United States Patent

Krafft

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[54] **MULTISPECIMEN FATIGUE CRACKING MACHINE**

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[52] **U.S. Cl.**.....**73/100,** 73/91

[51] **Int. Cl.**.....**G01n 3/32**

[58] **Field of Search**.....73/91, 100

[56] **References Cited**

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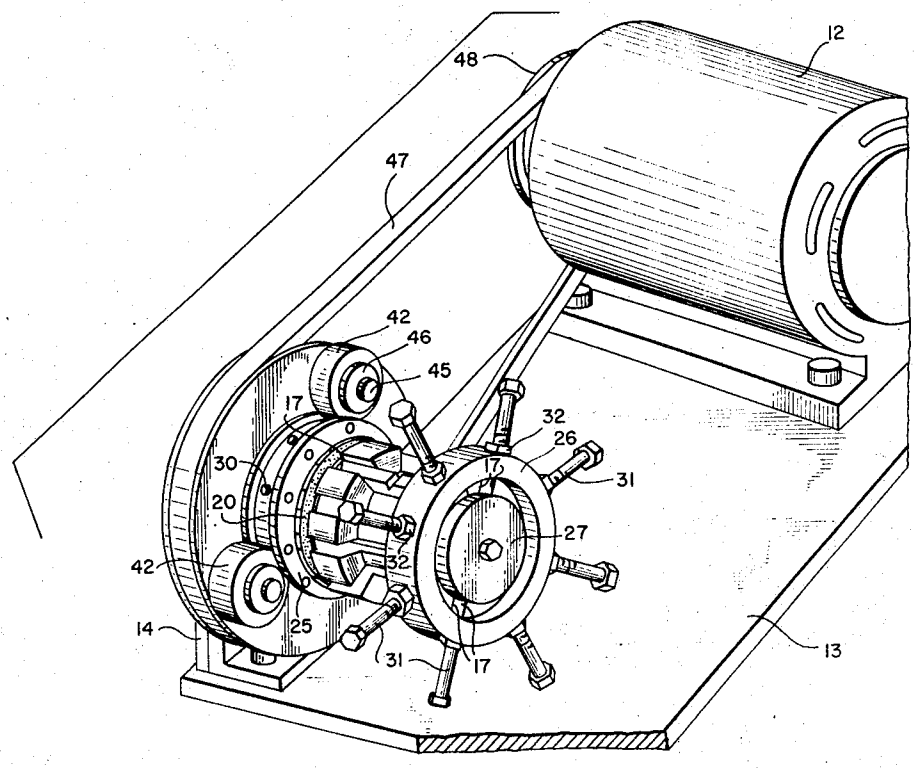
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[57] **ABSTRACT**

This disclosure is directed to a machine for inserting fatigue cracks in up to eight specimen at once while allowing independent observation and stress control of each specimen. Eight specimen are fixed in a circular arbor and means is provided for repetitively flexing the specimen to cause cracks to initiate and grow from the root of a notch to a desired depth.

