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FRETTING CORROSION TEST FIXTURE

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FRETTING CORROSION TEST FIXTURE

ABSTRACT OF THE DISCLOSURE

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A fretting corrosion test fixture for evaluating materials or coatings in variable temperature environments and having a load bar and a flexure bar rigidly mounted at their respective one ends in the jaws of a vise and separated by a shim of selected thickness. The load and flexure bars are cantilevered out from the vise, the other end of the flexure bar being connected to an eccentric drive assembly for deflecting the flexure bar. A pair of material specimens having a combined thickness equal to that of the shim are attached, respectively, near the end of the load bar and intermediate the ends of the flexure bar and in contact with each other. A cylindrical furnace is mounted for enclosing the specimens for high temperature evaluation. Fretting corrosion is produced on the attached fretting specimens under controlled conditions by deflecting the flexure bar a predetermined amount resulting in relative movement and load at the interface of the specimens.

STATEMENT OF GOVERNMENT INTEREST

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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 relates generally to material and coating test fixtures and particularly to a fretting corrosion test fixture.

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Fretting describes corrosion damage occurring at contact areas between materials under load subjected to small relative movement or slip.

1 The fretting corrosion damage appears as pits or grooves in the metal
surrounded by corrosion debris and is also known as friction oxidation,
wear oxidation, chafing, and false brinelling. Fretting has been observed
at the interface of metallic joints in engine components, automotive parts
5 and airframe structures. Fretting corrosion is very detrimental because
of the destruction of metallic components and the formation of oxide
and metallic particulate. Frequently, the result is a loss of tolerances
and loosening of mating parts. Further, fretting causes fatigue fractures
since the loosening of components permits excessive strain, and the pits
10 formed by fretting act as stress-raisers.

The basic requirements for the occurrence of fretting corrosion
are:

- (1) The interface must be under load;
- (2) Vibration or repeated relative motion between the two
15 surfaces must occur, and
- (3) The load and the relative motion of the interface must be
sufficient to produce slip or deformation on the surfaces.

Methods and fixtures for performing fretting corrosion studies primarily
involve lubrication wear equipment. One other method of inducing fretting
20 corrosion wear is to alter fatigue testing equipment by applying normal
loads to induce fretting fatigue. Testing in high temperature environ-
ments often require complex and relatively expensive test fixtures not
readily adaptable for placing test specimens within a high temperature
environment.

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SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide a fretting corrosion test fixture which localizes fretting action so as to make it easily accessible to high temperature studies. Another object is to provide a fretting corrosion test fixture which utilizes conveniently replaceable fretting specimens whose size and shape can be readily modified for the application of differing flexure loads. Yet another object is to provide a relatively simple and inexpensive fretting corrosion test fixture.

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Briefly, these and other objects are accomplished by a fretting corrosion test fixture which evaluates materials or coatings in variable temperature environments. The test fixture of the present invention has a load bar and a flexure bar rigidly mounted below the load bar at their respective one ends in the jaws of a vise wherein the bars are separated by a shim of selected thickness in the jaw area. The load and flexure bars are cantilevered out from the vise, the other end of the flexure bar being connected to an eccentric drive assembly for deflecting the flexure bar. A pair of fretting specimens having a combined thickness equal to that of the shim are attached, respectively to the end of the load bar and intermediate the ends of the flexure bar and in surface contact with each other. A cylindrical furnace is mounted on the test fixture for enclosing the specimens to provide high temperature fretting corrosion evaluation. Fretting corrosion is produced by repetitively deflecting the flexure bar a predetermined amount resulting in relative movement and load at the interface of the specimens. The specimens are

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1 easily replaceable on both the load and flexure bars and readily modified as to size and shape for applying differing fretting loads.

