# United States Patent

**Felton, Jr.**

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[54] **METHOD AND APPARATUS FOR EVALUATING THERMAL STABILITY OF QUENCHING OILS**


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[52] **U.S. Cl.** .....**73/15 R**, 73/64

[51] **Int. Cl.** .....**G01n 25/00**, G01n 33/26

[58] **Field of Search** .....73/53, 61.3, 64, 15 R



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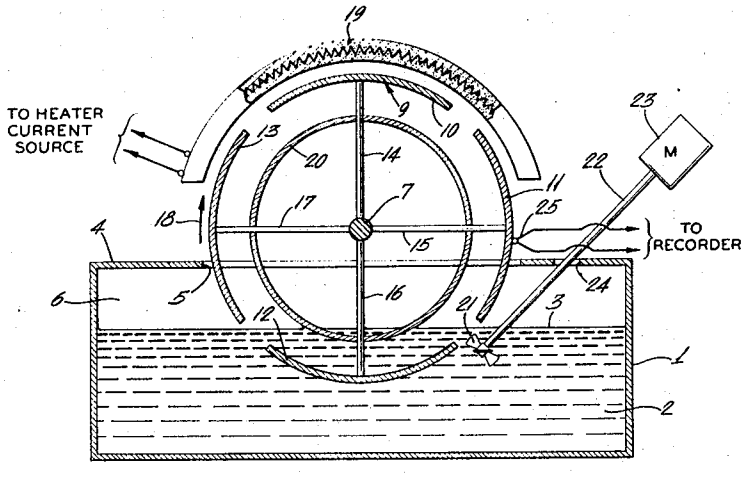
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[57] **ABSTRACT**

In a testing apparatus for use in evaluating the thermal stability of a quenching oil, a metallic member is first heated to an elevated temperature, then dipped into a bath of the oil to be tested, then withdrawn from the bath for reheating. These steps are automatically carried out in a cyclic, repetitive manner for a preselected number of cycles, following which the oil sample may be chemically tested to determine its degree of degradation, which is an indication of its thermal stability.


**4 Claims, 5 Drawing Figures**



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SHEET 1 OF 2

FIG. 1.

