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APPARATUS FOR DETERMINING THE EVAPORATION END POINT OF VOLATILE LIQUIDS

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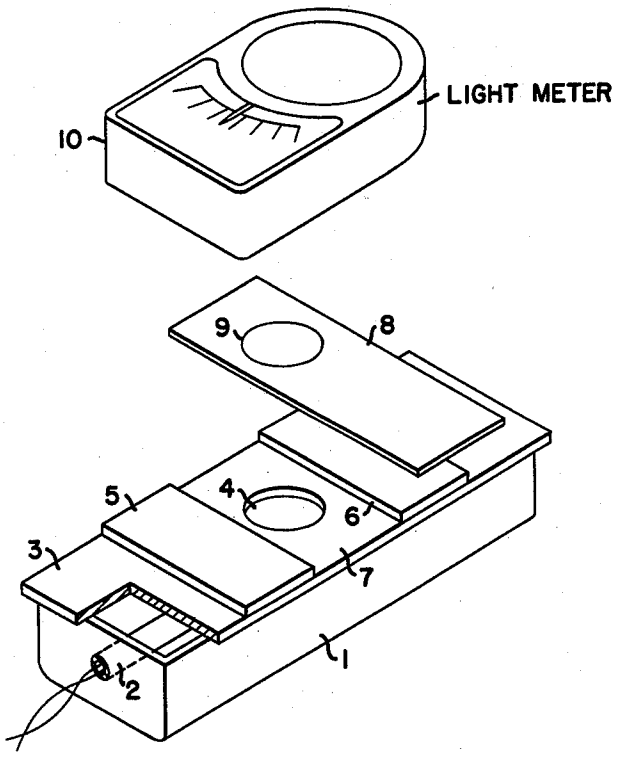


FIG.-1

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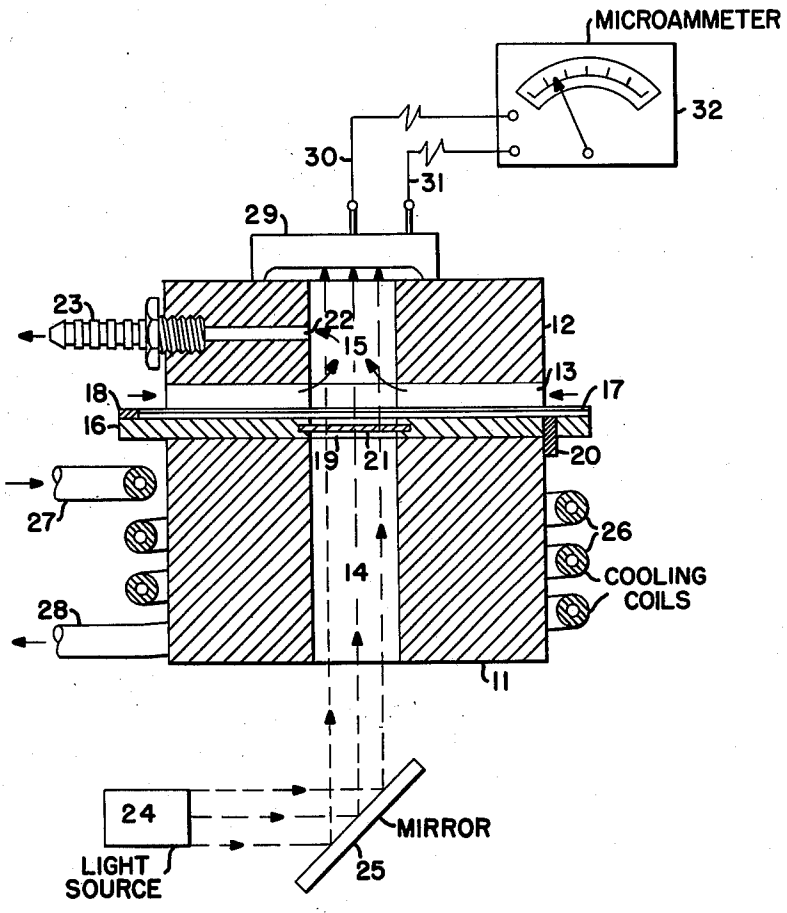


FIG.-2

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APPARATUS FOR DETERMINING THE EVAPORATION END POINT OF VOLATILE LIQUIDS

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Original application November 21, 1955, Serial No. 548,050. Divided and this application July 28, 1958, Serial No. 751,425

