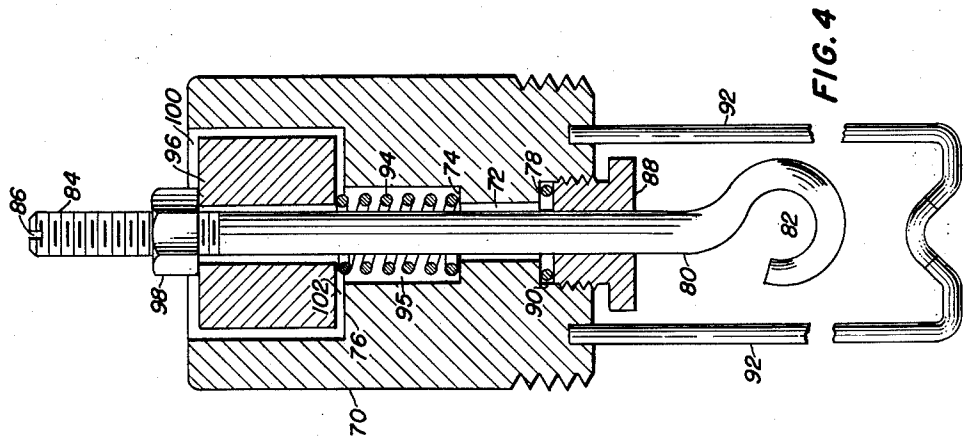
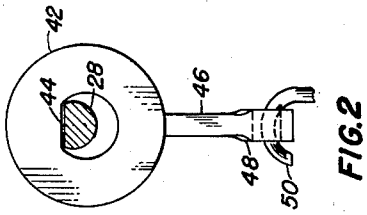
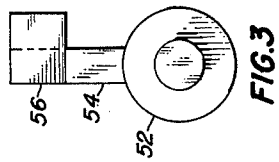
Sept. 3, 1963 E. SCHASCHL 3,102,419

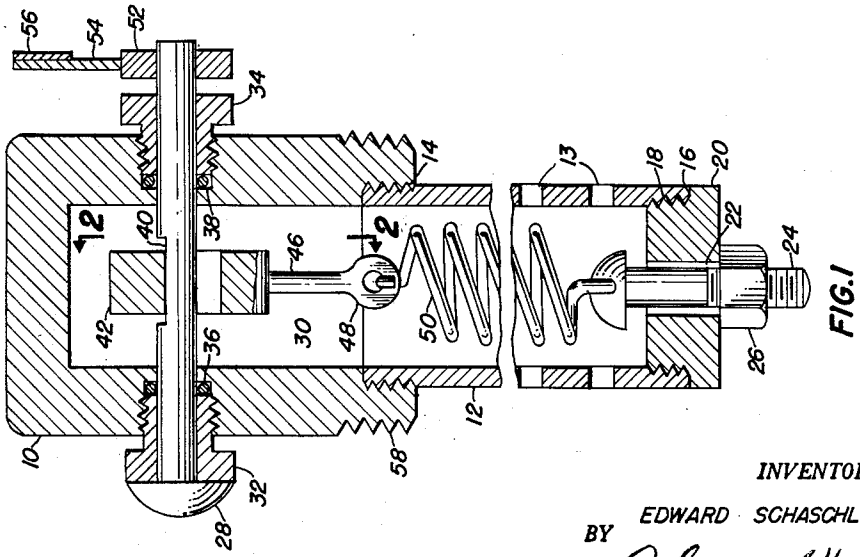
APPARATUS FOR DETECTING HYDROGEN EMBRITTLEMENT

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APPARATUS FOR DETECTING HYDROGEN EMBRITTLEMENT

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This invention relates to a device for determining the embrittling or intercrystalline-crack-producing characteristics of various fluids, such as crude petroleum.