6 Claims, 2 Drawing Figures



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SHEET 1 OF 2

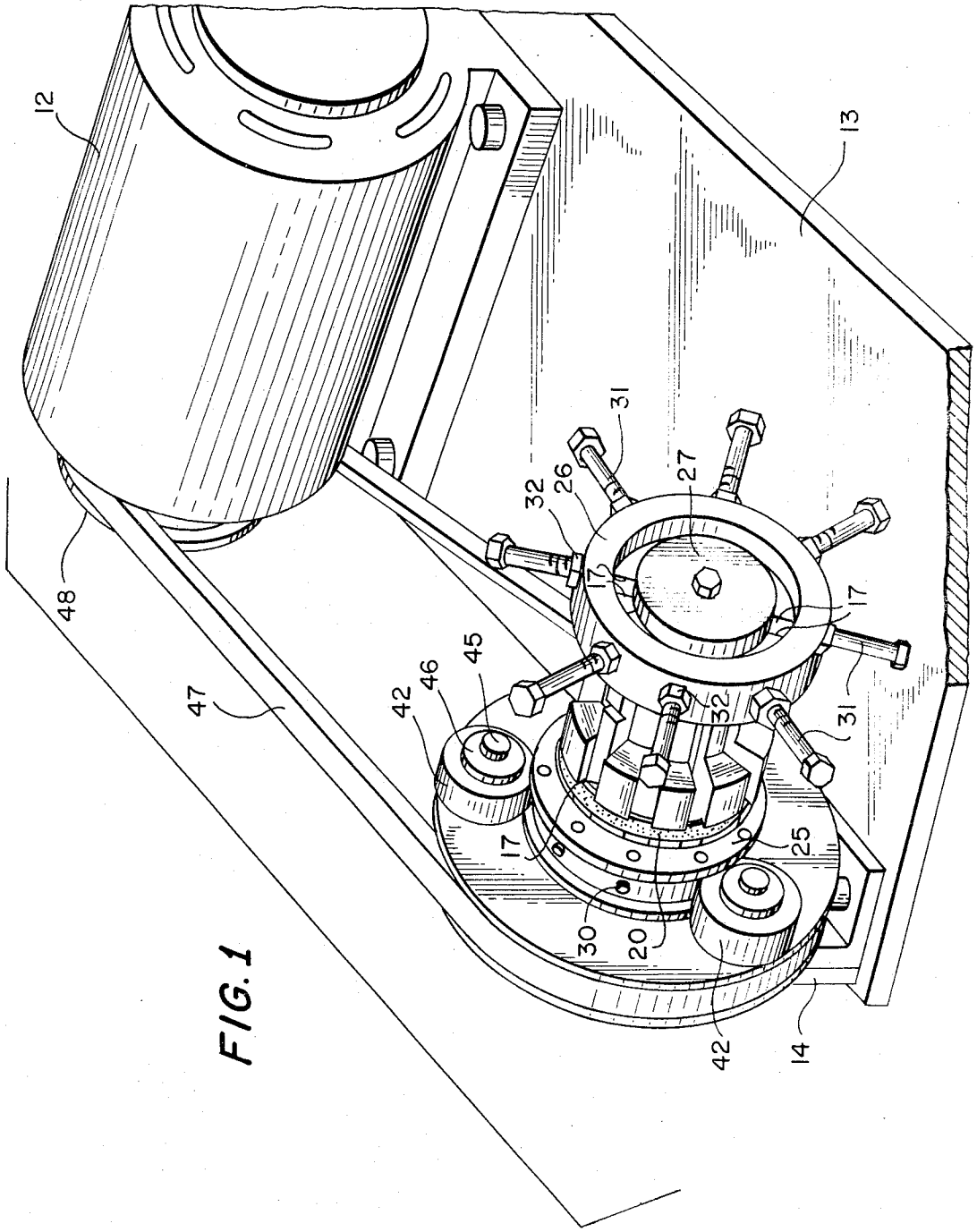


FIG. 1

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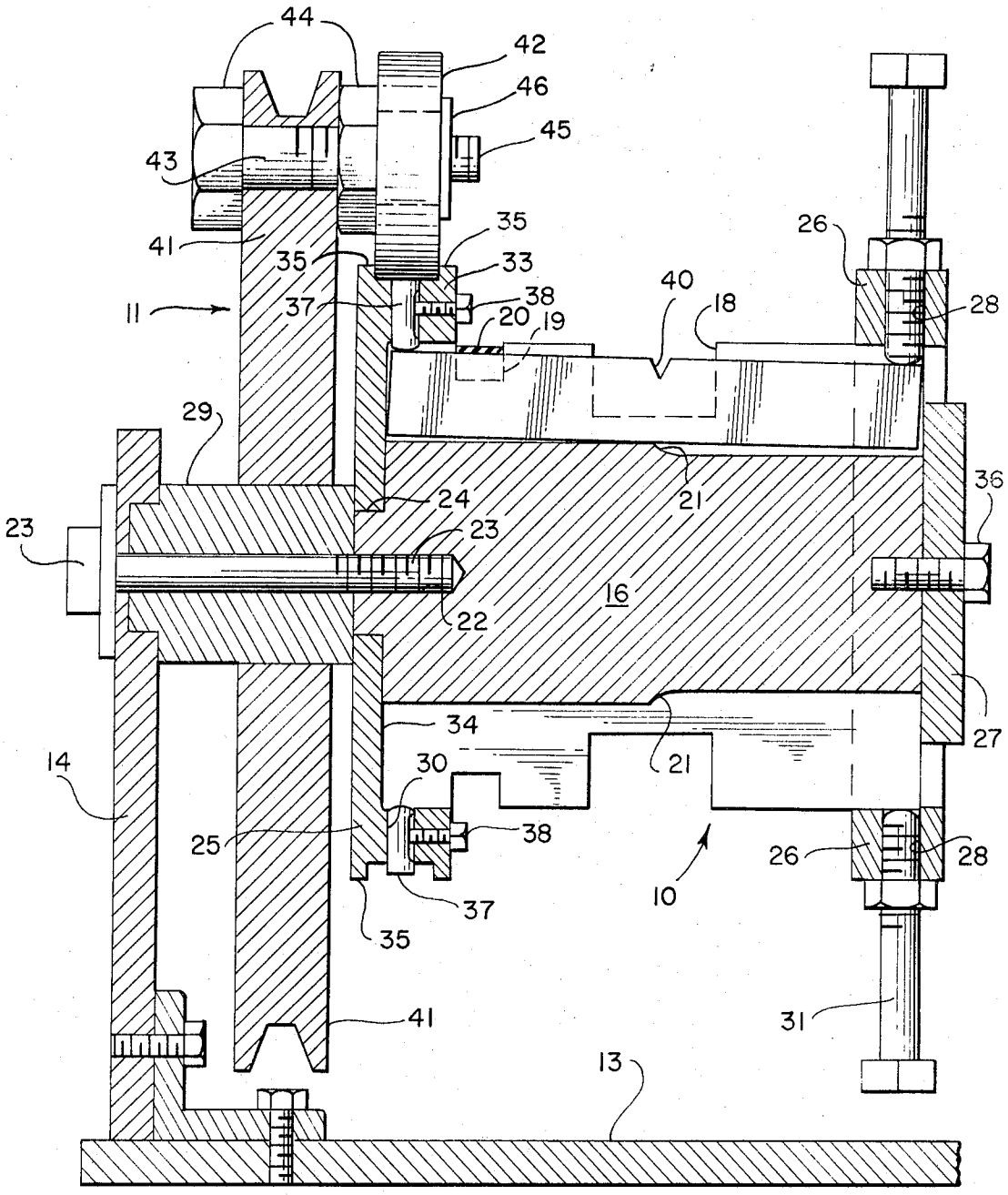