9 Claims. (Cl. 73—53)

The present invention relates to a photo-evaporimeter apparatus adapted for the determination of the evaporization rates of volatile liquids. More particularly, the invention relates to an apparatus for the photo-electric determination of evaporization rates. Specifically, the invention contemplates a means whereby a non-transparent, light-transmissive, wettable material is made more, or less translucent by wetting with the volatile liquid to be tested, and the intensity of light transmitted by the material is sensed and measured during evaporation of the liquid from the material. The evaporation end point of the liquid is determined at that point at which no further change occurs in intensity of the light transmitted. Under certain conditions, the determination may be based on a measurement with reference to the light transmission-characteristic of the material before wetting. This basis is only feasible when the volatile liquid employed is substantially colorless and does not effect a permanent change in the light transmissive character of the wettable material. The invention particularly contemplates employment of a wettable material which is an absorbent material. The present application is a division of U.S. Serial No. 548,050, filed November 21, 1955, entitled "Method and Apparatus for Determining the Evaporation End Point of Volatile Liquids."

It is an object of the invention to provide a means whereby the evaporation end point of a liquid may be determined easily and in a relatively short period of time, as compared with conventional procedures, and without complicated or delicate equipment and techniques. Another object contemplated is to provide a convenient and simple apparatus and operating procedure for evaporation end point determination wherein not only the overall rate of evaporation is indicated, but also the rate of evaporation for any time interval less than required for total evaporation or end point determination. It is a further object of the invention to permit such determinations to be made from extremely small sample portions of the volatile liquid. It is also an object of the invention to provide a system and procedure for determination of evaporation end points and/or evaporation rates, adapted for employment in conjunction with suitable systems for process and product control in the refining or blending of fluid materials such as in the refining of hydrocarbon materials, or in the blending of refined products, wherein the evaporation characteristics of such materials are critical factors.

The invention and its objects may be more fully understood from the following description, when it is read in conjunction with the accompanying drawings wherein:

Fig. 1 is an exploded view, in perspective of a simple form of the apparatus contemplated;

Fig. 2 is a schematic showing in vertical section, of another form of the apparatus according to the present invention.

In Fig. 1, the numeral 1 designates a casing or housing for a light source such as a fluorescent tube indicated in the drawing by the numeral 2. The housing 1 is provided with a cover 3 in which there is provided a port such as is designated by the numeral 4. The port 4 is shown to be located in the cover between two strip elements 5 and 6 respectively, extending laterally over the cover in substantially right angular relation to the longitudinal axis thereof and between them forming a recess 7, wherein the cover is the bottom wall. If desired, of course, the recess may be a part of the cover being formed integrally therein. This recess is adapted to receive a strip of a non-transparent, light transmissive, wettable material designated in the drawing by the numeral 8. Preferably, the strip of material is an absorbent material and has a longitudinal dimension greater than the width of the cover 3 or casing 1 and is provided with a defined circular area 9 imprinted or otherwise impressed upon the surface of the strip. The circular area 9 is of substantially the same dimension as the port 4 and is spaced from one end of the strip 8 by a distance substantially equal to the distance of the port 4 from either edge of the cover. Also as shown or indicated, the strip 8 has a lateral dimension substantially equal to the width of the recess portion 7 and the circular area 9 is located on the strip in spaced relation to the side edges thereof. When the strip is inserted in the recess, the circular area 9 will substantially correspond to, and be disposable in substantial registration with the port 4. The depth of the recess as provided by the thickness of the elements 5 and 6 is gauged so as to be slightly greater than the thickness of the strip of absorbent material 8.

The elements 5 and 6, or the surface of the cover 3, when the recessed portion is formed integrally, provides a support for a light meter 10, such as a Standard Weston Light Meter (Model No. 715) as manufactured and offered for sale by the Weston Electric Instrument Corporation of Newark, N.J. The instrument as employed in the present invention was provided with a gradient scale covering a 50° range with 1° divisions. For the present purpose, the back of the meter was removed and replaced with a shield having a port therein corresponding to the port 4 in its dimension, and located so that the shield port could be made to coincide with the light port 4. Preferably, the port 4 is also covered with some translucent material, such as thin white paper, frosted glass, or cloth, in order to slightly diffuse the emitted light. The intensity of the light source may be fixed, but preferably some suitable and conventional means for controlling light intensity is included in the circuit connected thereto.