Serious difficulties from embrittlement in oilfield apparatus, pressure vessels, and chemical-processing equipment have been encountered. The prior art has recognized the embrittlement problem chiefly in relation to boiler operation, wherein it was noted that while water in a boiler seldom contains a sufficient concentration of deleterious materials to produce embrittlement problems, should the deleterious materials become highly concentrated by evaporation, the boiler water can produce embrittlement cracks and failures in steel which is maintained under stress in contact with such concentrated solutions. The prior art accordingly developed methods and techniques for artificially concentrating various materials in boiler water and determining the propensities of such concentrated solutions to produce cracks under conditions of stress.

It is now known that other chemical agents produce embrittlement cracking to a much greater extent than does boiler water. The prior art techniques for evaluating the embrittling propensities of various fluids have proved unsatisfactory because of the need to produce artificially severe concentrations of the deleterious agent, or because the devices were too insensitive to produce meaningful results within a reasonable period of exposure to fluids which were not artificially concentrated. When concentrated solutions are used, the information thereby obtained cannot readily be extended or interpreted to produce meaningful estimates of the likelihood of embrittlement failure of parts contacted by fluid which is not so concentrated.

Certain conditions which occur in oil wells and oil-processing equipment promote the failure of ferrous alloys by a phenomenon known as "hydrogen embrittlement." Actual failure occurs in the form of smooth cracks, similar in appearance to hacksaw cuts, when the ferrous-alloy object or structural member is subjected to stress. Even mild corrosion in the presence of certain sulfur compounds may cause hydrogen embrittlement of ferrous alloys and resulting failure when the alloys are stressed above specific critical values. It is recognized in the art that each ferrous alloy has a critical stress level at which failure will occur after hydrogen embrittlement has taken place, and that the time required for hydrogen embrittlement is dependent upon the characteristics of the environment. However, heretofore there have been no adequate means of testing the effects of various fluids on the failure of ferrous alloys.

It is an object of this invention to provide a simple test apparatus to determine the resistance of various ferrous alloys to hydrogen embrittlement when exposed to particular environments. Yet another object of this invention is to provide a test device for determining the critical stress at which hydrogen-embrittlement failure will occur upon exposure to a particular embrittling fluid. This invention in part stems from the discovery that stressed coil springs are peculiarly susceptible to hydrogen embrittlement, and that ferrous springs, when tensioned and exposed to an embrittlement producting fluid, will fail in a much shorter perior of time than will conventional stressed structures.

Broadly, the device of this invention comprises a metal

test specimen in the form of a ferrous spring, means for tensioning the spring and supporting it in exposure to a fluid to be tested, and means for indicating the failure or breaking of the spring. In use, a preselected stress is applied to the spring, the assembly is positioned in the environment under study, and the length of time required for the spring to fail is noted. Sequential tests may be made at increasing stresses to determine the critical stress of the metal alloy under study, or, alternatively, a stress at least equal to the critical stress may be applied to the spring and other test conditions may be altered, as by adding embrittlement inhibitors to the fluid under study, or altering the composition of the fluid.

This invention is best decribed with reference to the drawings, of which:

FIGURE 1 is a frontal, sectional, view of a test device constructed in accordance with this invention.

FIGURE 2 is a view in the direction 2—2 of FIGURE 1.

FIGURE 3 is a right side view of the flag assembly of FIGURE 1.

FIGURE 4 is a sectional view of a portion of an alternate device constructed in accordance with this invention.

Referring to FIGURE 1, base 10, which may be a bull-plug, supports perforated, projecting, support-member 12, which is of tubular cross-section, and is rigidly secured to base 10 by threads 14. Support-member 12 is provided with perforations such as perforations 13. The projecting end 16 of the tubular support-member is threaded at 18 to accept end-plug 20.

End-plug 20 includes an axial hole 22 through which extends eye-bolt 24. Nut 26 limits the upward movement of eye-bolt 24, the downward movement being limited by the striking of the head of the bolt against plug 20. Eye-bolt 24 may be provided with a flat area on one side thereof, to mate with a corresponding flat area in hole 22, thereby preventing rotation of the eye-bolt as nut 26 is rotated.

