

Serial Number            09/267,916  
Filing Date              2 March 1999  
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19990915 047

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3 CALIBRATED STOP BOLT FOR LONGITUDINAL SHOCK TEST FIXTURE

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5 STATEMENT OF GOVERNMENT INTEREST

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

10  
11 BACKGROUND OF THE INVENTION

12 (1) Field of the Invention

13 This invention relates generally to a simulated stop bolt,  
14 and more particularly to a calibrated stop bolt including a  
15 plurality of strain gauges for accurately measuring the dynamic  
16 load applied to the calibrated stop bolt during a shock test.

17 (2) Description of the Prior Art

18 Most work to date in torpedo tube shock improvement has  
19 centered on variations in the bearing plate and stop bolt  
20 designs. However, such modifications are often difficult to  
21 implement due to the limited information available on the dynamic

1 loads transmitted to the submarine stop bolt. More particularly,  
2 current load limits for submarine stop bolts have been determined  
3 from static load tests. These values are conservative for high  
4 frequency shock events where higher material strengths are often  
5 encountered. This results in the difficulty of implementing  
6 modifications since the shock energy must be dissipated, and the  
7 load transmitted to the submarine stop bolt is limited, based  
8 upon values determined by static testing alone.

9 Shock test fixtures utilized in conjunction with a  
10 heavyweight shock machine are the primary method for testing the  
11 effectiveness of torpedo bearing plate designs. In conventional  
12 shock testing, the torpedo bearing plate is restrained by a dummy  
13 or simulated stop bolt which acts as an interface between the  
14 torpedo bearing plate and the shock test fixture to prevent  
15 relative motion between the torpedo and the fixture. An example  
16 of such a conventional system is shown in FIG. 1, which is a  
17 cross-sectional side view of a simulated stop bolt 110, torpedo  
18 bearing plate 116 and longitudinal test fixture 126. Stop bolt  
19 110 includes two extensions 114a, 114b which fit through two  
20 corresponding holes in the longitudinal test fixture 126, thereby  
21 restraining the bearing plate 116 on torpedo 119. By restraining

1 movement of the bearing plate, relative motion between the  
2 torpedo and the shock test fixture is prevented. However,  
3 conventional longitudinal shock test fixtures are unable to  
4 measure the dynamic load transmitted to the simulated stop bolt,  
5 thus limiting the ability to improve bearing plate designs.

6 There is therefore needed an improved simulated stop bolt  
7 for shock testing which is capable of measuring the dynamic load  
8 transmitted to the simulated stop bolt, so that improvements in  
9 the design of torpedo bearing plates and submarine stop bolts can  
10 be implemented.

#### 11 12 SUMMARY OF THE INVENTION

13 This invention provides a calibrated stop bolt for measuring  
14 the dynamic load transmitted to the calibrated stop bolt during a  
15 shock test. The stop bolt includes an anterior extension and a  
16 posterior extension, for restraining a torpedo bearing plate  
17 therebetween, and also includes a plurality of strain gauges  
18 mounted at the top portion of each extension. In one embodiment,  
19 eight strain gauges are utilized, with two strain gauges placed  
20 on each side of the two extensions, i.e., in a full bridge  
21 arrangement. The full bridge arrangement is the preferred

1 arrangement because it doubles the rated sensitivity of a single  
2 strain gauge. The calibrated stop bolt is preferably mounted to  
3 a base plate and bolted at each end to a longitudinal test  
4 fixture. The calibrated stop bolt can be utilized with a  
5 conventional longitudinal shock test fixture, torpedo shape and  
6 heavy weight shock machine, as are known to those of skill in the  
7 art.

8 During a shock test, the bearing plate and calibrated stop  
9 bolt engage alternately at the interface between the bearing  
10 plate and the anterior and posterior stop bolt extensions,  
11 respectively. When the bearing plate and stop bolt engage, the  
12 strain gauges measure the strain at each location of the gauges.

13 These strains can then be related to the load experienced at the  
14 interface of the bearing plate and the anterior stop bolt  
15 extension, and the interface of the bearing plate and the  
16 posterior stop bolt extension, so as to determine the dynamic  
17 load transmitted to the stop bolt during the shock test. The  
18 measurements taken during the shock test may be recorded, for  
19 example on a digital recording device, an analogue tape, or  
20 computer disc, in order to utilize the measurements in other,  
21 subsequent analysis.

1           It is therefore an object of the present invention to  
2 provide a calibrated stop bolt having a plurality of strain  
3 gauges mounted thereto for measuring the strain experienced by  
4 the calibrated stop bolt.