For a better understanding of these and other aspects of the invention, references may be made to the following detailed description
5 taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a fretting test fixture constructed in accordance with the invention;

FIG. 2 is a side elevational view of a portion of the fixture
10 shown in FIG. 1;

FIG. 3 is a plan view of FIG. 2;

FIG. 4 is an enlarged fragmentary plan view of the specimen holding portion of the flexure bar;

FIG. 5 is an enlarged and inverted fragmentary plan view of
15 the specimen holding portion of the load bar; and

FIG. 6 is an elevational view illustrating the application of a furnace to the test fixture shown in FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. 1, there is shown a perspective view of
20 a fretting test fixture 10 constructed in accordance with the present invention. A table 12 has a top surface having a vise 14 rigidly attached thereto. A motor 16 is positioned under the top surface of the table 12 and has an output shaft 18 connected to an eccentric drive assembly. The eccentric drive assembly comprises a variable eccentric
25 disc 20 connected to the end of the output shaft 18 and positioned exterior

1 to one end of the table 12, a cranking arm 22 connected at one end to
the disc 20, an adjustable crank end 24 having a radial bearing insert
26, and a clamp 28 connected to the bearing 26. A motor speed control
30 is securably attached to a front panel of the table 12 and is elec-
5 trically connected to the motor 16. A counting device 32 is also se-
curably attached to the front panel of the table 12 and is connected to
the eccentric drive assembly in any convenient manner such as, for ex-
ample, a switching mechanism or a photocell detector which indicates
the strokes produced by the crank arm 22. The vise 14 comprises a
10 plurality of clamping screws 34, an upper jaw 36, and a lower jaw 38.
Intermediate the jaws 36, 38 and shown clamped in the vise 14 is a load
bar 40 adjacent the upper jaw 36, a flexure bar 42 adjacent the lower
jaw 38, and a shim 44 intermediate the load bar 40 and the flexure bar
42. A first fretting specimen 46 is securably attached by screws 48 to
15 the free floating cantilevered end of the load bar 40, The end of the
flexure bar 42 that is pointing away from the vise 14 is securably at-
tached to the clamp 28 by a plurality of screws 50. Intermediate the ends
of the flexure bar 42 and adjacent the specimen 46 is a second fretting
specimen 52 placed in orthogonal alignment to the first specimen 46 and
20 securably attached to the flexure bar 42 by a plurality of screws 54.

Referring now to FIG. 2, there is shown a side elevational view
of the test fixture shown in FIG. 1. The clamping screws 34 produce a
downward force on the upper jaw 36 which compressively holds the load
bar 40, the shim 44, and the flexure bar 42 adjacent the lower jaw 38.

25 More clearly indicated is the positioning of the first specimen

1 46 secured to the end of the load bar 40 by the screws 48, and the second
specimen 52 in surface contact with the first specimen 46 and attached
intermediate the ends of the flexure bar 42 by screws 54. Also shown in
greater detail is the crank end 24 having threads at the end thereof
5 which engage with the top portion of the cranking arm 22 so as to shorten
or lengthen the effective length thereof.

Referring now to FIG. 3, there is shown a top plan view of
that portion of the test fixture shown in FIG. 2. The load arm 40 is
shown extended in a cantilevered fashion from the vise 14 and having a
10 triangulated shape with a varying width somewhat smaller than the width
of the underlying flexure bar 42 which is also triangular in shape. Both
the bars 40, 42 are preferably triangularly shaped because of the more
uniform absorption and application of load stress known to be associated
with this configuration. The respective widths and thicknesses
15 of the bars 40, 42, however, may be suitably enlarged or diminished
to reflect the designers choice of more or less rigidity or surface
area. More clearly shown is the positioning of the first specimen 46 in
longitudinal alignment with the length of the load bar 40. Also more
clearly shown is the positioning of the second specimen 52 in orthogonal
20 alignment with the first specimen 46 and secured to the flexure bar 42
intermediate the ends thereof.

FIG. 4 shows an enlarged fragmentary plan view of the specimen
holding portion of the flexure bar 42 and more clearly illustrates one
possible shape of the second specimen 52. In this example, the specimen
25 52 has been narrowed at the mid section thereof to provide a predetermined

1 sample cross-sectional area which can readily be altered as to thickness,
length and width. The specimen 52 may also be readily removed and re-
placed upon the bar 42 by the removal of the screws 54.

