Sept. 13, 1966 JINICHI ITO ETAL 3,272,065

OIL TESTER

Filed Jan. 8, 1963 5 Sheets-Sheet 1

Fig. 1

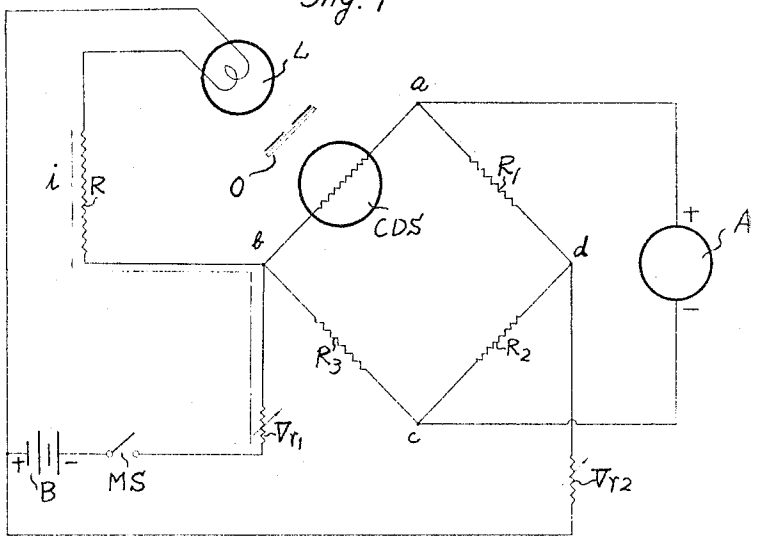
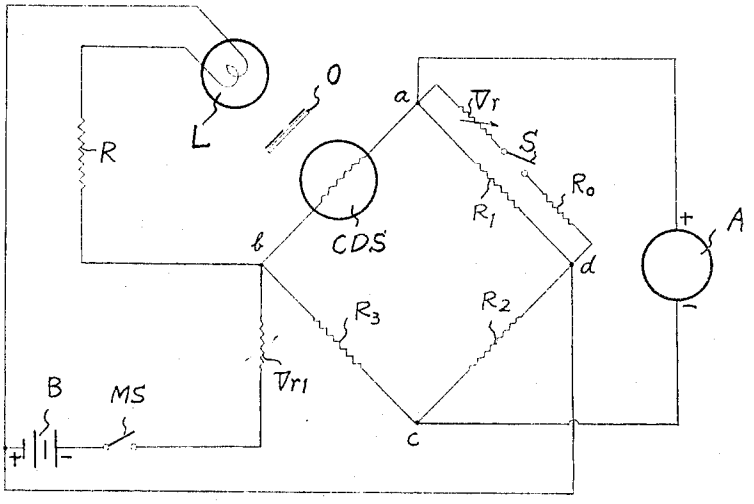