5           It is another object of the present invention to provide a  
6 calibrated stop bolt capable of measuring the dynamic load  
7 transmitted to the calibrated stop bolt during a shock test in  
8 order to prove that bearing plate modifications are in compliance  
9 with submarine interface requirements.

10  
11                           BRIEF DESCRIPTION OF THE DRAWINGS

12           The invention will be described with reference to the  
13 appended drawings, wherein common features of the invention are  
14 identified with common reference numerals in the multiple views  
15 provided of the invention and wherein:

16           FIG. 1 is a cross-sectional side view of a longitudinal test  
17 fixture, a torpedo bearing plate and conventional stop bolt;

18           FIG. 2 is a perspective view of a longitudinal shock test  
19 fixture, torpedo shape, and heavy weight shock machine; and

20           FIG. 3 is a cross-sectional side view of a calibrated stop  
21 bolt assembly according to the present invention which may be

1 utilized in conjunction with the longitudinal shock test fixture,  
2 torpedo shape and heavy weight shock machine of FIG. 2.

3  
4 DESCRIPTION OF THE PREFERRED EMBODIMENT

5 The calibrated stop bolt assembly of the present invention  
6 is illustrated most clearly in FIG. 3. As will hereinafter be  
7 more fully described, the general basis for the invention is for  
8 strain gauges to measure the strains on a calibrated stop bolt  
9 during shock testing. The measured strain can then be related to  
10 the load experienced at the interface of a bearing plate and an  
11 anterior stop bolt extension, and the interface of the bearing  
12 plate and a posterior stop bolt extension, so as to determine the  
13 dynamic load transmitted to the calibrated stop bolt during the  
14 shock test.

15 The calibrated stop bolt 10 of the present invention  
16 includes a body member 12, an anterior extension 14a and a  
17 posterior extension 14b, extending from body member 12, for  
18 restraining torpedo bearing plate 16 therebetween. Mounted at a  
19 top portion 18a, 18b of the anterior and posterior extension 14a,  
20 14b, respectively, are strain gauges 20. The strain gauges are  
21 preferably mounted as close to the top portion of each extension

1 as possible, without causing the extensions to bend during shock  
2 testing. The strain gauges 20 are utilized to measure the strain  
3 at the interface or engagement area 22a, 22b between torpedo  
4 bearing plate 16 and the anterior and posterior extensions 14a,  
5 14b of the stop bolt 10. Accurate dynamic load measurement is  
6 primarily a function of the length of the stop bolt extensions  
7 14a, 14b relative to the expected variation in the length of the  
8 bearing plate engagement area 22a, 22b. In the present  
9 embodiment, the length ( $l_1$ ) of the anterior and posterior  
10 extensions is preferably between about 2-3 inches, and is most  
11 preferably about 2.5 inches; while the length of the engagement  
12 area ( $l_2$ ) may preferably vary between about .26 and .36 inches.  
13 For an extension length of about 2.5 inches and bearing plate  
14 engagement length of between .26 and .36 inches, the arrangement  
15 results in load measuring accuracy of +/-3%. Other lengths may  
16 be utilized for the extension and bearing plate engagement,  
17 however, the above values were chosen to maximize accuracy while  
18 lowering root stresses to an acceptable level. For example,  
19 although longer length extensions may be utilized to further  
20 increase the accuracy of the measurements, increasing the length  
21 of the extensions also increases bending stresses at the top of

1 the extensions which may prove unacceptable by causing the  
2 extensions to bend during testing.

3 The strain gauges are preferably mounted in a full bridge  
4 arrangement, so as to accurately measure the strain placed on the  
5 stop bolt at the interface between the anterior and posterior  
6 extensions and the bearing plate. In a preferred embodiment,  
7 eight strain gauges are utilized, with two strain gauges placed  
8 on either side of the top portion of the anterior and the  
9 posterior extensions, i.e., in a full bridge arrangement as shown  
10 in FIG. 3. The full bridge arrangement is preferred because it  
11 doubles the rated sensitivity of a single stain gauge. Other  
12 numbers of strain gauges may be utilized, although at least four  
13 gauges should preferably be provided so that a strain gauge is  
14 mounted on either side of the top portion of both the anterior  
15 and the posterior extensions. The strain gauges may preferably  
16 have a gauge factor of 2.050 at 24°C, be 1/8" long, with a 120  
17 Ohm resistance, such strain gauges being available from  
18 Micromasurements Group, Inc. as style EA-062AP-120, or  
19 alternately, other conventional strain gauges as would be known  
20 to those skilled in the art may be utilized.