FIG. 5 is an enlarged and inverted plan view of the specimen
5 holding portion of the load bar 40. Similar to the view shown in FIG. 4,
the specimen 46 is securably attached to the end of the bar 40 by the screws
48 which permit ready removal and replacement of the specimen. Similar to the
specimen shown in FIG. 4, specimen 46 is also illustrated by way of ex-
ample as having a modified cross-sectional area which may be easily
10 formed to provide different thicknesses, lengths, or widths. That portion
of the load bar 40 underlying the area about each of the screws 43 is
shown having an arc-like contour due to the desirability of providing
sufficient bar strength about the threaded holes adapted to receive the
screws 48. Although in the example of the foregoing embodiment, the
15 specimens 46, 52 are shown placed, respectively, on load bar 40 and
flexure bar 42 in an orthogonal arrangement, the specimens may just as
easily be placed in any other convenient arrangement which will achieve
the desired load stresses and relative motion between the interface of
the contact surfaces of the specimens.

20 FIG. 6 illustrates an elevational view of a second embodiment
of the present invention showing the application of a furnace 56 to the
test fixture 10. The furnace 56 forms a heated cylinder which encloses
the load bar 40, the flexure bar 42, and the mounted specimens 46, 52.
Appropriate openings are provided at the respective ends of the furnace
25 56 to accommodate the bars and also to provide for the necessary freedom
26 of movement of the bars during testing operations. The furnace 56 is

1 attached to the top surface of the table 12 by a pair of supports 58.
A plurality of tapping terminals 60 are provided at the top of the fur-
nace 56 and are adapted to receive electrical energy which will heat the
furnace. Temperature control is maintained within the furnace 56 by
5 activating one or more of the appropriate terminals 60 to produce the
desired amount of heat.

Referring now to FIGS. 1-5, the operation of the present inven-
tion will now be explained. Fretting specimens of the particular material
that is desired to be tested such as, for example, titanium are machined
10 to their desired shape and thickness. The machined specimens may be of
equal thickness and are modified as shown in FIGS. 4 and 5 to include a
predetermined cross sectional area when the specimens are mated in the
test fixture. The specimens selected may also be constructed of different
materials such as one from titanium sheet and one from aluminum sheet for
15 evaluating a titanium-aluminum interface. Once the type of material and
the shape of material are selected for the specimens, the shim 44 is
sized to have a thickness equal to the combined thicknesses of the speci-
mens 46, 52. Each of the specimens 46, 52 are attached, respectively,
to the load bar 40 and the flexure bar 42 in the manner shown in the
20 drawings. The load bar 40, the selectively sized shim 44, and the flexure
bar 42 are then clamped in the vise 14 by the screws 34. The other end of
the flexure bar is then connected to the clamp 28 by means of the screws
50. During the actual testing operation by the fixture 10, it is necessary
that opposing load forces be applied in a normal direction to each of the
25 specimen surfaces and at the interface thereof. In addition, it is also

1 necessary that relative movement or slip amplitude occur at the interface
of the specimens 46, 52 thereby producing a fretting corrosion effect.
Accordingly, the thickness, length, and materials comprising the bars
40, 42 are preselected to set up initial testing conditions as to the
5 stresses and loading forces to be applied to the specimens during the
test. Moreover, the eccentricity of the cranking arm 22 will be adjusted
to provide the desired degree of reciprocating stroking action and con-
sequential flexing of the flexure bar between the vise 14 and the clamp
28. The eccentricity of the flexing stroke as produced at the cranking
10 arm 22 is most easily adjusted in a conventional manner by moving the
end of the arm 22 either nearer to or farther from the center of the
disc 20 as permitted by a diametrical slot milled in the disc 20 and
securing a bolt thereby which forms an axle for the end of the arm 22.
Having secured the specimens to the respective bars and tightened the
15 vise 14, an adjustment is made so as to provide for zero spacing be-
tween the specimens 46, 52 when the cranking arm 22 is at the lowermost
position of its stroke. This adjustment is most easily accomplished
by manually placing the cranking arm at the lowermost stroke position
and by adjusting the screw threads at the end of the arm end 24 so as to
20 provide minimal surface contact at the specimens interface. Accord-
ingly, it is intended in the present invention that after the foregoing
adjustment has been made, the test specimens shall always be in contact
with each other during the test operation and, consequentially, have a
load applied at the interface surfaces during the entire period of the
25 test. The applied load, however, will alternately increase and decrease

1 in a sinusoidal fashion according to the position of the flexing stroke.