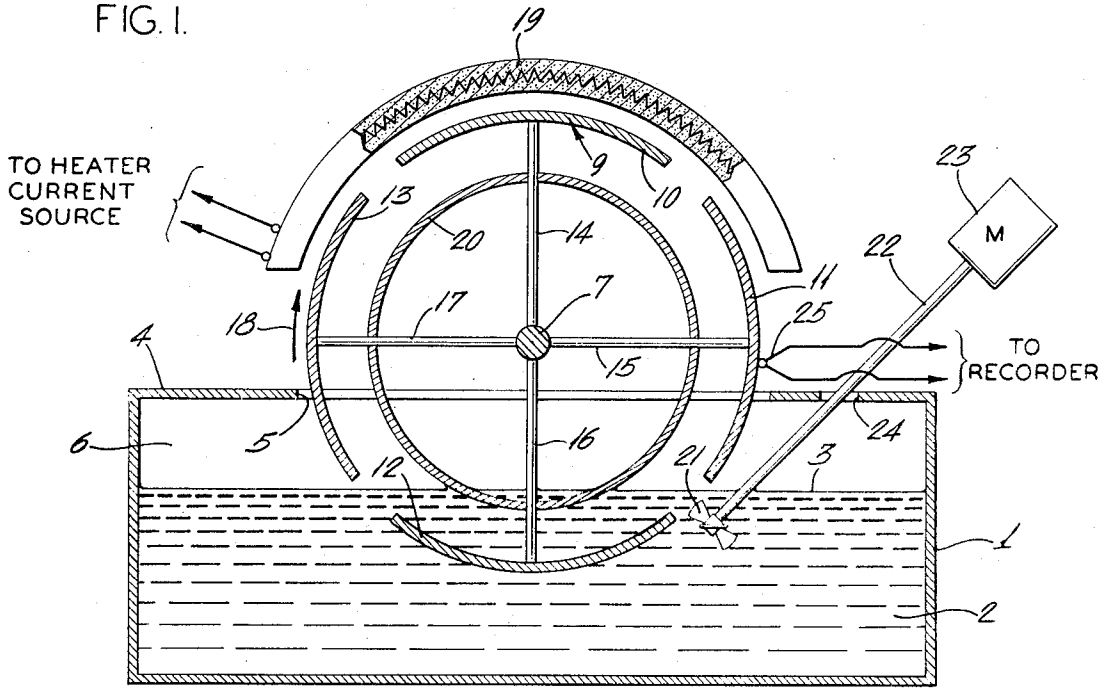
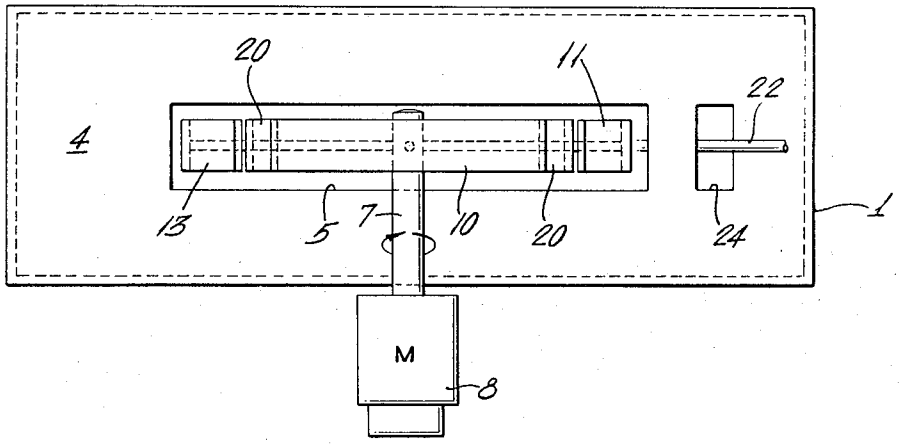



FIG. 2.




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FIG. 3.

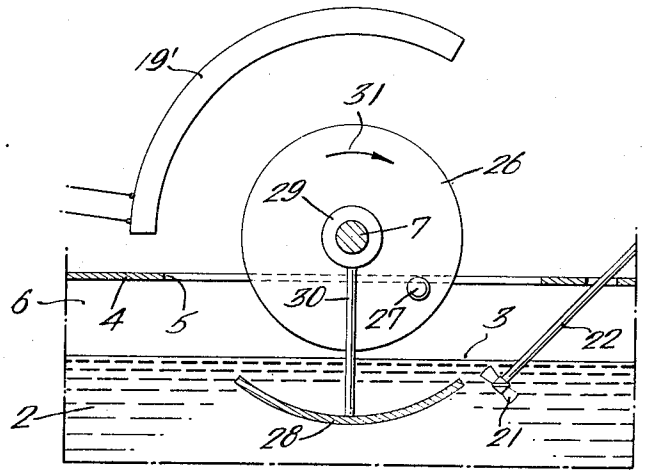



FIG. 4.