1       The stop bolt is preferably fabricated from a high strength  
2 material which will not deform during testing. The stop bolt is  
3 particularly susceptible to deformation at the interface with the  
4 bearing plate and at the top portion of the extensions. It is  
5 also preferred that the material utilized be corrosion resistant,  
6 since corrosion would interfere with the operation of the strain  
7 gauges. In the present embodiment 17-4PH stainless steel which  
8 was heat treated to H900 condition was utilized, although other  
9 materials of similar strength and corrosion resistance may be  
10 utilized, as would be known to those skilled in the art.

11       Prior to testing, the calibrated stop bolt 10 is mounted in  
12 a base plate 24 and bolted at each end to a longitudinal test  
13 fixture 26. In a preferred embodiment, the base plate 24 is  
14 disposed between body member 12 and the longitudinal test fixture  
15 26. The calibrated stop bolt 10 can be utilized with a  
16 conventional longitudinal shock test fixture 4, torpedo shape 6  
17 and heavy weight shock machine 8 as shown in FIG. 2.

18       The operation of the calibrated stop bolt 10 of the present  
19 invention will now be described. During a shock test performed  
20 according to known procedures, the bearing plate 16 and  
21 calibrated stop bolt 10 engage alternately at the interface 22a,

1 b of the bearing plate 16 and the anterior and posterior stop  
2 bolt extensions, 14a, b respectively. When the bearing plate and  
3 stop bolt engage, the strain gauges measure the strain at each  
4 location of the gauges. These strains can then be related to the  
5 load experienced at the interface of the bearing plate and the  
6 anterior stop bolt extension, and the interface of the bearing  
7 plate and the posterior stop bolt extension, so as to determine  
8 the dynamic load transmitted to the stop bolt during the shock  
9 test. The dynamic load may then be utilized to prove that  
10 bearing plate modifications are in compliance with submarine  
11 interface requirements. The measurements taken during the shock  
12 test may be recorded, for example on a digital recording device,  
13 analogue tape or computer disc, in order to utilize the  
14 measurements in other, subsequent analysis.

15 While there is shown and described herein certain specific  
16 structure embodying the invention, it will be manifest to those  
17 skilled in the art that various modifications and rearrangements  
18 of the parts may be made without departing from the spirit and  
19 scope of the underlying inventive concept. For example, the  
20 material utilized for the stop bolt assembly and the number (more  
21 or less) and location of the strain gauges may be varied by one

1 of skill in the art. Therefore, the invention is not limited to  
2 the particular forms shown and described herein,

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1 Attorney Docket No. 78417

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3 CALIBRATED STOP BOLT FOR LONGITUDINAL SHOCK TEST FIXTURE

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5 ABSTRACT OF THE DISCLOSURE

6 A calibrated stop bolt is provided for measuring the dynamic  
7 load transmitted to the calibrated stop bolt during a shock test.

8 The stop bolt includes an anterior extension and a posterior  
9 extension, for restraining a torpedo bearing plate therebetween,  
10 and also includes a plurality of strain gauges mounted at the top  
11 portion of each extension. In one embodiment, eight strain  
12 gauges are utilized, with two strain gauges placed on each side  
13 of the two extensions, i.e., in a full bridge arrangement. The  
14 calibrated stop bolt is preferably mounted to a base plate and  
15 bolted at each end to a longitudinal test fixture. The  
16 calibrated stop bolt can be utilized with a conventional  
17 longitudinal shock test fixture, torpedo shape and heavy weight  
18 shock machine.