In the operation of the device as illustrated by Fig. 1, a strip of absorbent material such as that indicated by the numeral 8, is wetted with a liquid for which the evaporation point is to be determined. Wetting is accomplished by applying a drop (0.02 to 0.05 cu. centimeter) of the liquid to the center of the circular area 9 on the strip. The strip is then immediately inserted in the recess 7 so as to bring the end of the strip nearest the circular area into registration with the opposite edge of the cover 3 and the recess 7. In this way, the circular area is brought into coincidence with the port 4 and the corresponding port provided in the back of the light meter. The light meter scale readings are then recorded at intervals over such period of time as required to reach a point of no change in the recorded intensity of light transmitted through the absorbent material. The time taken to reach this point is the evaporation time for the liquid.

Preferably, the determination is made under controlled temperature conditions. This may be accomplished by enclosing the instrument with a shield spaced from the instrument from about one to about two inches, and wherein the shield is provided with suitable openings to permit a substantially uniform flow of air upwardly within the shield. For the purposes intended, the heat de-

rived from the light source, in conjunction with thermal circulation of air over the surface of the strip, is usually sufficient to induce evaporation of the sample applied to the absorbent strip. In the region of the sample employing a 6" double type fluorescent lamp, the temperature has been found to average between 109° and 120° F. Where especially accurate results are required, the determination should be carried out in an atmosphere of air maintained at a substantially constant temperature and humidity.

The absorbent material employed for the strip 8 may be substantially any non-transparent material having the ability to transmit light under the conditions of operation. A variety of materials has been found to afford satisfactory results when employed in the manner set forth above. Such materials include both felted and woven fibrous materials, such as blotting paper, filter paper, and natural fiber cloth. Although an absorbent fibrous material is generally preferred for the purposes set forth, fritted glass, and ground or etched glass may also be used. When using a ground or etched glass strip, the liquid sample is applied to the rough surface thereof. Finely woven metallic cloth has also been employed with success. In this instance, however, the light transmission effects are reversed, the intensity of light transmitted by the dry cloth being greater than that transmitted by the wetted cloth. Thus the percent change is indicated by an increasing light value instead of a decreasing value.

In tabulating the results as shown by light meter readings, for uniformity, it is preferred that this be done in terms of percent change in total light meter scale deflection for any given time interval. When using materials such as mentioned above, excluding metallic cloth, total scale deflection may be defined as the maximum meter reading with 100% sample present, that is when the wetted strip of absorbent material is first inserted, minus the final meter reading after complete evaporation of the sample, at that point where no further change in the light meter scaled reading is apparent. When using a metallic cloth, the total scale deflection will be the final reading minus the initial reading, but still at that point at which no further change occurs. The error in meter reading is entirely dependent upon the calibration of the meter itself and the spacing of the scale markings. With the scale marked in 1° intervals it is possible to read it within 0.5°. Under such circumstances, the meter reading error should not be more than about equivalent to the readable scale unit divided by the total scale deflection.

Employing an apparatus substantially as shown by Fig. 1 of the drawings according to the method set forth with reference thereto, the evaporation rate and end point of a series of six different hydrocarbon liquids were determined in a series of separate determinations for each liquid. In each determination, the ambient atmosphere of the instrument was air, conditioned and substantially maintained at a constant temperature of 72° F. and a relative humidity of 40%. Each liquid was further subjected to an evaporation end point determination by means of a Modified Jolly Balance, employing conventional techniques for the operation thereof, to provide a basis of comparison for the results obtained by the presently disclosed apparatus and method.

The nature of the liquids employed in these determinations and the results obtained are indicated from the following tables:

Table I

Liquid	Boiling Range, ° F.	Photo-Evaporimeter							Modified Jolly Balance	
		Evaporation Time for Individual Runs in Seconds				Average Time in Seconds	Percent Deviation	Relative Time (Toluol=1)	Evap. Time in Minutes	Relative Time (Toluol=1)
		Run #1	Run #2	Run #3	Run #4					
A	152-158	40	50			45	±11	0.39	15	0.25
B	229-233	110	110	120	120	115	±4	1.00	60	1.00
C	251-289	160	170			165	±3	1.43	78	1.30
D	278-290	250	260	260		257	±2	2.23	130	2.16
E	317-350	660	720			690	±4	6.00	360	6.00
F	316-385	960	1,080	1,090		1,040	±5	9.04	600	10.00