To start the test procedure, the motor 16 is activated by the speed control 30 to provide a desired rpm output at the shaft 18 which rpm will coincide with the frequency of the flexing action produced in the load bar 40 and flexure bar 42. As the reciprocating cranking arm 5
22 begins its upward stroke the flexure bar is flexed toward and against the load bar in a plane formed by the longitudinal axes of both bars. Both the flexure and load bar bend in an upward direction with the result that the specimens 46, 52, which are secured to the respective
10 bars, begin to move relative to each other with a shear-like motion. The relative distance over which the specimens move is known as the slip amplitude. The opposing loads produced by the flexing load bar 40 and the flexure bar 42 at the interface of the specimens while testing titanium materials, for example, have resulted in normal load forces of
15 up to 850 psi, while the slip amplitude at the interface of the titanium specimens has been approximately .001 inch. The counter 32 is conveniently employed to count the number of strokes or flexures at the specimens interface and produces an accurate indication of the number of fretting strokes to which the specimens have been subjected during the test.

20 Referring now to FIG. 6 there is shown a second embodiment of the present invention in which a cylindrical furnace 56 is mounted on the test fixture table 12 by means of supports 58 to enclose portions of the bars 40, 42 as well as the secured specimens 46, 52. In operation, the furnace is heated to a temperature which is controlled and selected
25 by application of an electrical power source to one or more of the terminals

1 60 provided at the top of the furnace 56. Each of the terminals 60 are
connected in a conventional manner to various portions of a heating ele-
ment (not shown) within the furnace 56. The furnace 56 is sufficiently
sealed at the respective ends thereof to contain the heat but provides
5 for openings sufficient to pass the bars 40, 42 and allow for unrestricted
flexing movement. As is well known in the art, fretting corrosion will
vary with increased temperatures and it is desirable to examine the ef-
fects of such corrosion upon appropriate specimens at a variety of tem-
perature environments. This embodiment of the present invention thus
10 provides a convenient method of enclosing the test specimens within a
high temperature environment, all of which is done in a work area which
is easily accessible to the test operator.