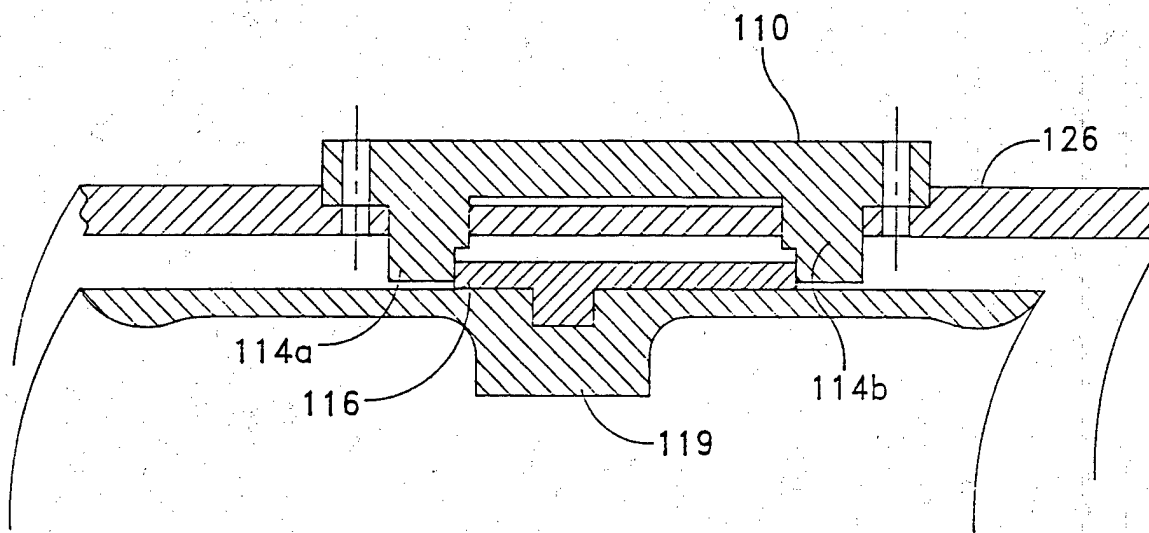


FIG. 1  
(PRIOR ART)