Fig. 2

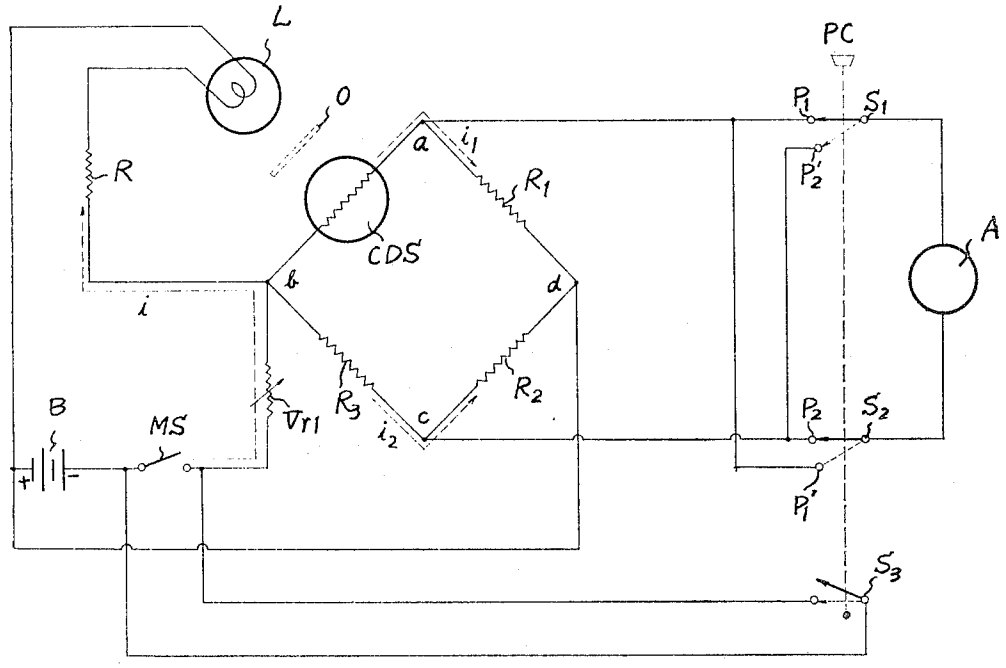


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Fig. 3



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Fig. 4

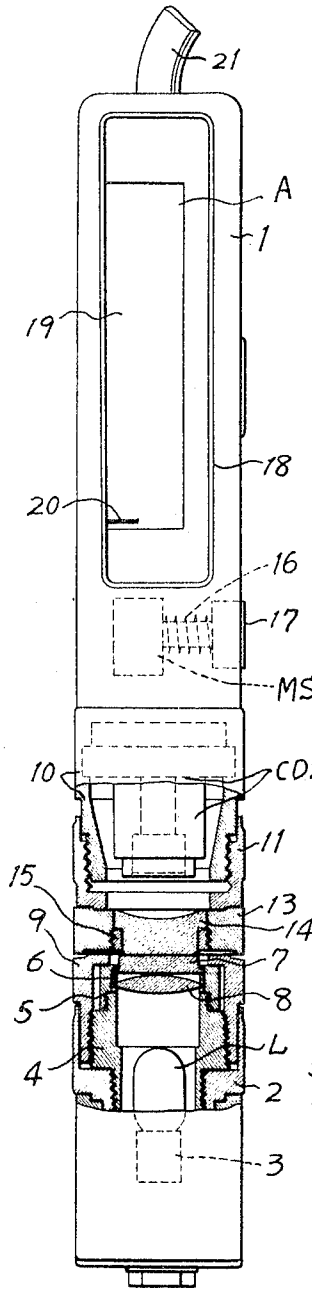
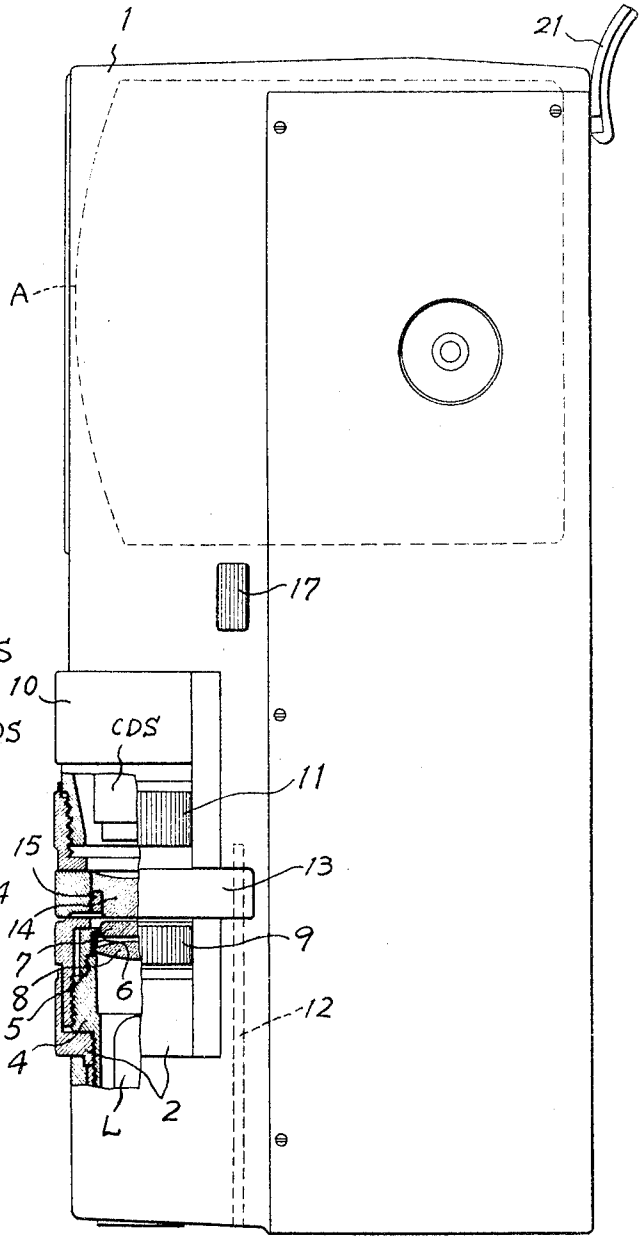