FIG. 2

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MULTISPECIMEN FATIGUE CRACKING MACHINE

STATEMENT OF GOVERNMENT INTEREST

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

BACKGROUND OF THE INVENTION

This invention is directed to fatigue cracking of notched specimen and more particularly to a multispecimen fatigue cracking machine.

The standard ASTM method of evaluating plane strain fracture thoughness K_{Ic} requires preliminary insertion of low stress fatigue cracks in the notch of a specimen. In the early efforts to characterize brittle fracture, cracks were simulated with sharply tipped notches. Eventually, it became apparent that no matter how sharp the notch was machined, a natural fatigue crack would often result in still lower values of the fracture toughness. Since preexisting cracks rather than notches are the usual source of difficulty with engineering structures, the fatigue crack was specified as mandatory for valid tests of fracture toughness K_{Ic} (e.g., see ASTM test method E-399-70T, Part 31, 1970 ASTM Standards). This requirement poses a serious practical difficulty. The K_{Ic} data are badly needed; for high strength alloys, K_{Ic} is a basic standard of fracture resistance. But the conventional methods of cracking, designed for one specimen at a time, are very slow and costly. At a typical growth rate of two microinches per cycle, about 50,000 cycles are required for 1/10 inch of crack growth, typically 25 minutes at 2000 cycles per minute. It is not unusual to average 60 minutes per specimen, allowing time for stepup, crack initation from the notch, and shut down for intermittent examinations. Aside from the processing time, the capital equipment costs of cracking with a high quality fatigue testing machine adds to the overall expense and inconvenience through tie up and wear on the precision test apparatus.

STATEMENT OF THE OBJECTS

It is therefore an object of the present invention to provide a simple means for simultaneously producing a low stress fatigue crack in a plurality of specimen.

Another object is to provide a device for simultaneously producing fatigue cracks in a plurality of specimen while allowing independent observation and stress control of each specimen.

Still another object is to provide a more stable system for growing fatigue cracks simultaneously in a plurality of specimen.

Yet another object is to provide a simple device for fatigue crack formation which may be operated by unskilled as well as by skilled personnel.

Other and more specific objects of the invention will become obvious to those skilled in the art from the following description when considered in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 illustrates a view of the overall device.

FIG. 2 illustrates a cross-section of a side view.

DESCRIPTION OF THE INVENTION

Now referring to the drawing, there is shown for illustrative purposes in FIG. 1, a fatigue cracking machine made in accordance with the teaching of this invention. As shown, the machine includes three main assemblies, a specimen holding assembly **10**, a rotatable element **11** for depressing specimen held by the specimen holding assembly and a drive motor **12**. The motor is held in place on a plate **13**, the specimen assembly is secured in a fixed position by an upright bracket **14** which is secured to the plate **13** and the rotatable element **11** rotates about one end of the specimen holder.