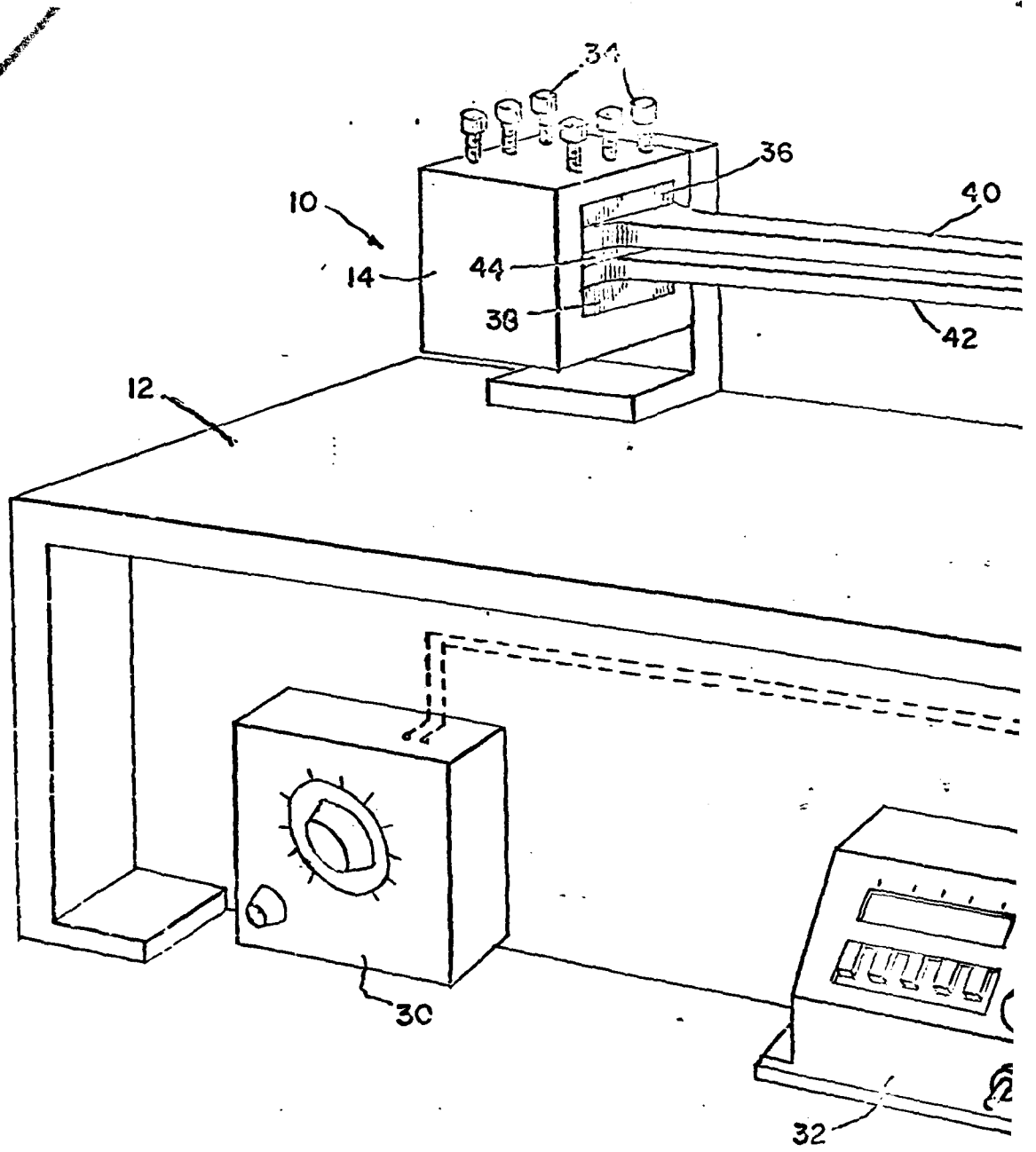
Test specimens other than metal such as plastics, coatings,
or lubricants are easily adaptable for use within the present invention.
15 At the end of the test of such specimens, fretting corrosion may be eval-
uated by noting the amount and composition of debris produced by the test
or by other testing standards such as the reduced weight or volume of the
test specimens.

Thus it may be seen that there has been provided a novel fretting
20 corrosion test fixture which generates a corrosive action upon a variety
of test materials and which testing may be conveniently accomplished in
high temperature environments.

Obviously, many modifications and variations of the invention
are possible in light of the above teachings. It is therefore to be un-
25 derstood that within the scope of the appended claims the invention may

1 be practiced otherwise than as specifically described.