Eccentric shaft 28 passes transversely through base 10, which base includes a hollow portion 30 within its cup-shaped configuration. Eccentric shaft 28 is supported by bearing members 32 and 34, which bearing members when threaded in place in base 10 compress O-ring seals 36 and 38 to provide a fluid-tight seal between the base 10 and shaft 28. Shaft 28 includes an eccentric portion 40, which preferably is ground flat on one side of that portion of the shaft which extends within the hollow portion 30 of base 10. Ring 42, which encompasses the shaft 28, includes a corresponding flat area 44 which mates with the eccentric flat area of shaft 28 when the ring is urged in a downward direction, as by tension applied to rod 46, which is secured to ring 42 on the side thereof opposite from the aforesaid flat area. Rod 46 terminates at eye 48, which eye is adapted to receive a test coil-spring 50. Spring 50 is secured to the eye of rod 46 at one end, and to eye-bolt 24 at the other end, and is tensioned therebetween. Spring 50 is preferably a helical coil-spring of uniform diameter fabricated of a ferrous alloy, the embrittlement characteristics of which are to be determined. When spring 50 is tensioned, as by rotation of nut 26, the flat areas of ring 42 and shaft 28 cooperate to impede rotation of shaft 28. Externally of the base 10, an eccentric signalling device, which includes ring 52, rod 54, and signal flag 56, is supported from shaft 28. The weight and length of rod 54 are sufficient to compel, under force of gravity, rotation of shaft 28 when no tension is applied to rod 46 by spring 50.

The device may readily be assembled and disassembled by means of the threads 14 and 18, to insert and remove test springs. When assembled, nut 26 is rotated to provide the desired tension to spring 50, and the device

inserted in a vessel containing the environment to be studied, as by screwing the base in place by means threads of 58, which are adapted to mate with standard pressure-vessel fittings. Tension in spring 50 retains shaft 28 in the angular position shown, against the torque applied by the weight of rod 54.

In use, after an appropriate period of exposure, for example 1 month, coil-spring 50 ruptures, releasing the downward force applied by ring 42 to shaft 28. The shaft, then free to rotate, turns in bearings 32 and 34, and the flag drops from the horizontal to the vertical position, signalling failure of the spring. An advantage of the unitary design of the device of this invention is that none of the parts become disengaged from the device on the rupture of the spring, and therefore they cannot be lost in the test fluid.

The spring 50, as aforestated, is fabricated of a ferrous alloy of interest. The remaining elements of the test assembly may be fabricated of any desired material, but are preferably made of a non-ferrous alloy of high corrosion resistance to the fluid under study, as substantially all of the elements are exposed to the test fluid which may enter freely through the perforations of support 12. Suitable materials, which are not subject to hydrogen embrittlement, include brass, bronze, aluminum, and stainless steels. Chrome-plated steel elements may be used, or the probe elements may be coated with a corrosion-impervious resin or plastic. Discretion should be employed in the selection of materials to prevent excessive corrosion which may develop due to galvanic cell action between the ferrous coil-spring and other, uncoated, probe elements.

Referring to FIGURE 4, an alternate test structure is shown. Base 70 is a bull-plug, provided with an axial, stepped hole 72, which includes shoulders at 74, 76, and 78. Rod 80, which passes axially through hole 72, terminates at one end at eye 82, and at the other end with threaded portion 84. A screwdriver slot 86 may be provided in the threaded end of rod 80. The rod is supported by bearing plug 88, which compresses an O-ring seal 90 between shoulder 78 and rod 80, to provide a seal therebetween. Support rods 92 are pressed into the lower end of base 70, which is adapted for exposure to the test environment. These rods provide an anchor for the lower end of a test coil-spring, the upper end of the spring being secured to eye 82 of rod 80. A second coil-spring 94 lies in the annular recess 95 between rod 80 and the interior side wall of base 70. This coil-spring bears upward against signal block 96, which encompasses a part of the threaded portion 84 of rod 80, and is secured against upward movement along the rod by nut 98. Enlarged recess 100 in the base 70 accommodates signal block 96, when rod 80 is urged downwardly by the tension of the test coil-spring, not shown. Adjustment of the spring tension in the test spring may be accomplished by rotation of nut 98. Screwdriver slot 86 provides one expedient by which undesired rotation of rod 80 may be prevented while nut 98 is rotated. Alternatively, the rod may be keyed to the base 70. As nut 98 is tightened, rod 80 is drawn upward until tension is applied to the test spring. Further rotation of nut 98 draws signal block 96 down into recess 100, due to the fact that spring 94 is of relatively small cross-section and therefore readily compressed. Movement of signal block 96 is halted when the lower surface 102 of the block strikes shoulder 76. Further rotation of nut 98 raises rod 80, tensioning the test coil-spring.