The specimen assembly **10** includes an arbor **16** which is machined from a solid cylindrical element such as cold rolled steel. The arbor is machined to include eight longitudinal slots **17**, a centrally located circumferential slot **18** and a shallower circumferential slot **19** near one end. The bottom of each of the longitudinal slots include a raised ridge **21** in the area of the circumferential slot **18** which acts as a fulcrum for the specimen. The circumferential slot **18** is provided to enable one to view the specimen during fatigue cracking. The circumferential slot **19** serves to receive a retaining spring **20** which restrains the inner end of the specimen when in use. The end that includes slot **19** is provided with an axially aligned threaded hole **22** within which a bolt **23** is threaded to hold the specimen assembly in place on the bracket **14**. The opposite end is provided with a cap disk **27**, which is installed by bolt **36** to keep the specimens in their slots during the fatigue cracking. The arbor is provided with a boss **24** on one end about which an idler ring **25** is matched and a spacer **29** is provided to space the specimen assembly from the upright bracket **14**.

The outer end of the arbor is fitted with a specimen retaining ring **26** which is secured by a press or shrink fit about the end of the arbor. The ring is provided with radially extending threaded holes **28** which are spaced sufficiently to align with the center of the slots. Bolts **31** are screw threaded into the threaded holes **28** which apply a desired force on the end of a specimen in the slot. A nut **32** is provided on the bolts to lock the bolts in place when the nut is threaded against the outer surface of the ring. The opposite ends of the specimen are held in place by the spring with the ends of the specimen projecting under the idler ring **25**.

The idler ring is made with an outer ring portion **33** which surrounds the inner end of arbor and is press fitted thereon and an inwardly extending end portion **34** that matches with the boss **24** of the arbor and fits against the inner end of the arbor. The outer ring **33** of the idler ring is provided with radially extending non-threaded holes **30** that are centered on the longitudinal slots and flanges **35** which extend outwardly from opposite sides of the non-threaded holes and are spaced to provide a radial track therebetween. Plungers **37** are fitted within the non-threaded holes for radial motion therein and are of a length that they extend beyond each surface of the ring portion. The plungers **37** are each provided with a linear flat surface along the length of the central region which cooperates with a set screw **38** to prevent the plungers from falling from the hole while allowing linear motion. The inner end of plungers

37 and the bolts 31 are slightly pointed, for instance, a 3 degree cone, to provide symetry of loading contact on the specimen. The specimen is positioned within the arbor such that the bottom of the specimen in the area of a preformed notch 40 is over the fulcum with the bolts 31 applying a force on the outer end while the top of the inner end of the specimen is against the plunger 31.

The rotatable element 11 is rotatable about bearings on the spacer between the upright bracket 14 and the inner end of the specimen assembly. The rotatable element includes a V-pulley wheel 41 which has a greater diameter than the specimen assembly and is centered about the axis of the specimen assembly. Three roller wheels 42 spaced 120° apart are secured to the pulley wheel by suitable eccentric studs 43 with their axis on a circle about the axis of the pulley wheel. The wheels may be well known bearings which have an outer ring of a width commensurate with the spacing between the flanges 35 and the idler ring 25. The bearings are arranged such that they rotate on the outer surface of the idler ring and since the studs are eccentric, the bearings may be adjusted to preload the bearing against the idler ring and to center the pulley wheel on the axis of the specimen assembly.

The studs are provided with nuts 44 on the opposite side of the pulley wheel which secured the studs in place and a bolt 45 with washer 46 secures the bearing on the other end of the stud. The V-pulley wheel is driven by a suitable belt 47 which loops the V-pulley wheel and a drive wheel 48 which is secured to the motor shaft.

In operation and setting up the specimen for fatigue cracking, the specimen are pre-notched on one side thereof centrally of the length as is well known in the prior art. The bolts in the outer ring that apply a force on the outer end of the specimen are backed off such they do not protrude into the inner area bounded by the outer ring. A specimen with the notch facing outward is inserted longitudinally into each of the slots in the arbor below the inner end of the flange on the outer ring. The specimen is moved to the inner end and the spring is raised permitting the inner end of the specimen to be forced under the spring. The specimen is moved inwardly until the inner end is below a plunger in the idler ring. With the inner end of the specimen under the plunger, the outer end will slide into place in front of the flange on the outer ring. Also, the notch will be positioned outwardly of and above the fulcrum on the arbor. All specimen are loaded into their respective slots. With the specimen in their slots, the V-pulley wheel is rotated until the roller bearing or wheel secured thereto is directly over one of the plungers. At this time a displacement transducer (not shown for clarification of the drawings) is installed in the outward facing notch of the specimen over which the bearing is positioned. The displacement transducer measures the stress intensity factor (K_I) at the notch root from the deflection at the lips of the notch. The bolts 31 are then adjusted inwardly against the outer end of the specimen to flex the specimen to the desired level of (K_I) for the fatiguing operation. The bolt is then locked in place by the lucking nut. This operation is carried out for each of the specimen. The fatigue operation is now ready to begin.