Fig. 5



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Fig. 6

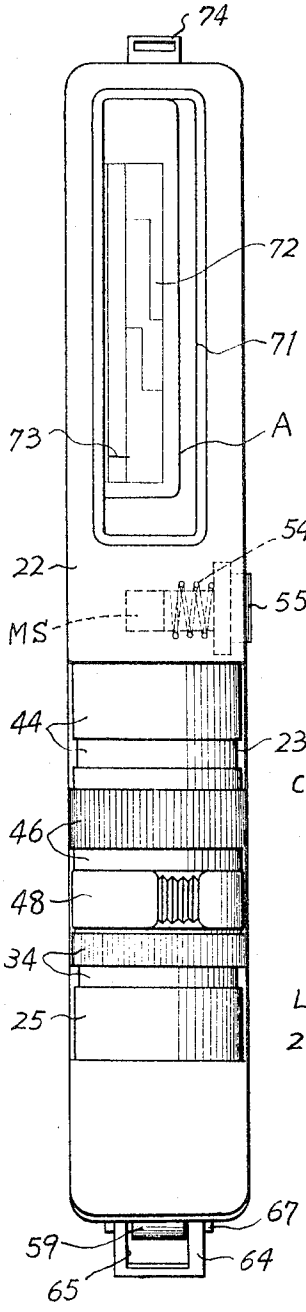
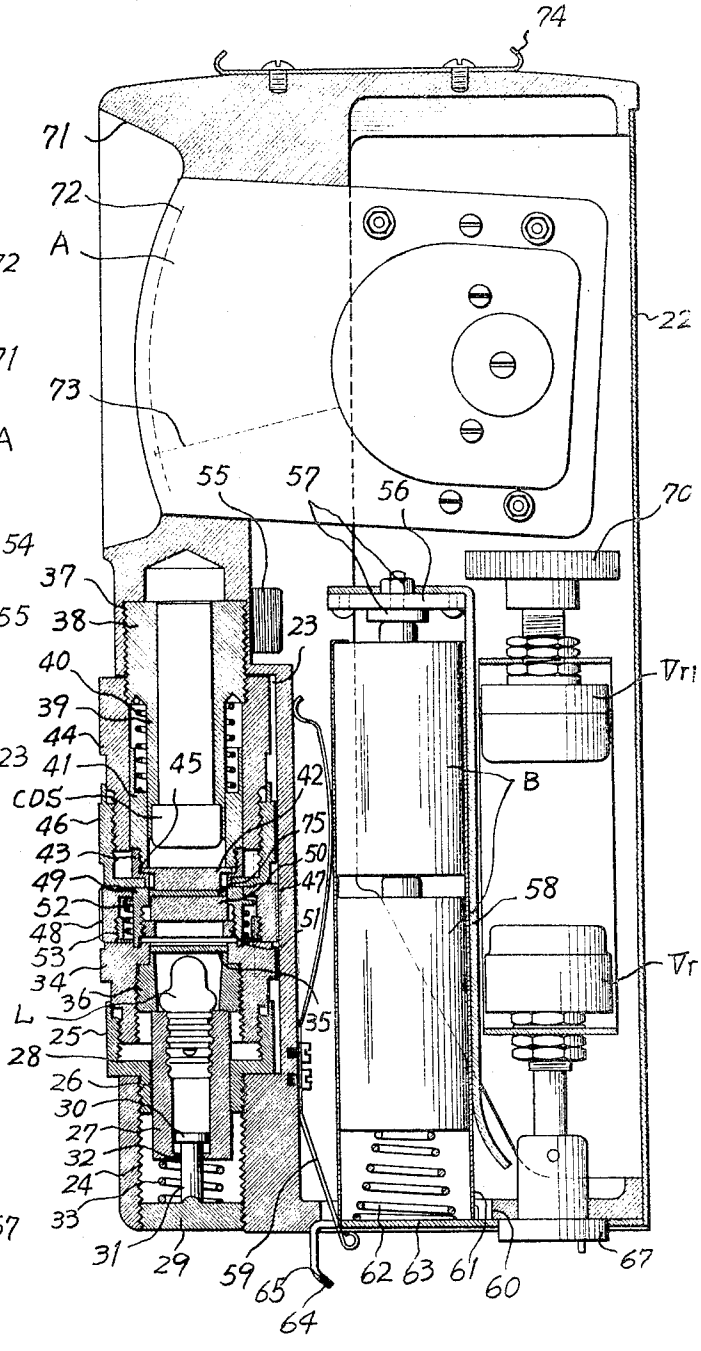


Fig. 7



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Fig. 8

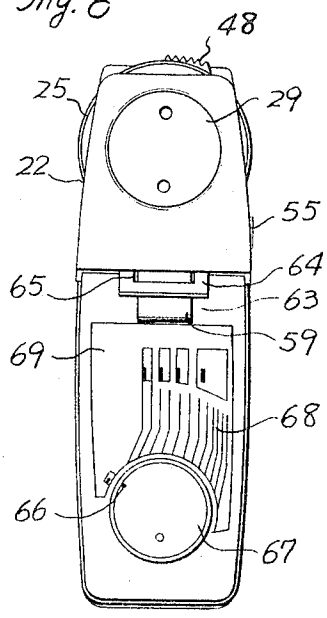


Fig. 9



Fig. 10

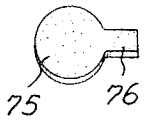


Fig. 11

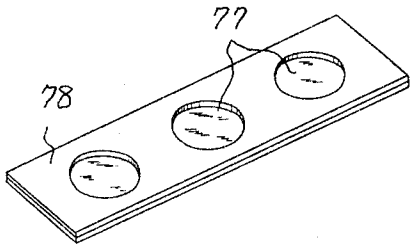
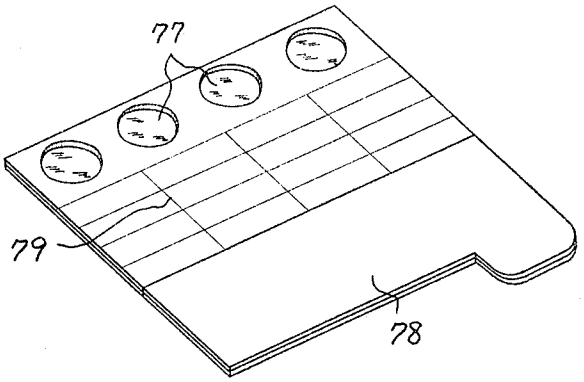