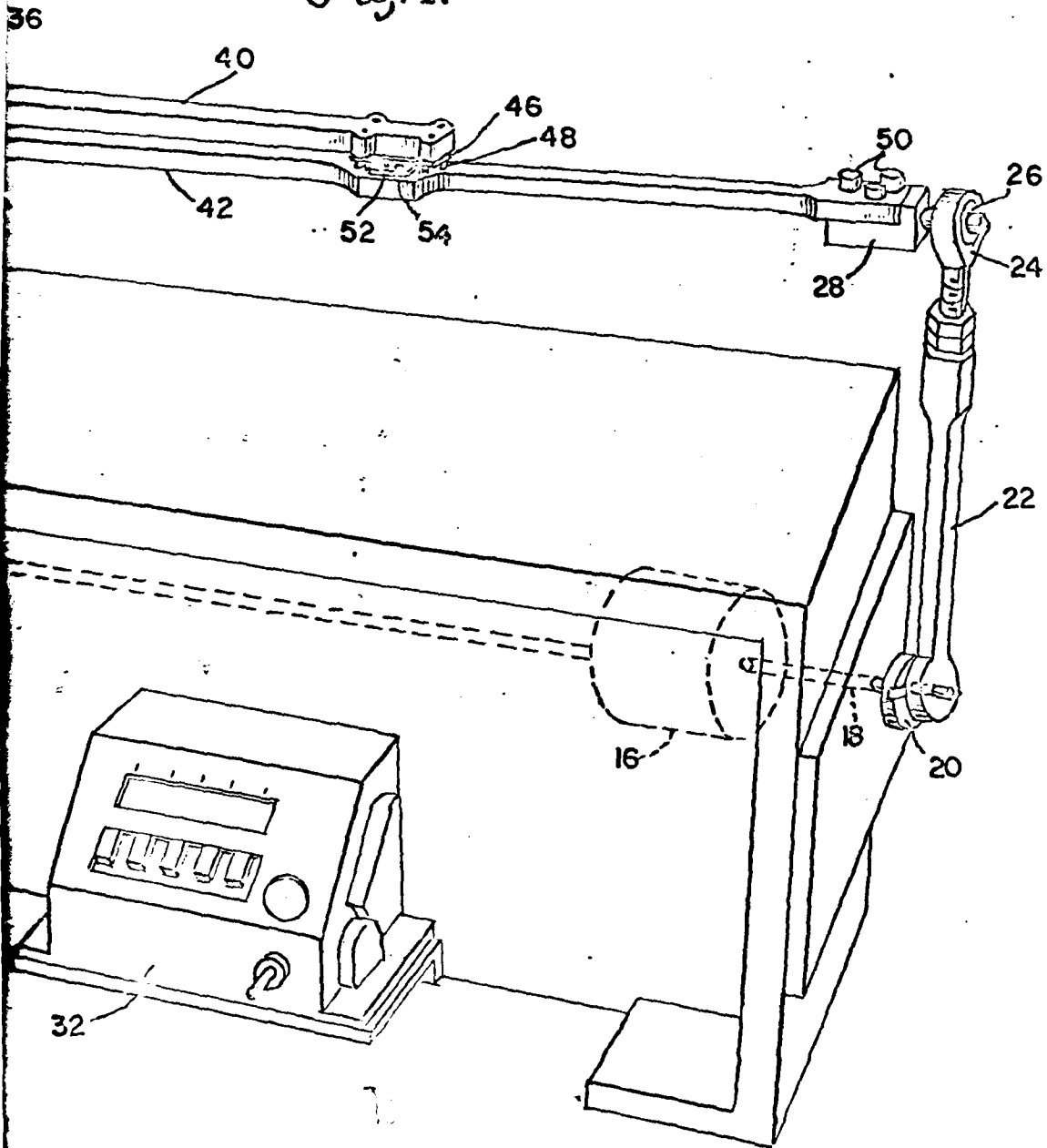
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Fig. 1.