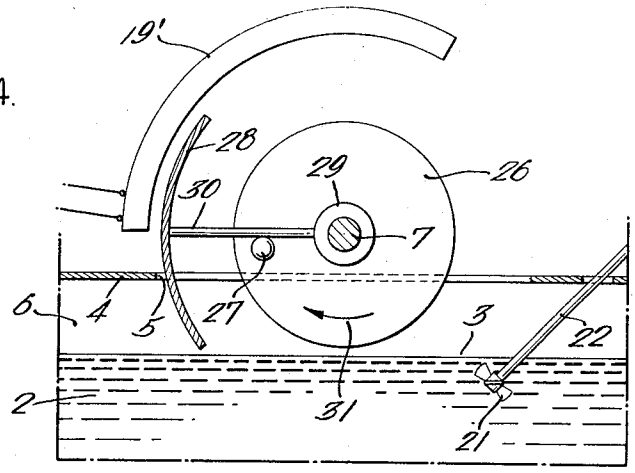
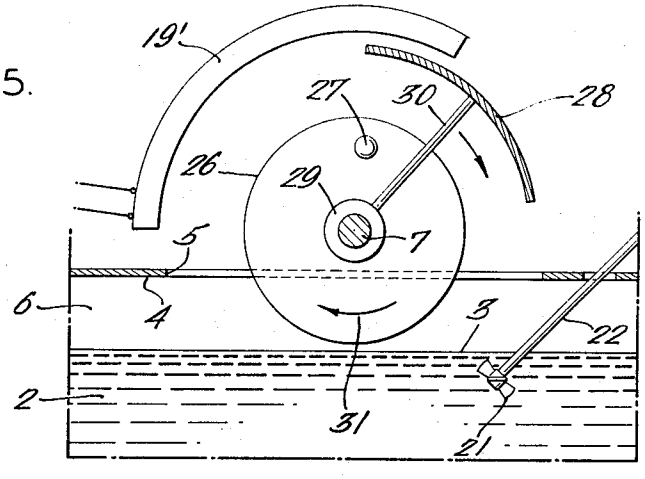



FIG. 5.




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# METHOD AND APPARATUS FOR EVALUATING THERMAL STABILITY OF QUENCHING OILS

This invention relates to a testing apparatus and method, and more particularly to an apparatus useful in evaluating the thermal stability of a thermal quenching oil (liquid hydrocarbon).

In the metalworking industries, it is common practice to use certain hydrocarbon liquids known as quenching oils for the purpose of quenching (i.e., very rapidly cooling) pieces of metal which have been heated to elevated temperatures. On the other hand, the repeated subjecting of the quenching oil to thermal shock (by the dipping thereinto of very hot pieces of metal) eventually causes degradation of the oil, with the formation of sludge, a marked increase in the viscosity of the oil, etc. It is important to the refiner and marketer of quenching oils to be able to evaluate the thermal stability of the quenching oils he is offering for sale, so that he will know whether or not his products meet certain specifications.

An object of this invention is to provide a testing apparatus useful for evaluating the thermal stability of a liquid, and specifically of a quenching oil.

Another object is to provide testing apparatus of the aforementioned type which closely simulates the conditions involved in actual commercial use of a quenching oil.

A further object is to provide quenching oil testing apparatus which is simple in construction, and easy to operate.

A still further object is to provide a novel (laboratory) testing apparatus for quenching oils.

The objects of this invention are accomplished, briefly, in the following manner: In one apparatus embodiment, a segmented wheel, comprising a plurality of arcuate metallic segments mounted for rotation in the fashion of a wheel about a common substantially horizontal axis, is rotated in a cyclic, repetitive manner (either intermittently or continuously) by a suitable driving means such as a motor. The segments of the wheel are arranged above a bath of the liquid (quenching oil) to be tested so that they dip into the liquid during a portion only of their rotation. A heater is mounted above the segments to heat them to an elevated temperature prior to their dipping into the liquid for quenching. A blanketing atmosphere of nitrogen is provided above the surface of the liquid, and an agitator (stirrer) is located closely adjacent to the point of entry of the heated segments (hot members) into the oil. In carrying out the test, the apparatus is turned on and is run for a time which will result in a preselected number of contacts or dips of the heated members into the liquid (oil), and then the oil is sent to a chemical laboratory for analysis, to determine its degree of degradation. In another apparatus embodiment, a single arcuate member is utilized, rotating in non-uniform or intermittent fashion.

A detailed description of the invention follows, taken in conjunction with the accompanying drawings, wherein:

FIG. 1 is a vertical section through one embodiment of an apparatus according to the invention;

FIG. 2 is a top or plan view of the apparatus of FIG. 1, with the heater removed; and

FIGS. 3–5 are partial views similar to FIG. 1 but of another embodiment, this other embodiment being illustrated in three different positions of operation.