Upon failure of the test spring, after suitable exposure to an environment under study, coil-spring 94 pushes signal block 96 outward from recess 100 so that the signal block, which is preferably bright in color, becomes visible. Thus the rupture of the test spring is indicated. An advantage of the structure shown in FIGURE 4 is that adjustment of the tension in the spring may be made without removing the device from the vessel containing

the test environment. Thus, a spring tension at a value lower than the critical value for the ferrous alloy from which it is fabricated can be retensioned to a higher value by rotation of nut 98. This retensioning can be done periodically until the critical value of stress has been exceeded, and the spring ruptures. In this manner the critical stress for the ferrous alloy under study can be bracketed.

It is preferred that the threads of both eye-bolt 24 of FIGURE 1, and of rod 80 of FIGURE 4, be cut with a pitch which is a convenient fraction of an inch, such as 10 threads per inch. Thus, for example, one complete rotation of nut 98, or nut 22, will apply a stretch of $\frac{1}{10}$ of an inch to the spring. If it is desired to stress the test spring to any desired value, the test-spring deflection corresponding to this stress can be calculated in a conventional manner, and the nut rotated until tension is first felt to be applied to the spring. The nut may then be rotated the necessary number of times to deflect the spring through a distance which will apply to the desired stress. It is for this reason that threads having a pitch of 10 to the inch are most convenient.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. An embrittlement-detection probe comprising a base adapted to mate with an opening in a test-environment-confining wall to provide a first portion of said base exposed to said environment and a second portion not so exposed, a support member secured to said first portion of said base and projecting therefrom, signaling means associated with said base for supporting one end of a coil-spring adjacent said first portion of said base, and a ferrous coil-spring supported at one end by said signaling means and at the other end by said projecting support member, said signaling means being operable to produce a visible signal adjacent said second portion of said base in response to the breaking of said spring.

2. An apparatus according to claim 1 in which said signal is the change of position relative to said base of a member retained in position by the tension of said spring prior to the breaking thereof.

3. An apparatus in accordance with claim 2 in which said base is threaded for insertion in a pressure-vessel fitting.

4. An apparatus in accordance with claim 2 in which said first portion of said base is hollow and said signaling means comprises an eccentric shaft extending transversely of said spring through said base and the hollow portion thereof, means for applying rotative torque to said shaft, and a link connecting said spring and the eccentric portion of said shaft whereby tension in said spring restrains rotation of said shaft.

5. An apparatus in accordance with claim 4 wherein said means for applying torque comprises a weight supported radially of said shaft and externally of said base.

6. An apparatus according to claim 1 in which said base includes an aperture extending therethrough and communicating with said second portion thereof, said aperture being substantially coaxial with said spring and said signaling means comprising a rod adapted at one end to support one end of said coil-spring slidably disposed within said aperture, means limiting the movement of said rod towards said coil-spring, and means urging said rod in the direction to project from said second portion of said base.

7. An apparatus in accordance with claim 6 including means for forming a seal between said rod and said aperture.

8. An apparatus in accordance with claim 7 including a recess in said second portion of said base disposed radially of said aperture, a signal block adapted to fit within said recess and encompassing a portion of said rod, said rod having a threaded portion at the end thereof opposite from the end adapted to support said coil-

spring, nut means cooperating with said threaded portion for limiting axial movement of said signal block relative to said rod, and a coil-spring disposed coaxially with said rod, bearing against said base and said signal block to urge said signal block outward from said recess.

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