Fig. 12



United States Patent Office 3,272,065 Patented Sept. 13, 1966

3,272,065

OIL TESTER

Jinichi Ito and Shozo Shibuya, Tokyo, Japan, and Toyoo Yamada, 137 Kirisato-cho, Ota-ku, Tokyo, Japan; said Ito and said Shibuya assignors to said Yamada

Filed Jan. 8, 1963, Ser. No. 250,118
Claims priority, application Japan, Feb. 1, 1962, 37/3,625; Feb. 5, 1962, 37/5,184; Feb. 6, 1962, 37/4,582; Apr. 19, 1962, 37/16,207; June 7, 1962, 37/23,556; June 27, 1962, 37/26,861
2 Claims. (Cl. 88—14)

The present invention relates to an oil tester.

One who possesses an automobile has generally a deep interest in an appropriate term for renewal of the engine oil in order to insure an economical and trouble-free running of his car. But judgement of an appropriate term requires a wide range of tests. As a result, he follows a conventional practice, instead of determining a suitable term for his own car.

It is a good practice to exchange or renew a high grade oil in a shorter interval than that recommended for lower grade oils, which means however, a waste of oil and higher expense. On the contrary, however, using oil for too long an interval of time will result in shorter engine life and increased repair expenses. An economical determination of the renewal term for engine oil varies depending upon such elements as the design of the engine, proper adjustment, quality of fuel and lubricant used and the service conditions of the automobile, i.e., atmospheric temperature, frequency of low velocity running and stopping, load conditions, quantities of sand and dust in the air, etc. Heretofore it has been generally difficult to determine the optimum oil usage term for a given automobile.

The present invention therefore relates to an oil tester capable of determining, in a short period of time, the optimum renewal term for the engine lubricant of a particular automobile.

It is known that the deterioration of engine oil gives rise to an oxidized sludge caused by contamination of sand and dust, metallic powders and water, and dilution of the oil with fuel. The amount of the oxidized sludge produced is closely connected with the deterioration of the engine oil.

In general, in the oxidation of lubricating oil, material rich in free carbon is produced from direct heat decomposition when the lubricant is exposed to high temperature in air (oxygen) and particularly when it is exposed to the high temperature of an engine cylinder. This oxidation alters the light transmission factor and absorption coefficients in addition to the effects of sludge formation and such alternation may be expressed as a fatigue degree.

According to the present invention, the fatigue degree of engine oil is determined by measuring the alteration of the light transmission factor and absorption coefficient. In one embodiment of the invention, a photoconductive substance, corresponding to the specific general absorption degree displayed by engine oil at a predetermined state of deterioration is used together with a suitable electric circuit to compare the fatigue degree of an oil sample by measuring the difference in photoabsorption between the standard and the sample and thereby determining the quality of engine oil. Thus, the oil tester according to this invention is adapted to exactly indicate the exchange time applicable to engine oil used under different conditions, and, moreover, is adapted to be applicable to a wide range of measurement. Further, the oil tester may be constructed in a small physical embodiment and is quite simple to operate.

The present invention is applicable for use in many

processes involving color analysis, and is particularly effective for the comparison of turbid material, for instance, bluish green, etc., because its spectrum characteristics are also sensitive over the ultrared zone.

In the following, the present invention will be described in detail in connection with the accompanying drawings, of which:

FIGS. 1 to 3 are electrical wiring diagrams for the apparatus according to the present invention;

FIG. 4 is a front view of the apparatus of this invention with a part thereof being broken away;

FIG. 5 is a side view thereof with a part being broken away;

FIG. 6 is a front view of another embodiment of the present invention;

FIG. 7 is a longitudinal sectional view thereof;

FIG. 8 is a bottom surface view thereof;

FIGS. 9 and 10 are oblique views of filter paper sheets; and

FIGS. 11 and 12 are oblique views of retaining plates for the filter paper sheets.

Referring to the drawings of this invention, as illustrated in FIG. 1;

A photoconductor CDS comprising cadmium cells, germanium cells or the like and three fixed resistors R_1, R_2, R_3 are coupled together to form a bridge circuit. An ammeter A is connected across terminals *a* and *c* of said bridge, and the *b* and *d* terminals are connected in series with a variable resistance Vr1, main switch Ms, cell B and compensation variable resistance Vr2. The terminal *b* of the bridge circuit and cell B are connected in series with a resistance R for adjusting the sensitivity of the bridge circuit and a tungsten electric bulb L for applying light to the photoconductive material.

