg of the frame to the
21 other to obtain the desired ratio of biaxial loading. By moving
22 one set of pins 33 inward to a point 35 under the point of load
23 application, that is, approximately under the location of the
24 cut-off webs, the forces on the test specimen in one direction
25 can be reduced to zero, thereby providing a uniaxial compression
26 testing configuration. Similarly, any desired ratio between the

1 forces in a biaxial test can be easily set up by moving one or
2 the other sets of lower roller pins 33. Changing the location of
3 the pins 33 provides a unique feature wherein the application of
4 a single force to the test fixture can produce any desired ratio
5 of forces applied biaxially to the test specimen. This ratio
6 will remain constant as the single force is varied over a desired
7 test range.

8 FIG. 4 provides a bottom view of the X-configuration offered
9 by beam 11 and beam 12. The lower flanges 34 are visible at the
10 intersection of the two beams 11, 12 and these flanges 34 are
11 joined by welds 41 running along diagonal cuts. This weld
12 results in a consistent flexibility of test structure 10 along
13 both beams 11 and 12.

14 FIGS. 5 and 6 depict typical force application devices which
15 provide the single vertical force necessary to operate the
16 invention. In FIG. 5, a hydraulic actuator 51 grounded to
17 structure 52 is used to apply the desired force to anvil 27
18 having load application points 28. Actuator 51 acts as load
19 application device 31. Another load application device is the
20 screw jack 61 grounded to structure 52 as shown in FIG. 6. Other
21 devices including electrically driven jack, levers, or the like
22 can be substituted for device 31 within the scope of the
23 invention.

24 In FIG. 7 there is shown an alternate embodiment 70 of the
25 biaxial compression test device of the current invention. This
26 embodiment uses ball bearings 72 in place of roller

1 bearings 21. A plurality of ball bearings 72 allows compression
2 of specimen 30 without creating shear forces parallel to roller
3 bearings 21. Alternate embodiment 70 is further provided with
4 load plates 74 having end pieces for containing ball bearings 72.
5 This embodiment is useful when specimen 30 undergoes a large
6 amount of contraction during the test. This embodiment of the
7 test device also uses support prisms 76 in place of the roller
8 pins 33 of the first embodiment. Support prisms 76 allow
9 pivoting of the supported beam while not permitting motion in a
10 lateral direction.

11 In FIG. 8 there is shown a force transfer assembly in
12 accordance with an alternate embodiment of the current invention.
13 For clarity in showing all aspects of this embodiment, the anvil,
14 bearings, support plate and lower roller pins have been removed.
15 Four rigid beam segments 80 are shown joined at right angles to
16 each other to a bending plate 82. A gap is defined above bending
17 plate 82. Beam segments 80 are made from box girder having an
18 upper plate 84, a lower plate 86, and side plates 88. A force
19 application flange 90 extends into the gap from the upper plate
20 of each segment 80.

21 The advantages and new features of the present invention are
22 numerous. The upper bearing and shim arrangement avoid the
23 transmission of tangential and bending loads to the test
24 specimen. A single force actuator applies a biaxial load to the
25 specimen. The ratio of forces in the two directions may be
26 adjusted by the simple operation of positioning the lower roller

1 pins and will remain adjusted at the selected ratio over a wide
2 range of load applications.

3 It will be understood that many additional changes in the
4 details, materials, steps and arrangement of parts, which have
5 been herein described and illustrated in order to explain the
6 nature of the invention, may be made by those skilled in the art
7 within the principle and scope of the invention

8 . Although the current embodiment shows an
9 assembly made from beams, it is apparent that any substantially
10 rigid stock such as box girders, solid square stock of the like
11 can be used for this device. Likewise, any of the bearings shown
12 herein can be replaced with mechanically equivalent bearings
13 known in the art.