Referring first to FIGS. 1 and 2, which illustrate one embodiment of apparatus according to the invention, a suitable receptacle 1 contains a sample of the quenching oil 2 to be tested or evaluated, and thus serves as means providing a bath of the liquid to be evaluated. The quenching oil 2 would ordinarily be a refined hydrocarbon product derived from crude petroleum. Within the receptacle 1, and above the surface 3 of the liquid 2, a non-oxidizing atmosphere is provided, for example by blanketing this region 6 with a relatively inert gas such as nitrogen. A sufficient flow of nitrogen into this region is provided from a supply of compressed gas (not shown) to maintain the nitrogenous or non-oxidizing character of space 6. This region is semiconfined by means of a receptacle cover or closure 4 having a centrally-located rectangular aperture or opening 5 therein.

According to this invention, a metallic member is heated to an elevated temperature and then dipped down or immersed into the quenching oil 2 by way of opening 5 so as to be quenched by such oil, the heating and dipping being carried out in a cyclic, repetitive manner for a preselected number of cycles of heating and dipping. It is pointed out that, after the dipping, the member is withdrawn from the liquid (quenching oil) bath, for reheating. This cyclic, repetitive operation is preferably carried out in a rotary fashion by mounting the member (hereinafter described) on a horizontally-extending shaft 7 which is mounted above the receptacle 1 and which extends at right angles with respect to the longer dimension of opening 5. Shaft 7 is rotated (either continuously or intermittently, as will be described) by means of an electric motor 8 which drives the shaft 7 through suitable reduction gearing (not shown), providing an arrangement for adjusting the speed of the member.

The metallic member previously referred to is designated generally by numeral 9, and in the FIG. 1 embodiment is actually separated into a plurality (four in number) of arcuate sections or portions 10, 11, 12, and 13 which are segmentally arranged (circumferentially spaced from each other) in the form of a (discontinuous) wheel. The separation of the "wheel" into segments reduces the heat flow into cooler portions of the "wheel" while it is being heated, since the heating means is of limited circumferential extent (as will become apparent). The portions or pieces 10–13 are preferably cut from a short length of stainless steel pipe to insure roundness, the individual pieces of metal being rather thin (in the radial direction) so that they will heat rapidly. By way of example, the metallic sections 10–13 may be sized to together form a "wheel" on the order of 6 to 8 inches in diameter.

The sections 10–13 are held in position in the form of a discontinuous wheel arrangement, and are secured to shaft 7 so as to rotate therewith, by means of separate individual radially-extending spokes which are preferably made from stainless steel and which are as small in diameter as possible, to reduce the flow of heat away from pieces 10–13 while the latter are heating. One end of a spoke 14 is secured to the outer periphery of shaft 7, and the other end of this spoke is secured as by welding to the inner surface of arcuate section 10. One end of a spoke 15 is secured to shaft 7, and the other end of this spoke is rigidly secured to the inner surface of arcuate portion 11. Similarly, one end of a

spoke 16 is secured to shaft 7, and the other end of this spoke is rigidly secured to the inner surface of arcuate piece 12. Finally, one end of a spoke 17 is rigidly secured to shaft 7, and the other end of this spoke is welded to the inner surface of arcuate section 16. It may be observed that adjacent spokes extend at angles of 90° to each other, viewed as in FIG. 1.

The shaft 7 is rotated by motor 8 to rotate the discontinuous wheel 9 (i.e., the segments 10–13) in the direction indicated by the arrow 18 in FIG. 1, about the axis provided by shaft 7. The arrangement is such that the segments 10–13 dip into the bath 2 during a portion of their rotation, by means of the opening 5. Thus, in the FIG. 1 position segment 12 is entirely immersed in the liquid bath 2, segment 11 is about to enter the bath, while segment 13 has just left or been withdrawn from the bath.