In the drawing, O may represent a stained oil or other test sample which is interposed between the lamp L and photocell CDS for comparison with a standard. The standard may be either a filter of known light transmissive characteristics or may be a variable iris diaphragm. If the standard chosen is a filter the test is limited to the spectrum passed by that filter. In the case of the variable iris diaphragm, it may be calibrated to facilitate a wide range of measurement.

A characteristic feature of a bridge circuit, such as decribed above, is that no electric current passes through ammeter A when all the resistances of the bridge circuit are equivalent, despite the potential imparted on terminals *b* and *d* of the bridge.

To balance the bridge, the electric current *i* imparted to the electric bulb L is varied by means of the variable resistance Vr1. The internal resistance of the photoconductance CDS is accordingly varied until it is made equivalent to the three resistors R1, R2, R3 of the bridge circuit by means of the illumination supplied by the electric bulb L. The illuminating power of the bulb L varies approximately linearly with current *i* within the range of electric current used. The current *i* will be constant when the bridge is balanced and the resistance of the photoconductor CDS coincides with values of the fixed resistors R1, R2, R3 according to the relationship $CDS=R_3/R_2\times R_1$. The voltage appearing at *b* point of the lamp circuit will also remain constant.

Accordingly, if all of the resistances are equal, the voltage across the lamp circuit (terminals *b* and *d*) is the same as that across the bridge circuit (terminals *a* and *c*), and the sensitivity of the bridge circuit remains constant due to the fixed value of resistor R.

Furthermore, it is possible for the sensitivity of the bridge circuit to be varied over any suitable range and still remain stable, by means of changing the value of resistor R although higher constant voltage will be re-

quired for balancing the bridge circuit in accordance with increase of internal resistance of electric lamp L.

When this apparatus is used, the main switch MS is closed turning on the lamp L, and the intensity of illumination is then adjusted so that the resistance of photoconductor CDS equals $R1 \times R3/R2$. This condition is indicated by a zero reading on ammeter A. Next, a sample of contaminated engine oil O is interposed between the lamp L and photoconductor CDS. The light transmitted thru the sample to impinge on photoconductor CDS is diminished by an amount determined by the light transmissive properties of the oil sample and is directly proportional to the degree of imbalance imposed on the bridge as measured by ammeter A.

Accordingly, by means of this apparatus and method for using same, the accuracy of measurement is assured by the use of a single circuit, simplified manipulative steps and a simplification of cells and other parts.

In another method of using this apparatus, first a filter O having an approximately equivalent transmission factor to an exchange time oil (oil matured to be renewed) or an iris to obtain an equivalent quantity of light therethrough is interposed between the electric lamp L and photoconductor CDS. The main switch MS is set at ON-position to turn on the lamp L and apply a voltage across the bridge. The resistance Vr1 is then varied to change the voltage applied to lamp L and thereby vary the resistance of CDS. In so doing the bridge may be balanced or calibrated by setting the ammeter A at zero scale deflection. When the ammeter A is set to zero scale deflection, the filter O is removed, or the iris, when used, is opened to its maximum aperture and the sample of material to be measured is interposed between the lamp and photocell. As a result of the difference in light transmissive qualities of the standard and the sample and the bridge will be unbalanced and the degree of unbalance will be reflected by the scale deflection of ammeter A. The transmission factor and thus the degree of contamination of the oil sample may then be determined from the ammeter A.

Thus, according to said device and method therefor, the transmission factor can be clearly determined in the zone of increased sensitivity.

Now referring to FIGURE 2, a bridge circuit is formed by consecutively connecting the photoconductor CDS and three equivalent resistors R1, R2, R3. Connected in parallel with resistor R1 and between bridge terminals *a* and *d* is a series circuit comprised of a variable resistor Vr having a standard indication scale dial, a switch S and a resistor Ro for adjusting the sensitivity of the bridge. An ammeter A is connected across the bridge terminals *a* and *c*, and a battery B, switch MS and variable resistor Vr1 is connected across bridge terminals *b* and *d*. Also connected across the bridge terminals *b* and *d* and in parallel with the battery circuit is a tungsten lamp L and a resistance R.

In the drawing O represents either a transparent standard such as a filter or quantity of stained oil, or an iris which may be set to a chosen standard light transmissive value.

When this embodiment of the invention is used, a standard sample, filter or iris opening having light transmission characteristics equivalent to oil at its optimum change condition is located at O and with the switch S in its open position, the switch MS is closed thereby lighting the lamp L and illuminating the photocell CDS through the standard. The bridge is then balanced by varying resistance Vr1 until a zero scale deflection is obtained on ammeter A. The standard is then removed thus causing the bridge to become unbalanced. Next, the switch S is closed and the bridge again is balanced by varying resistance Vr. The bridge is now calibrated and the transmission factor of an oil sample relative to the standard may be determined by placing the sample at O and balancing the bridge using Vr. The amount of adjustment necessary to balance the bridge as indicated by the indicator on

Vr is a measure of the transmission factor of the sample tested.