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3 BIAXIAL COMPRESSION TESTING DEVICE

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5 ABSTRACT OF THE DISCLOSURE

6 A biaxial compression testing device formed by two modified
7 beams joined together to form an X-shape with the support
8 structure, such as webs and upper flanges, removed in the region
9 of the X intersection, thereby leaving a rectangular opening.
10 The rectangular opening has dimensions slightly greater than the
11 widths of the beams and is open from the upper surfaces downward
12 to the lower surfaces which are joined together forming an X-
13 configuration. This configuration has a flexing characteristic
14 in the direction perpendicular to the plane of the joined beams.
15 A test specimen support plate is attached to the underside of one
16 of the upper surfaces and is located so as to slide below the
17 opposing upper surface during flexing of the x-beam assembly.
18 Each beam is supported by a roller pin. Additional roller pins
19 are located on the specimen support plate between each beam upper
20 flange and a specimen to be tested. These roller pins prevent
21 any torsional load from reaching the test specimen. The single
22 actuating force is applied to cause the X-beams to flex into a
23 concave shape thereby applying a part of the actuating force
24 axially along each beam. The configuration provides a force
25 transfer assembly which is actuated by a single load force, but
26 provides a biaxial load on the test specimen.

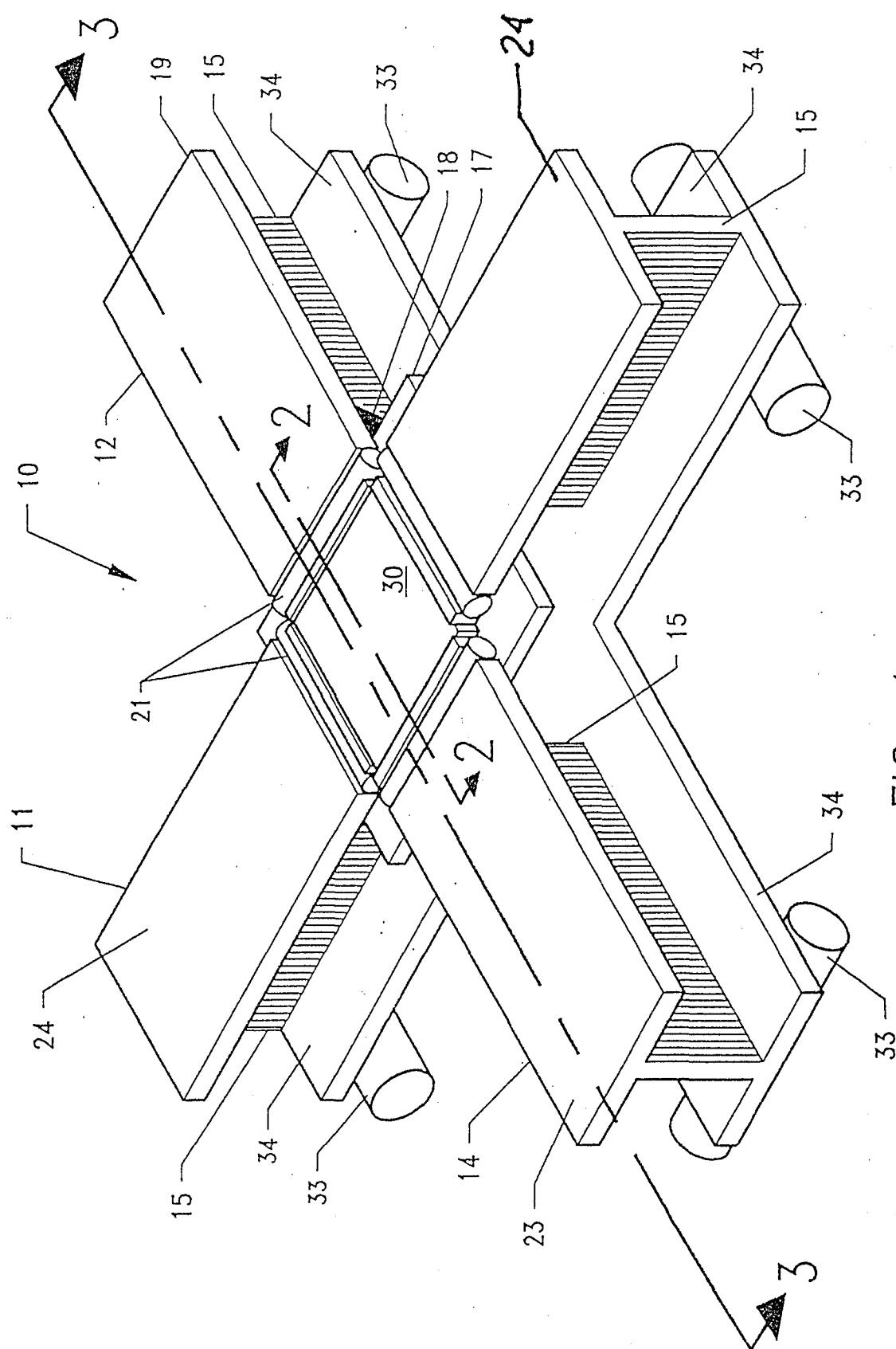


FIG. 1

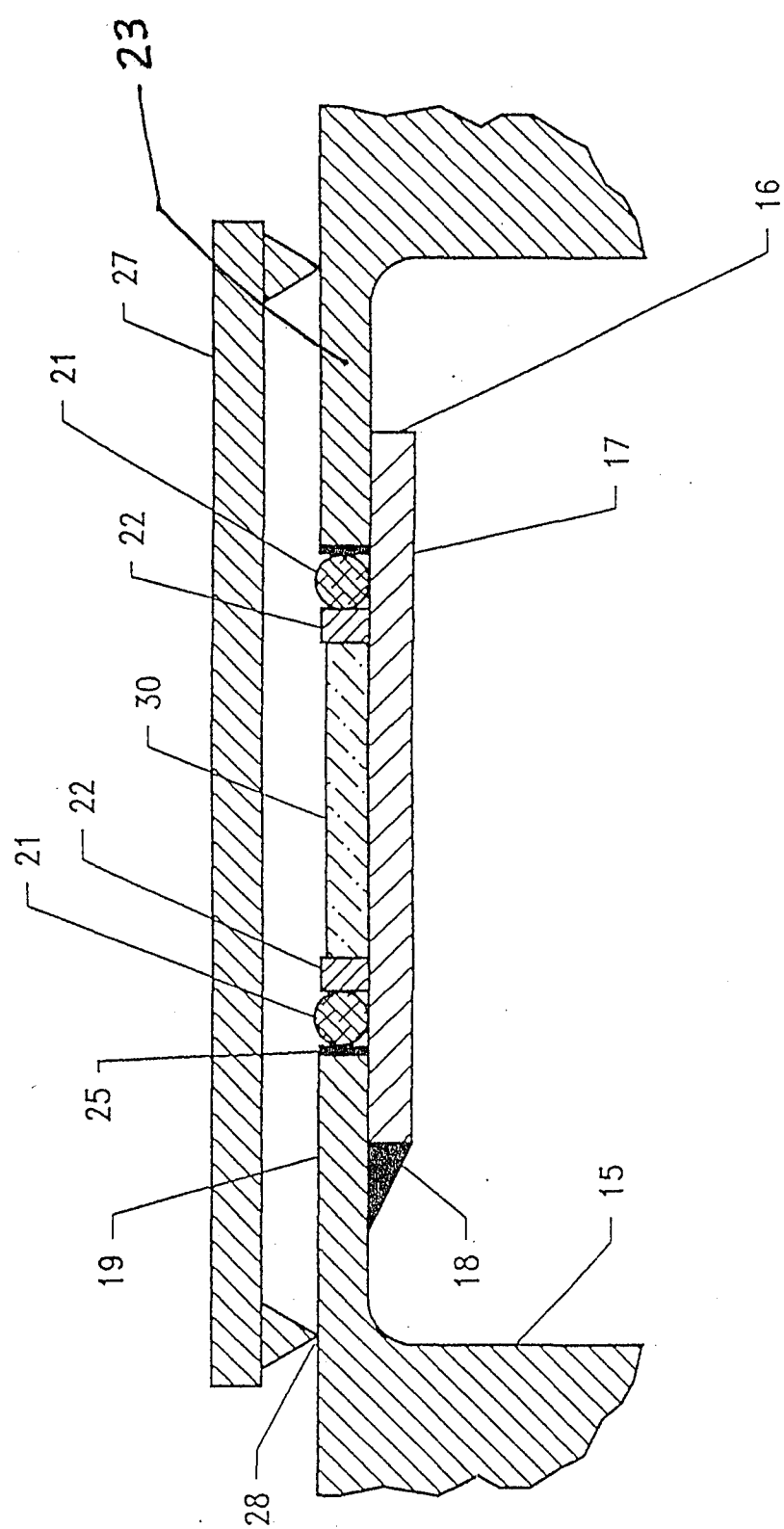


FIG. 2

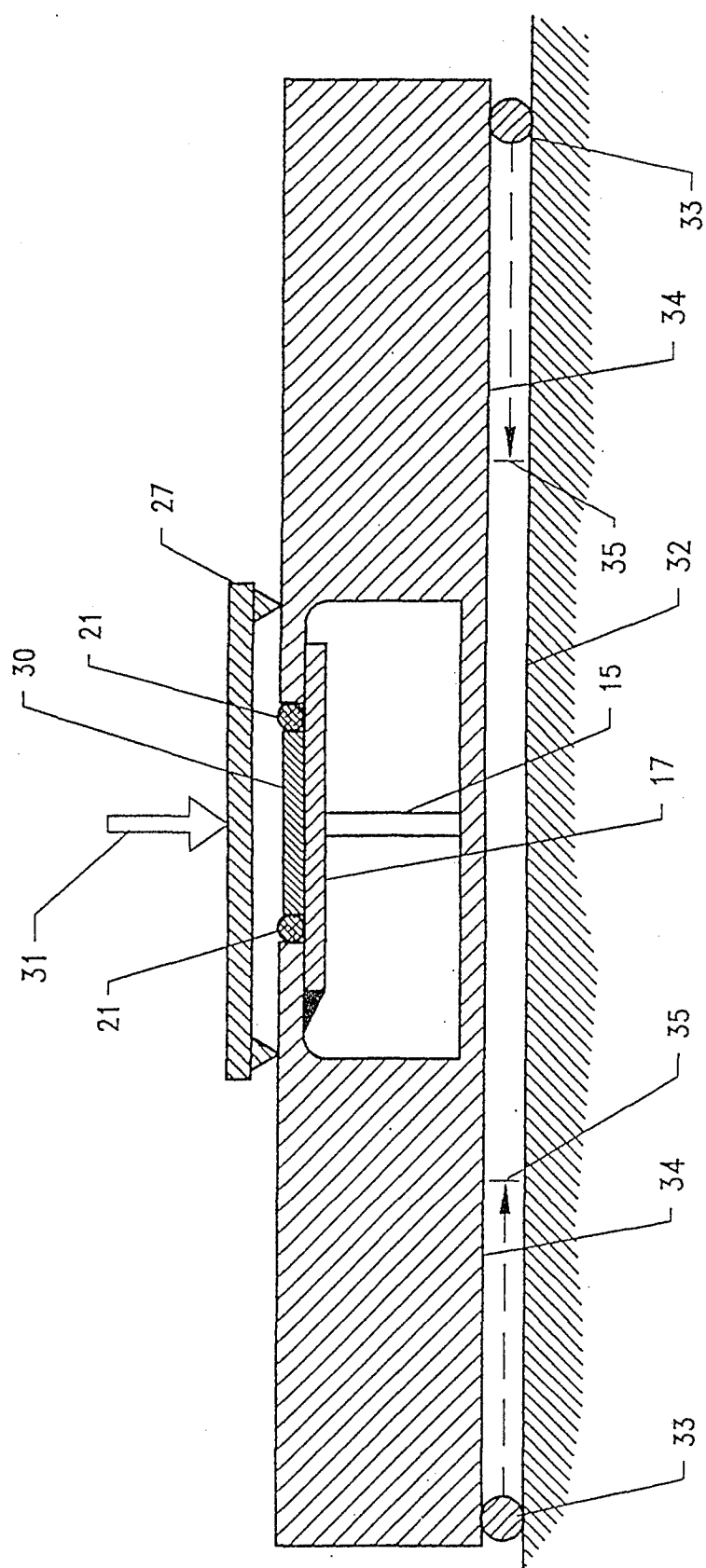