According to this invention, actual conditions of use of a quenching oil are simulated by plunging or dipping hot metal into the quenching oil sample 2. To heat the segments 10–13 to an elevated temperature prior to each entry or dipping thereof into the liquid bath 2, a plate-type electrical heater 19, of arcuate configuration, is mounted above the "wheel" 9 closely adjacent to the same, outside of the bath, so that the arcuate segments 10–13 are heated as they pass under this heater, which latter is energized from a suitable source of electrical current. It will be appreciated that each of the segments is heated after it is withdrawn from the bath, and before it reenters the same, i.e. before it is dipped or plunged into the quenching oil bath. Thus, as the "wheel" 9 rotates, the oil bath 2 is subjected in a cyclic, repetitive manner to contact with the hot elements or sections (test pieces). In the FIG. 1 position, segment 10 is being heated by heater 19.

By way of example, in operation the quenching oil sample 2 may be subjected to a preselected number (such as one hundred) of dippings thereinto of the hot metal pieces. Following the test, the quenching oil sample is removed from the container or receptacle 1 and sent to a chemical laboratory, where its degree of degradation is ascertained. This degree of degradation, of course, is an indication of the thermal stability of the oil. During the operation of the testing apparatus, the blanket of nitrogen in the region 6 provides a non-oxidizing atmosphere which reduces the tendency of the quenching oil to burst into flame when contacted by the hot metal. It may be noted that many actual, commercial quenching operations make use of a similar inert atmosphere, above the quenching oil.

A continuous ring (hollow cylinder) 20 of stainless steel is located radially within "wheel" 9 and concentric therewith. Ring 20 is held in position by means of the spokes 14–17, each of which passes through and is welded into a respective hole provided in this ring. The ring 20 obviously rotates with shaft 7 and "wheel" 9. This inner metal ring 20 serves as a shield, minimizing the splashing of oil from the bath 2 onto the heater 19, and also minimizing the heat which reaches the oil 2 directly from the heater 19.

The oil bath should be agitated vigorously, at or immediately adjacent the point of entry of the hot metal into the oil, in order to improve the quenching action. This agitation is accomplished by means of a blade 21 located near the point of entry of the segments 10–13 into the oil 2, and fastened to the end of a shaft 22 which is rotated by a driving motor 23. The shaft 22 is more or less tangent to "wheel" 9, but offset therefrom, and the agitator produces a substantially uniform agitation on both sides of the metal sections 10–13 as they dip into the oil. The shaft 22 extends upwardly from blade 21 through an opening 24 provided in cover 4. It may be here noted that almost all commercial quenching operations employ vigorous agitation in their quenching tanks.

It may be desired to measure and/or record the temperature of the heated metal pieces 10–13 prior to their entry into the liquid bath 2. This may be done by means of a thermocouple 25, which makes sliding contact with the heated metal sections at a location just above the cover 4. The output leads from this thermocouple may be connected to a recorder, as indicated in FIG. 1.

As previously mentioned, the "wheel" 9 may be rotated either intermittently or continuously. The construction of the "wheel" previously described, with four sections or segments 10–13, is particularly suitable for continuous rotation, and at a fairly fast rate, such that sections in the position of section 11 in FIG. 1 (which is passing out of the heating zone of heater 19 but has not yet reached the liquid 2) will not lose too much of their heat before being dipped into the (cooler) quenching oil sample 2.

It is within the scope of this invention to rotate the "wheel" in intermittent fashion, such that a heated piece would be indexed downwardly into the bath 2 for quenching and then indexed upwardly out of the bath for reheating. For this mode of operation, it would be necessary to construct the "wheel" with only two segments, rather than the four illustrated in FIG. 1, so that one segment would be quenching while the other is being heated. This intermittent type of operation (with only two segments in the "wheel") might be advantageous in that the heated piece of material would move very quickly into the quenching oil bath.

Using the testing apparatus disclosed, a sample of oil could be tested in a short period of time, because of the relatively small volume of oil contained in the receptacle 1, and the relatively large surface area of the heated metal pieces 10–13.