Table II

Percent Change in Light Meter Scale Reading	Time in Seconds					
	A	B	C	D	E	F
10	3.0	7	9.5	10	10	18
20	5.5	14	19	22	15	42
30	8.5	22	30	36	30	72
40	11.5	30	41	54	54	117
50	14.5	39	55	76	90	180
60	17.0	49	71	102	154	279
70	22.0	61	88	133	240	408
80	27.0	75	107	170	357	576
90	33.5	92	131	211	507	780
95	38.5	102	147	233	594	888
100	45.0	115	165	257	690	1040
(Total Min.)	(0.75)	(1.92)	(2.75)	(4.34)	(11.5)	(17.0)

In Table I, the several hydrocarbon liquids are designated alphabetically, and identified by their typical boiling ranges. The liquid designated B is toluol, and as a relatively pure material is used as a reference in the results tabulated, and particularly for comparison of evaporation times determined according to the present invention with those determined conventionally by use of a Modified Jolly Balance. The total evaporation time for each liquid on each run made therewith is also shown. The average of these runs in each instance is shown in comparison with the time for evaporation of the sample required for operation of the Modified Jolly Balance. The shorter times of determination as shown over that for the conventional system are due primarily to the fact that samples of such smaller volume (0.002 to 0.05 cubic centimeters as compared with about 2.0 cubic centimeters) may be employed according to the present invention.

In view of the fact that the differences in the evaporation times of the respective systems is so wide, provision is made in Table I for a proportional comparison. The evaporation time for toluol by either system is taken as a base figure equal to 1. The time for evaporation of each of the liquids in either system is then shown in its proportional relationship to the evaporation time for toluol. When thus related, the substantial uniformity of results by either system is evident.

Table II is derived from data obtained from the evaporation determinations made for each of the liquids designated in Table I, and shows the percent change in light meter scale deflection indicated from a curve of average value plotted from such data. In this table, the total evaporation time shown for each liquid is as also shown in Table I. In addition, the equivalent total time in minutes is included in parentheses for each liquid.

The apparatus as illustrated by Fig. 2 is basically similar

to that as shown by Fig. 1. In Fig. 2, the numerals 11 and 12 respectively designate an instrument body and a capping piece therefor. These elements may be of any desired shape, but in the form contemplated by the drawing they are circular. The body 11 is provided with a generally rectangular recessed slotted portion 13, which extends diametrically across the body, opening upwardly through the upper end of the body and radially thereof at each end of the slotted portion. The body 11 and piece 12 each defines a concentric tubular passageway, 14 and 15 respectively, opening through their upper and lower ends. These passageways are of substantially equal diameter, and as shown, when the body and capping piece are assembled, are disposed in substantially coaxial relation. The upper end of the passageway 14, defines a port which opens through the bottom of the recess portion 13. As in the device as illustrated by Fig. 1, the passageways and thereby the port is intended to have a diameter less than the width of the recessed portion 13. With the capping piece 12 applied as shown, it cooperates with the body 11 and recessed portion 13 to form a passageway, rectangular in cross section, which intersects the axis of the passageways 14 and 15 at right angles thereto.

The numeral 16 designates a slide adapted for insertion in the recess portion 13, with the lower surface of the slide in slidable surface contact with the bottom wall of the recess portion, and supported thereby. The upper surface of the slide is preferably recessed to receive a strip of a non-transparent, light-transmissive material of the character previously described, and designated in Fig. 2 by the numeral 17. A stop member 18 is disposed laterally of the slide 16 at its forward end, providing an abutment for the forward end of the strip 17. The slide 16 is further provided with an orifice or port 19 opening through the recessed portion thereof intermediate the ends, and a lateral stop member 20 dependent from the lower surface at a distance from the center of port 19 substantially equal to that from the axis of passageway 14 to the outer wall of the body 11. By means of stop 20, the port 19 is automatically brought into coaxial registration with the passageways 14 and 15 when the slide is fully inserted in the recess 13. In similar fashion, the stop 18 provides for proper registration with port 19 of an indicated spot for application of a liquid sample on the strip 17, such as the circular area 9 on the strip 8 shown and described with reference to Fig. 1. In this instance, such a circular area would have a center spaced from the forward end of the strip 17 by a dimension equal to the distance from the stop to the center of the port 19. Further, as shown in Fig. 2, the port 19 is preferably provided with a light diffusion means such as a frosted glass insert indicated by the numeral 21 in the drawing.

The overall thickness of the slide 16 with strip 17 applied thereto is gauged to the depth of the recess 13, so as to be substantially less than such depth and to provide a free space above the strip 17 which opens inwardly from each end of the recess into communication with the passageway 15. The passageway 15 in turn communicates with a conduit passageway 22 extending radially therefrom through the cap piece. A nipple 23 threaded into the outer end of the passageway provides for connection to either a suction pump or a pressure pump, not shown, for circulation of air over the upper surface of the strip 17.