The fatigue operation begins by starting motor 12 which rotates the V-pulley wheel. As the pulley wheel is rotated the roller bearings or wheels attached thereto rotate along the outer surface of the idler ring depressing the plungers above the inner end of each specimen as the pulley wheel is rotated. Since there are three bearings secured onto the pulley wheel each specimen will be flexed three times for each revolution of the pulley wheel.

Since the arbor is provided with a circumferential slot in the area of the notch in the specimen, the notches can be visually examined. In order to visually examine each of the specimen, the motor may be turned off and the specimen assembly rotated by loosening the bolt 23 that secures the specimen assembly to the upright bracket. Once the specimen assembly is rotated to a desired position, the bolt may be tightened to secure the specimen assembly in place. Since the bolt is mounted on the axis of the specimen assembly no further adjustment of the specimen will be necessary.

In the event a crack length of a desired length is obtained on any one of the specimen, that specimen can be unloaded by relaxing the force applying screw which holds the outer end downwarded. Since the arbor is stationary this can be done without stopping the operation on the remaining specimens.

It has been determined that an eight inch outside diameter V-pulley wheel, driven by an two inch outside diameter drive pulley on a 850 RPM motor will result in an orbital speed of 200 RPM for the machine. Since there are three bearings that contact each specimen, each revolution of the pulley wheel, 200 RPM of the pulley wheel will be equivalent to 600 cycles per minute or about 50,000 cycles in 80 minutes. This is equivalent to about 10 minutes per specimen. For such a machine, the arbor is 3¾ inches, therefore, it can be seen that eight specimen can be fatigue cracked in a relatively short time in a relatively small space. It is possible to drive the machine faster than this for even more rapid processing.

This machine permits an operator to visually observe the crack as it develops, operation time per specimen is drastically reduced and different specimen are being deflected at different times which reduces the load on the motor.

The device has been shown with eight specimen and three wheels or bearings for deflecting the specimen. The machine can be made with more or less number of specimen and/or deflecting elements without departing from the concept of the invention. Further, the device could be operated with the specimen holder in a vertical position with the driven pulley in a horizontal position. Such an arrangement would permit immersion of the specimen in a coolant or hot bath for producing fatigue cracks under other than ambient conditions. Further, the device could be operated in a vacuum or with different gases surrounding the specimen to determine effects of other conditions on different specimen.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed and desired to be secured by Letters Patent of the United States is:

1. A multispecimen fatigue cracking device, which comprises:
a specimen assembly means adapted for holding a plurality of elongated specimen,
said specimen assembly includes a fulcrum centrally of the length of each of said specimen,
means for securing said specimen on said specimen assembly,
means for depressing and holding one end of each of said specimen in a depressed position, and
means for sequentially depressing and relaxing the opposite end of each of said specimen,
whereby each of said specimen are repetitively flexed thereby causing cracks to initiate and grow in each of said specimen.

2. A multispecimen fatigue cracking device as claimed in claim 1; in which,
said specimen assembly means is cylindrical with linear slots therein within which said specimen are held and circumferential slots for observing and holding said specimen in place.

3. A multispecimen fatigue cracking device as claimed in claim 2; in which,
said means for sequentially depressing and relaxing one end of each of said specimen includes more than one depressing and relaxing element which revolves about the linear axis of said specimen assembly.

4. A multispecimen fatigue cracking device as claimed in claim 3; wherein,
said depressing and relaxing means is a rotatable wheel.

5. A multispecimen fatigue cracking device as claimed in claim 4; in which,
said specimen securing means includes a retaining ring on the outer end of said specimen assembly means and an idler ring on the inner end of said specimen assembly means,
said means for depressing and holding said specimen in a depressed position includes threaded bolts screw threaded through said retainer ring on the outer end of said specimen assembly means,
said idler ring on the inner end of said specimen having non-threaded holes therethrough on different radii thereof,
a plunger secured in each of said non-threaded holes in for movement within said hole,
said plunger positioned to contact the end of said specimen and for movement by said rotatable wheels for depressing and relaxing said specimen.

6. A multispecimen fatigue cracking device as claimed in claim 5; which comprises,
a lock nut on said bolts which lock said bolts in place in order to secure one end of said specimen in a depressed position.

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