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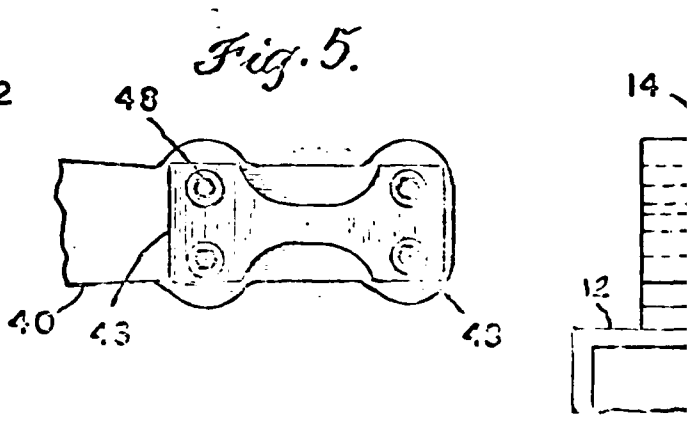
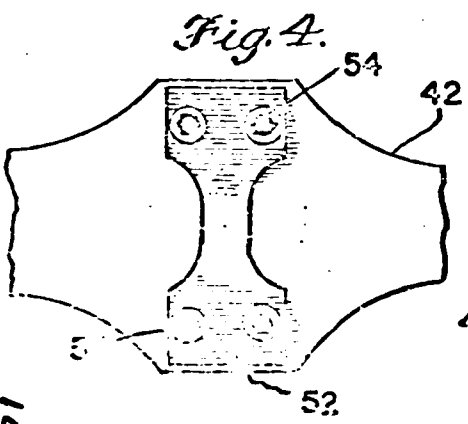
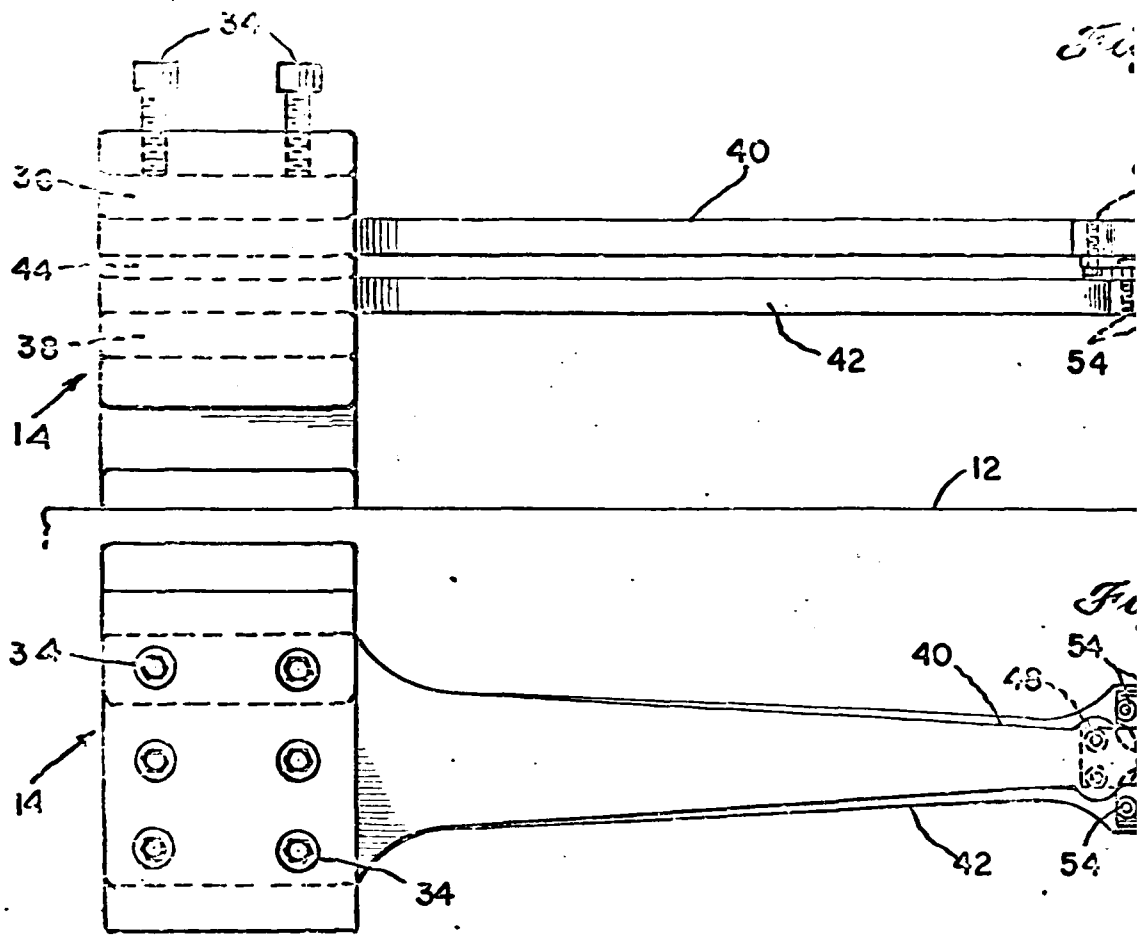


Fig. 2.