FIG. 3

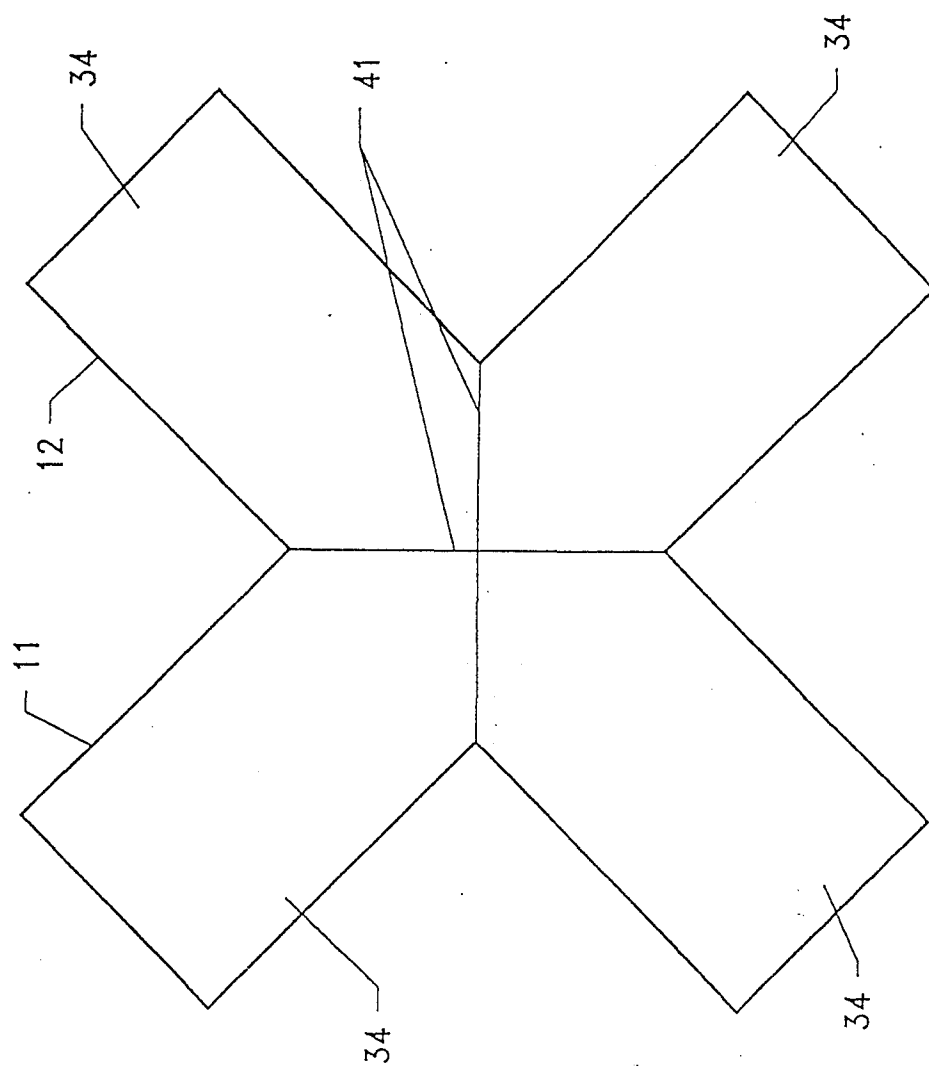


FIG. 4

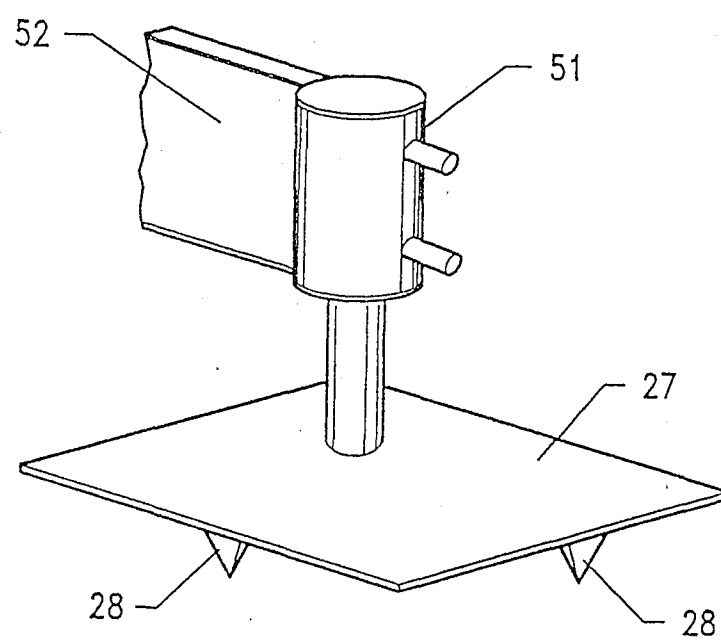


FIG. 5

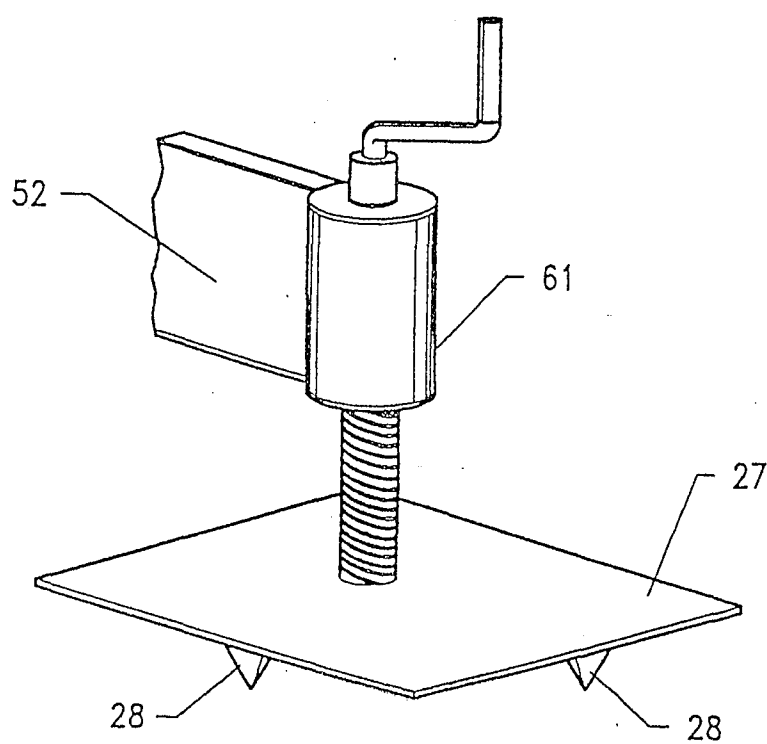


FIG. 6

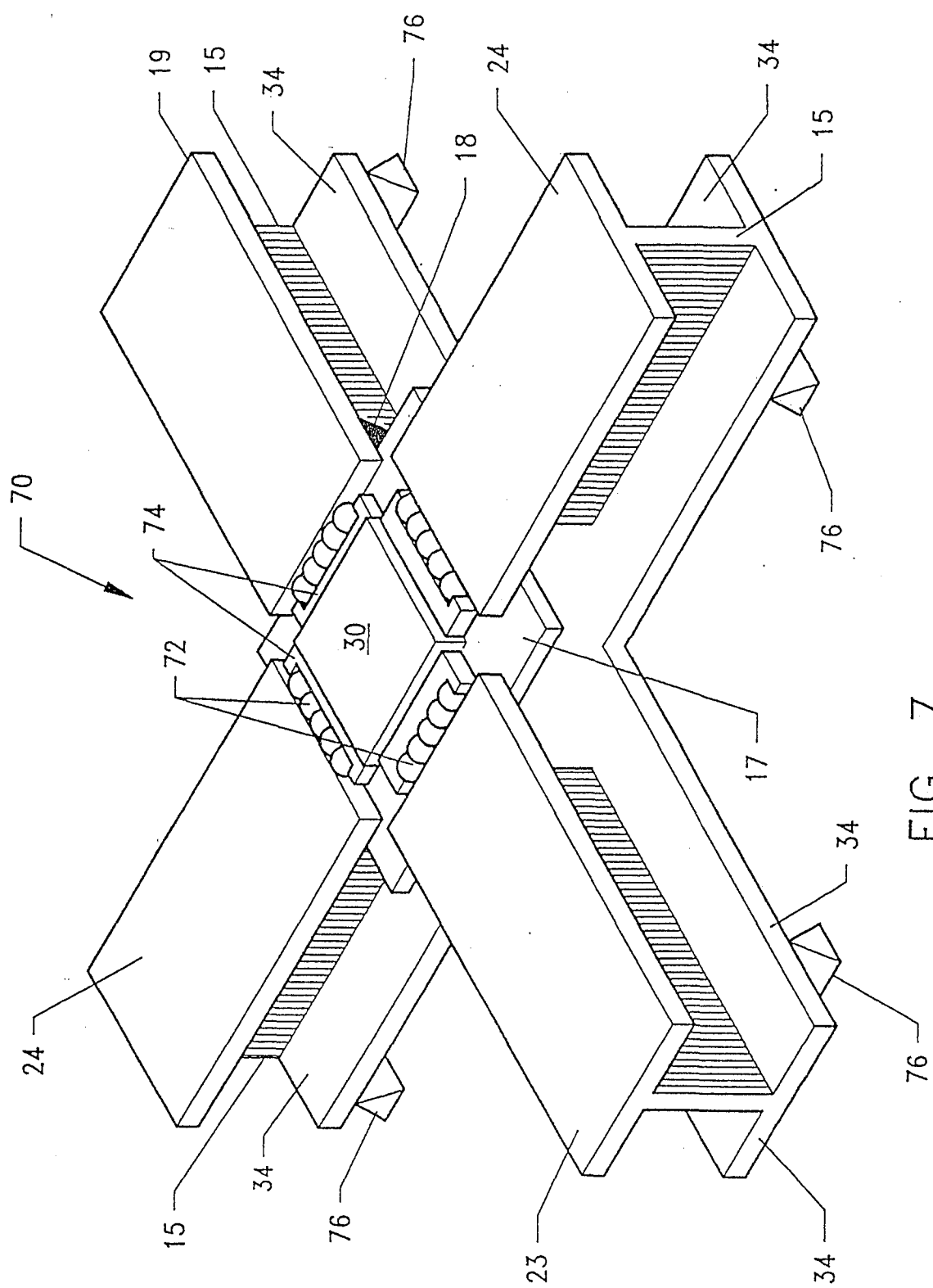


FIG. 7

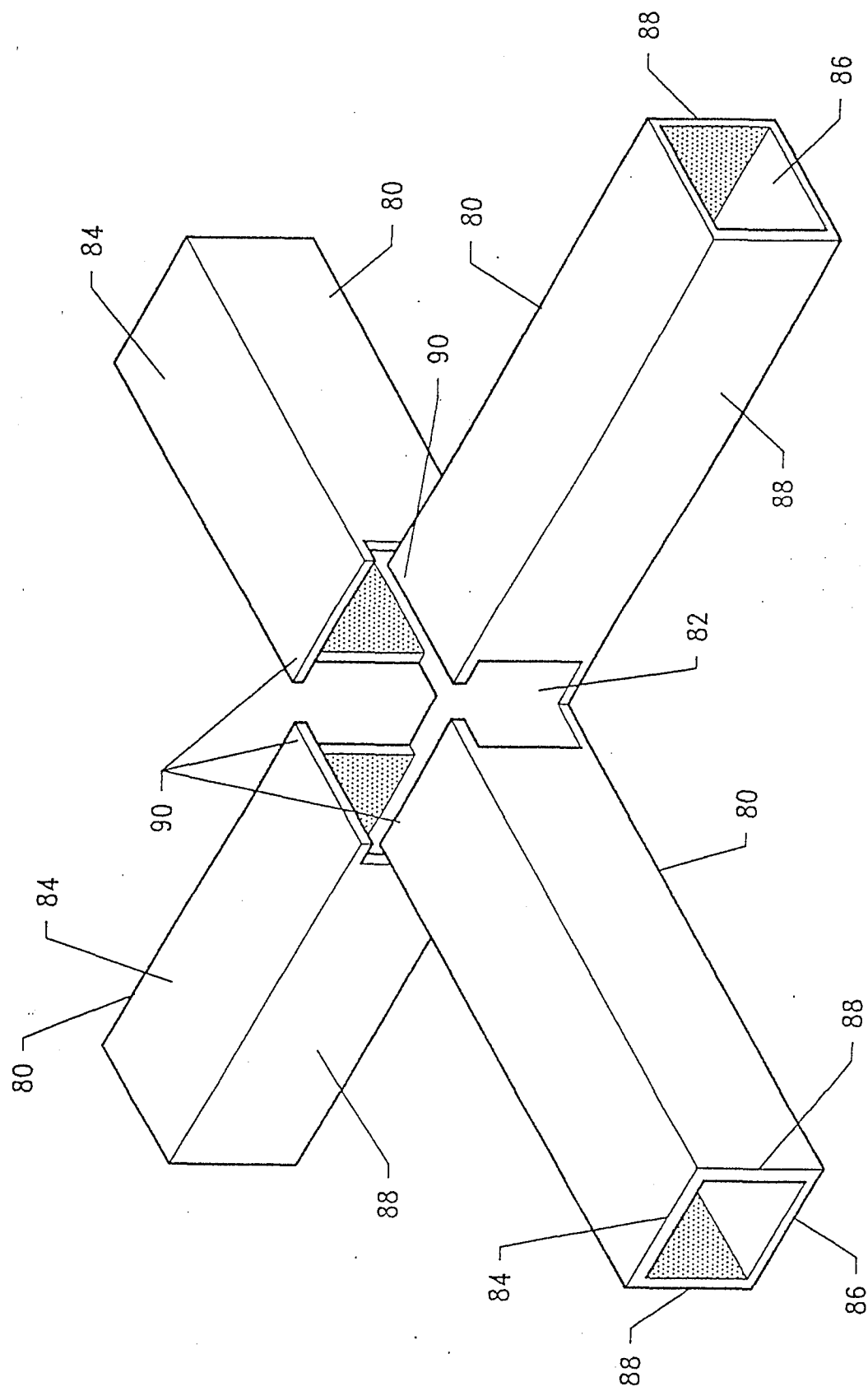


FIG. 8