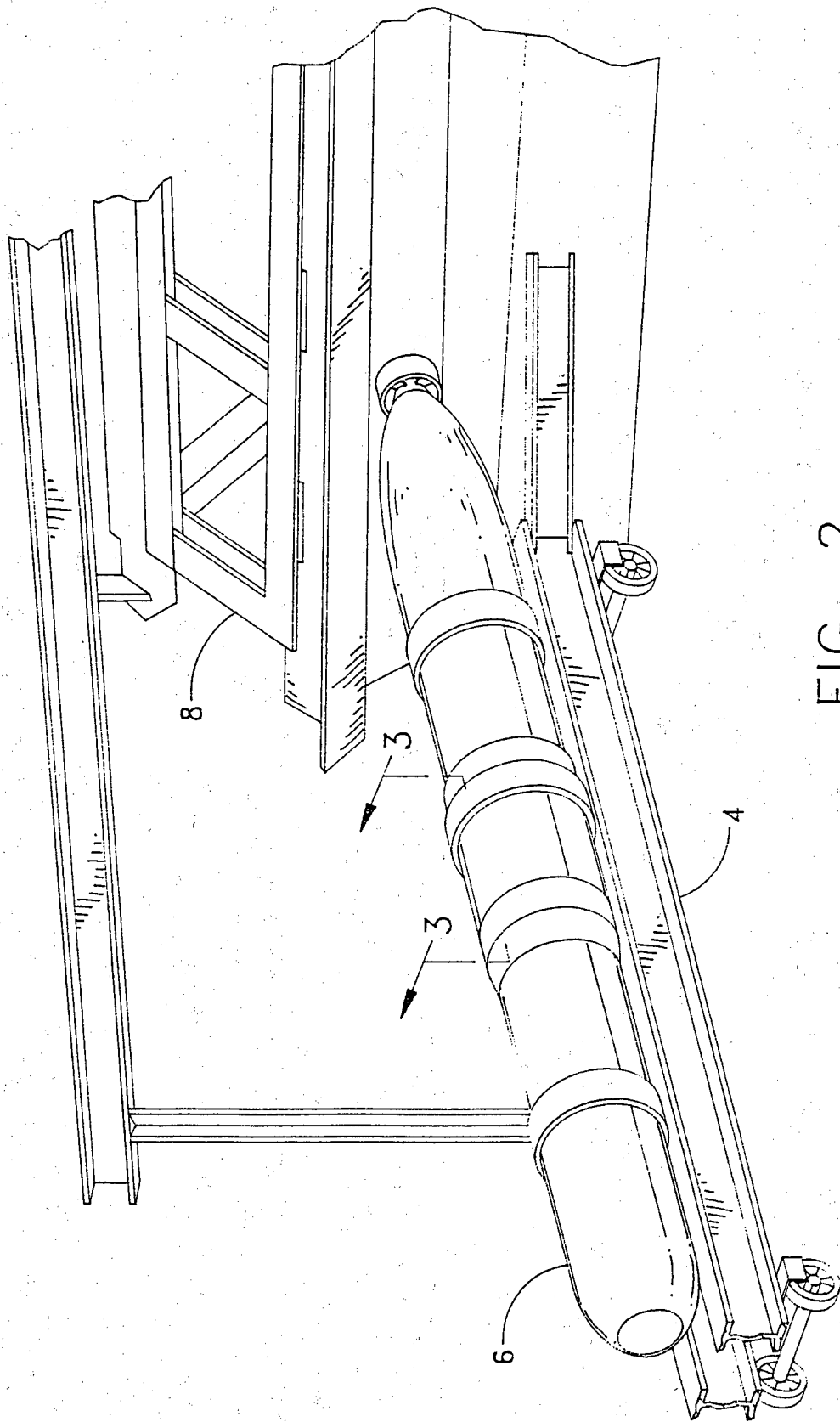


FIG. 2

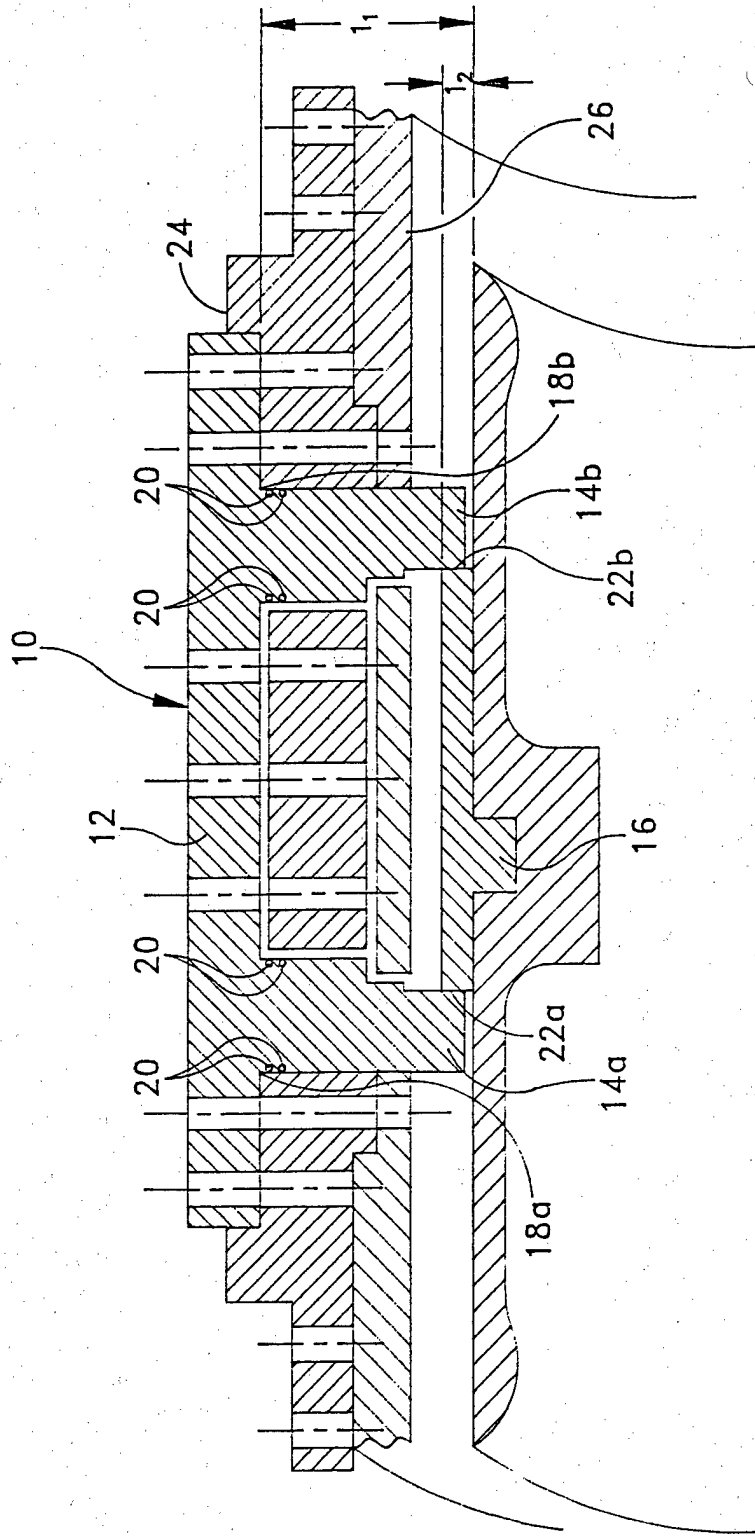


FIG. 3