Thus, the standard for transmission factors can be simply and exactly established by the dial scale of variable resistor Vr without further calibration.

In FIGURE 3, a photoconductor CDS and three equivalent resistors R1, R2 and R3 are consecutively connected to constitute a bridge circuit, the terminals *a* and *c* of said bridge circuit being coupled with an ammeter A via exchange switches S1 and S2. A variable resistor Vr1, main switch MS and a battery B are connected in series with the terminals *b* and *d*, and a resistor R and a tungsten lamp L for illuminating a photoconductor are coupled in series with the terminal *b* of the bridge circuit.

Exchange points P1 and P1′ are respectively connected to terminal *a* of the bridge and points P2 and P2′ are connected to terminal *c* of the bridge. A pair of switches S1 and S2 are provided to connect the ammeter A to points P1–P2′ and P2–P1′ respectively. A third switch ganged to the switches S1 and S2 is connected across the main switch MS and a push button PC is provided for operating the three switches simultaneously.

This embodiment of the present invention is calibrated by inserting a standard sample, filter or iris opening at O and balancing the bridge by varying Vr1 while PC is depressed. It will be noted that depressing push button PC closes switch S3 thus energizing the bridge and lamp L. The button PC is then released and the test sample placed at O. Upon closing switch MS and energizing lamp L, the bridge will be unbalanced by the resistance of photocell CDS as affected by the light passing through the sample at O. The degree of imbalance and thus the transmission factor of the sample will be indicated by ammeter A. If the unbalance is in such a direction as to "pin" the meter, the button PC is depressed so as to reverse the ammeter connections and thus enable a reaching to be taken on A.

Thus, the transmisison factors can be determined clearly in the increased sensitivity zone, and the apparatus and operation therefor can be simplified, by said process and apparatus.

As shown in FIGS. 4 and 5, a slide case cylinder **2** is provided at the lower portion of one side of the machine frame **1**, within said slide case cylinder **2** a lamp L secured to the socket **3** is provided at the lower central portion, and the lower portion of the lens cylinder **4** is screw fitted to a branch cylinder **5** at the center. The lens cylinder **5** is screw-fitted to the upper portion of the lens cylinder **4**, in which branch cylinder **5**, for instance, a red filter glass **7** and lens **8** are secured to the upper and lower portions through lens cushion **6**, and the lower interior periphery of the lower shadow slider cylinder **9** is vertically movably screw-fitted with the upper exterior perifery of the lens cylinder **4**.

A supporting cylinder **10** is provided above one side portion of the machine frame **1**, within which supporting cylinder **10** a photoconductor CDS is secured to the central portion thereof. The cylinder **10** is then threaded into the upper interior periphery of an upper shadow slider cylinder **11**.

A specimen stand **13** is journalled with the inside longitudinal shaft **12** between the upper and lower shadow cylinders **11**, and **9** in such a fashion that said specimen stand **13** may be horizontally rotated, and a specimen light penetrating stand **14** is secured to the central portion of said specimen stand **13** with the support cylinder **15**.

A main switch MS is secured above the photoconductor CDS and a push contact button **16** having a return spring is secured to said main switch MS.

In the upper portion of the frame **1**, an ammeter A, with a scale plate **19** and needle **20** is secured in front of an opening portion **18**. A band **21** is secured in the upper portion of the frame **1**.

For the said apparatus, wiring is provided as shown in FIGS. 1 to 3.

When this apparatus is used, the specimen stand **13** is turned to one side about the inside longitudinal shaft **12** as a fulcrum, then the material to be tested is placed on the specimen transmission stand **13**, and the specimen stand **13** is again turned so as to approach between the lamp L and photoconductor CDS. The specimen stand **13** may be moved vertically by rotating the upper and lower shadow slider cylinders **11** and **9** to render the specimen light transmisison stand **14** into focus with the light from the electric lamp L illuminating the photoconductor CDS through the material to be tested so as to measure the transmisison factor by the ammeter A.

Accordingly, the transmission factor can be determined very simply by this apparatus.

As illustrated in FIGS. 6 to 8, a notch **23** is provided in one side portion of the frame **22** and a screw hole **24** is formed below said notch **23**. The lower portion of a lamp holder cylinder **25** is threaded into the lower perforation **26** and a lamp socket cylinder **27** of vinyl chloride is inserted in the lower perforation **26** of said lamp holder **25**. An electric lamp L is secured to a socket **28** affixed to the upper portion of the lamp socket cylinder **27**. A screw cover **29** is screw-fitted to the lower portion of screw perforation **24**, and a projected rod **31** is protruded, having a flanged edge **30** on the upper portion thereof. From the upper surface of said screw cover **29**, said protruded rod **31** is inserted in a lower perforation **32**, and a compession spring **33** is interposed between the lower surface of the lamp socket cylinder **27** and screw cover **29**. The lower portion of the lower shadow slider cylinder **34** is vertically slidably screwed into the upper portion of the lamp holder cylinder **25**, and a glass filter **35** is inserted in the upper portion of said lower shadow slider cylinder **34**. A filter pushing cylinder **36** is fixed by screwing into the lower shadow slider cylinder **34** of the lower portion of said filter **35**.