Refer now to FIGS. 3–5, which illustrate another embodiment of testing apparatus according to this invention. In FIGS. 3–5, elements the same as those of FIG. 1 are denoted by the same reference numerals, while analogous elements are denoted by the same reference numerals but carrying prime designations.

The embodiment of FIGS. 3–5 provides a longer "oil drainoff" time and a shorter "plunging" time (from heater to oil bath). This embodiment utilizes a single test piece (arcuate member) with a steady, continuous (and somewhat slower than in FIG. 1) rotation of the driving shaft, but an intermittent, non-uniform, or somewhat interrupted movement of the test piece.

In FIGS. 3–5, a single arcuate member (test piece) 28 is loosely mounted on shaft 7, as by means of a sleeve 29, so that it can swing freely with respect to this shaft. Member 28 is carried by a rigid spoke 30 which is secured at one end to this member and which is secured at its opposite end to sleeve 29. A disc 26 is secured at its center to shaft 7, and this disc carries an outwardly-extending pin 27 which is arranged to come into con-

tact with spoke **30** as the disc rotates. The shaft **7** is rotated continuously in the direction **31** by a motor **8** as in FIG. **1**, but at a slower speed than in FIG. **1**.

A heater **19'** is utilized for heating member **28** and is positioned above the quenching oil sample **2**, the heater **19'** being located mainly in the fourth quadrant (i.e., in the quadrant defined by spokes **14** and **17** in FIG. **1**). The agitating or stirring means **21**, **22** etc. is partially illustrated in FIGS. **3–5**.

In FIG. **3**, the member **28** is shown submerged in the oil bath. It remains in this position until disc **26**, in its clockwise rotation, brings pin **27** into engagement with spoke **30**. At this point, the member **28** beings to move slowly (due to the slow rate of rotation of shaft **7** and disc **26**) upwardly out of the bath, in the clockwise direction. As member **28** moves upwardly in this manner, the oil begins to drain off this member, back into the bath. Ample time for oil drainoff is provided due to the slow rate of rotation of disc **26**.

As member **28** comes under heater **19'**, it begins to heat up, ample time for heating again being provided due to the slow rate of rotation of disc **26**.

In FIG. **4**, the member **28** is shown at some point during its slow upward travel, the trailing end of this member having just cleared the surface **3** of the liquid in this figure.

The member **28** continues its slow clockwise travel (and its exposure to heater **19'**) until spoke **30** reaches the vertically upward position, or just slightly beyond the same. When the member **28** reaches this position, it swings very rapidly down in the clockwise direction into the oil bath **2**, due to its own weight. Thus, the "-plunging" time (from the heater **19'** to the oil bath) is very short, so that the member **28** loses hardly any of its heat before reaching the quenching oil.

In FIG. **5**, the member **28** is illustrated at some point during its very rapid downward travel toward the bath **2**, after it has "left" the pin **27**.

As previously described, the member **28** remains in the oil (in the position of FIG. **3**, with spoke **30** in the vertically downward position) until pin **27** "catches up" with it and again begins to raise it upwardly, out of the oil and toward the heater **19'**.

From the foregoing description, it will be appreciated that the testing apparatus of this invention (which dips a hot metal member repeatedly into a quenching oil, while using an agitator and an inert gas blanket) closely duplicates, in the testing laboratory, the conditions of actual, commercial use of quenching oils.

The invention claimed is:

**1**. A testing apparatus for use in evaluating the thermal stability of a liquid which comprises means providing a bath of the liquid to be evaluated, a metallic member, automatically-operating means causing said member to travel in a cyclic, repetitive manner alternately completely into and completely out of said liquid bath, and heating means located entirely externally of said bath for heating said member to an elevated temperature during its travel outside of said bath.

**2**. Apparatus according to claim **13**, wherein said member is separated into a plurality of similar sections which are thermally isolated from each other.

**3**. Apparatus of claim **13**, including also means for measuring the elevated temperature of said member prior to its entry into said bath.

**4**. Apparatus of claim **13**, including also heat shielding means located between said heating means and said liquid bath, for minimizing the heating of said bath directly by said heating means.

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