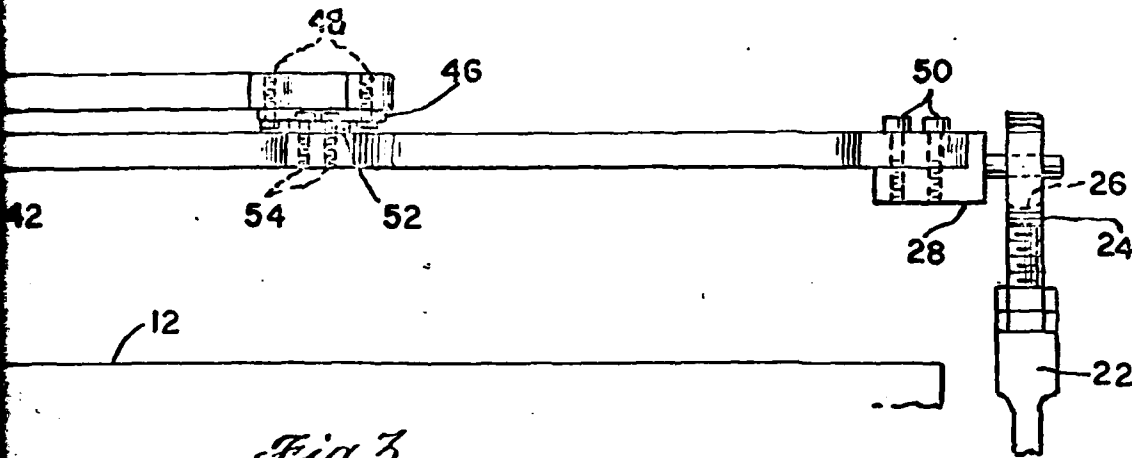


Fig. 3.

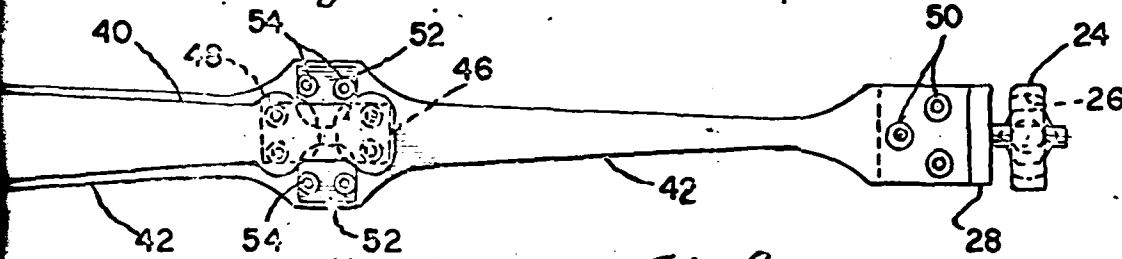
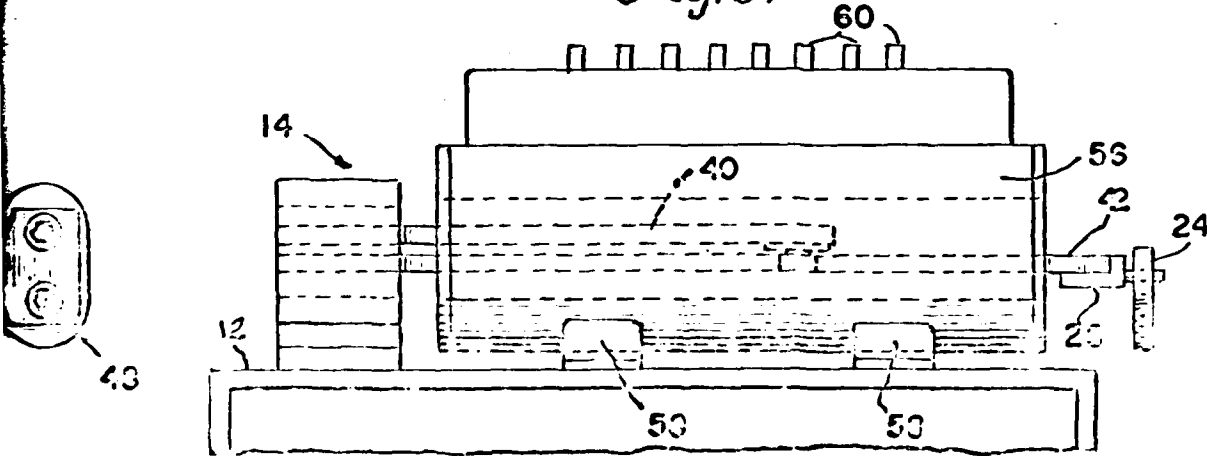


Fig. 6.



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