Above the notch **23** of the frame **22**, a screw hole **37** is formed into which is threaded the upper portion of the photoconductor holder cylinder **38**. The photoconductor CDS is secured in said holder cylinder **38**. A push spring **40** is mounted in a recess **39** of the lower perifery of the photoconductor holder cylinder **38**, and the upper portion of a quantitative lens pushing cylinder **41** is inserted in the recess **39**. The outer periferal portion of a quantitative lens **42** is provided at the lower portion of said lens pushing cylinder **41**, and the outer periferal portion of this lens **42** is fixed with a push cylinder **43** screwed on the outer perifery of the lower portion of the quantitative lens pushing cylinder **41**.

The upper portion of a retaining cylinder **44** is fixed by screwing on the outer perifery of the upper portion of the photoconductor holder cylinder **38**. The lower exterior perifery of said retaining cylinder **44** is freely vertically slidably screw fixed with an upper shadow slider cylinder **46** meshed with a lower vent hole **45** on the lower surface of the push cylinder **43**.

Between the upper and lower shadow slider cylinders **46** and **34** of the notch **23** of the frame **22** a specimen stand **48** is journaled on an inner longitudinal spindle **47** in a fashion that a free horizontal rotation of said stand may be possible. In said specimen stand **48**, is inserted a lens pushing cylinder **49**. In the upper portion of said specimen stand **48** is inserted said lens pushing cylinder **49**. In the lens pushing cylinder **49** is inserted a specimen light transmission lens **50** in the upper portion of said cylinder **49**. In the lens pushing cylinder **49** of the lower portion of said lens **50**, a branch cylinder **51** is screw fixed, while a compression spring **52** is mounted at the outer, periferal portion of said lens pushing cylinder **49** and a spring pushing cylinder **53** is screw fixed in the lower portion of the specimen stand **48**.

A microswitch MS is provided above one side portion of the frame **22**, in the exterior of said microswitch MS

being secured a push button **55** having a compression spring **54**.

Above the inside portion of the frame **22**, a battery contact plate **56** made of, for instance, vinyl chloride is secured, and said battery contact plate **56** is provided with a contact point **57**. The frame **22** is provided with a hanging battery holding plate **58**, of which the upper folded portion is fixed therein. The lower end of a battery holding resilient plate **59** opposite said plate **58** is protruded from a lower vent hole **60** of the frame **22**, and a battery case **61** having a battery B inserted therein is inserted between the battery holding plate **58** and battery holding resilient plate **59**. A bottom plate **64** having a battery compressing spring **62** is inserted into a lower vent hole **60** of the apparatus frame **22**. The lower portion of the battery holding resilient plate **59** is projected through a vent hole **65** of a one sided holding piece **64** for said bottom plate **63**.

Below the other side portion of the apparatus frame **22**, a variable resistor Vr is provided, and a dial **67** having a scale **66** for said variable resistor Vr is projected below the bottom plate **63**, which plate **63** is fitted with a label **69** having a sorting scale **68**, and above the other side portion of the apparatus frame **22** a variable resistor Vr1 having a knob **70** is provided.

In the upper portion of the apparatus frame **22**, an ammeter A is secured, whose scale plate **72** and needle **73** are faced near a front opening **71**. The upper portion of the frame **22** is also provided with a hook **74** for fixing a band.

Wiring diagrams for the apparatus are as shown in FIGS. 1 to 3.

In the operation of the apparatus, the specimen stand **48** is turned to one side about the inside longitudinal spindle **47** as a fulcrum. Then, a material to be measured is placed on the specimen transmission lens **50**, and again the specimen stand **48** is turned toward a space between the electric lamp L and photoconductor CDS. Then the upper shadow slider cylinder **46** is turned downwards, the outer incident light being interrupted by meshing the specimen stand **48** with lower slider cylinder **34** in respective grooves by means of the lens pushing cylinder **49**, the specimen light transmitting lens **50** portion being made a dark chamber. The lamp L is turned on by the pushing button **55** and the photoconductor CDS is illuminated through the material to be measured. The transmission factor of said material is then measured by ammeter A.

As shown in FIG. 9, the circular filter paper sheet **75** is formed, or as shown in FIG. 10 a holding piece **76** is protruded on one side portion of said filter paper **75**, and as shown in FIG. 11 a filter paper holding plate **78** is formed having several filter paper sheet-fitted recesses **77**, or as illustrated in FIG. 12, a filter paper retaining plate **78** is formed with several filter paper fitted recesses **77** and is provided with date and measured values inscription columns **79**.

When said filter paper sheets **75** are used, wiring shown in FIG. 2 is made for the apparatus shown in FIGS. 6 to 8.

This will be explained with respect to FIGS. 6 to 8. First the specimen stand **48** is turned to one side around the inside longitudinal shaft **47** as a fulcrum and then the filter paper sheet **75** having been saturated with material subjecting to the measuring as, for instance, contaminated oil or the like, is put on the lens **50** of the specimen stand **48**, which is again positioned between the lamp L and photoconductor CDS. Then the upper and lower shadow slider cylinders **46**, **34** are turned, and the filter paper sheet **75** is made attached under pressure with the lens **42** and **50** which are formed especially flat to receive light from the electric bulb L and illuminate the photoconductor CDS through the filter paper **75** and the absorbed material to determine the transmission factor.

This will now be explained with reference to FIG. 2.

To begin with, the filter paper sheet **75** adsorbed with standard exchange oil is interposed between the lamp L and photoconductor CDS and the main switch MS is set at ON-position to light the lamp L. The intensity of illumination of the lamp L is controlled by the variable resistor Vr**1** according to the transmission factor of the filter paper sheet **75**, so that the electric current flowing through the bridge circuit may be controlled as the needle of ammeter indicates zero, for balancing the bridge circuit. Thus, the maximum sensitivity point is established in the transmission factor portion of the filter paper sheet **75** by memorizing the transmission factor equivalently in the circuit.

Thus, according to this apparatus and method therefor, the filter paper sheet **75** having been adsorbed to an almost saturated state with material to be measured is adhered under pressure, and until the thickness of the filter paper is nearly restored, the adhesive agent is discharged from the fibril structure to a fixed quantity, thus the quantitative device being not needed.

In the actual use of said apparatus, the standard level of exchange transmission factor is regenerated, thus the filter paper sheet **75** adsorbed with test oil is interposed between the lamp L and photoconductor CDS to determine the transmission factor.

On the other hand, the filter paper is adsorbed with the material to be measured, thereby the measurement being ensured in an inclined or lateral position without running out of the specimen. In addition, the errors in the measurement due to contamination of foams, errors in the measurement due to cleaning dispersion agent contained in the engine oil, oxidation stabilizer and colour agent admixed may be reduced. For instance, the accumulated free carbon penetrated due to capillary action in the fibril structure, admixed metallic powder and resinous products are relatively of low transmission factors to rays of light, and are dispersed in the form of films or amorphous condition, thus enabling the measurement in preferable condition by dispersing the material for deterioration in a filter paper of predetermined transmission factor as compared with the case of measuring specimen with a single body. This process is most suitable for the measurement, of for instance, diesel oil, oils having relatively poor transmission, factor, and of oils in which sludge has formed.

Over all activity of cleaning dispersed agent can be judged by dropping a fixed quantity of deteriorated oil at the center of the measuring filter paper. Furthermore, preservation and storage of specimen can be made according to the present invention.

Generally, important causes for the deterioration of engine oil, as for instance, accumulation of free carbon, entering of powdered metals, formation of resinous substances due to oxidation, further deterioration of lubricating property due to emulsification and, dilution may be determined most appropriately.

What we claim:

1. A portable oil tester comprising: an adjustable bridge circuit having a first pair of terminals and a second pair of terminals and including a photoconductive cell element as one leg thereof; voltage supply means coupled across said first pair of terminals; a current sensitive device including an indicator coupled across said second pair of terminals; housing means for enclosing the above-recited apparatus including a frame member, an aperture in one wall thereof with said current sensitive device mounted thereat to provide for viewing said indicator; a supporting cylinder secured to one side portion of said frame member; means for mounting said photoconductive cell element therein; an upper shadow cylinder threadably engaged with said supporting cylinder and adapted to be moved in an axial direction by rotation thereof; a lamp holding cylinder secured to said frame member in an axial alignment with said supporting cylinder; a light source located within said lamp holding cylinder; electrical means for energizing said light source; a lower shadow cylinder threadably engaged with said lamp holding cylinder and being axially movable by rotation thereof; a specimen stand being pivotally attached to said frame member and being located between said upper and lower shadow cylinders to pivot into axial alignment with said upper and lower shadow cylinders into a test position and being pivotally movable outwardly in a substantially horizontal position for receiving a test specimen, the specimen when in said test position being in axial alignment with said photoconductive cell element and said light source and intersecting the light transmitted from said light source to said photoconductive cell element so as to make the bridge circuit responsive to the light transmission factor of the test specimen thereby providing a qualitative measurement of said specimen.

2. Apparatus as defined by claim **1**, and additionally including first variable resistance means connected in series between said voltage supply means and said first pair of terminals including means for being mounted on said frame member and having manual adjustment means adapted to be reached from said frame member; and second variable resistance means connected in parallel with one leg of said bridge circuit for adjusting the sensitivity thereof, including means for being mounted on said frame member and having manual adjustment means adapted to be reached therefrom for manual adjustment thereof.

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JEWELL H. PEDERSEN, *Primary Examiner.*

O. B. CHEW, *Assistant Examiner.*