In the apparatus as illustrated by Fig. 2, the required light source is indicated by the numeral 24. Preferably this source constitutes a projection lamp and condensing lens system with means for cooling the lamp and the light source generally in order to minimize the heating effect thereof. The beam of light from such source may be focused so as to pass directly into the lower end of the passageway 14, or preferably, as shown, it may be focused on an adjustable reflecting means such as a mirror indicated by the numeral 25, and the reflected beam directed into the passageway 14 by suitable adjustment of the reflecting means. In any event, in order to maintain a substantially constant temperature in the vicinity of the strip 17 and to overcome any possible heating effect of the light source, the body 11 is provided with means for circulating a heat exchange medium in indirect heat exchange relation thereto, such as the conduit coil 26 shown, including inlet 27 and outlet 28 thereof.

In Fig. 2, further, the numeral 29 designates a light-sensitive element supported over the upper end of the capping piece 12 so as to expose a light-sensitive surface over the upper end of the passageway 15. This light-sensitive element may be of any conventional type including a light meter as represented and described with reference to Fig. 1. In Fig. 2, the light-sensitive means shown is representative of a photo-electric cell unit also manufactured and offered for sale by the Weston Electric Instrument Company of Newark, N.J., and designated as their model 856, type 1. Electric leads 30 and 31 connect the unit 29 to a microammeter 32, adapted to register and indicate the strength of signals produced in the photocell unit 29 by light transmitted from the light source 24 through the light-transmissive strip 17.

Operation of the device as shown in Fig. 2 is quite comparable with that of the device as shown in Fig. 1. A drop of a liquid sample is applied to the strip 17 in place on the slide 16. The slide and strip are inserted in the recess 13 and positioned substantially as shown. The ammeter needle deflection is read at this point and at periodic intervals during evaporation. That point at which the needle deflection remains constant is then taken as the evaporation end point. The results obtained during the operation and from interval to interval are compared with similar data, obtained by the same operation with a sample of known evaporation characteristics.

What is claimed is:

1. An apparatus for measuring the evaporation rate of a volatile liquid, comprising a support member having obverse and reverse surface portions; a recess defined, at least in part, by said obverse surface portion, said recess including a bottom wall part; a passageway defined in said support opening through said support reverse surface portion and said recess bottom wall part, said passageway terminating at one end in a port defined by said recess bottom wall part; a strip of a translucent material, wettable by said volatile material, adapted to be inserted in said recess; light-sensitive means disposed in light-receiving spaced opposition to said port defined by said recess bottom wall part; and means, including said port and a light source, for directing a beam of light against said light-sensitive means, through said strip of wettable material, said light-sensitive means being adapted to exhibit the changing intensity of light transmitted by said wettable material during evaporation therefrom of a sample portion of said volatile material applied thereto.

2. An apparatus according to claim 1, wherein said wettable material is an absorbent material.

3. An apparatus according to claim 2, wherein said absorbent material is a fibrous material.

4. An apparatus according to claim 3, wherein said fibrous material is a felted fibrous material.

5. An apparatus according to claim 3, wherein said fibrous material is a woven fibrous material.

6. An apparatus according to claim 3, wherein said fibrous material is paper.

7. An apparatus according to claim 1, wherein said light-sensitive means is a photo-electric cell.

8. An apparatus for measuring the evaporation rate of a volatile liquid, comprising a support member constituting a walled housing defining a chamber and including walls having obverse and reverse surface portions; a recess defined, at least in part by the obverse surface portion of one said housing wall, said recess including a bottom wall part; a passageway defined in said housing wall opening through said wall reverse surface portion and said recess bottom wall part, said passageway termi-

nating at one end in a port defined by said recess bottom wall part; a strip of a translucent material wettable by said volatile material, adapted to be inserted in said recess; light-sensitive means disposed in light-receiving spaced opposition to said port defined by said recess bottom wall part; and means, including said port and a light source contained within said chamber, for directing a beam of light against said light-sensitive means, through said strip of wettable material, said light-sensitive means being adapted to exhibit the changing intensity of light transmitted by said wettable material during evaporation therefrom of a sample portion of said volatile material applied thereto.

9. An apparatus for measuring the evaporation rate of a volatile liquid, comprising a support member having obverse and reverse surface portions in spaced relation longitudinally of an axis of said support, and sidewall portions substantially parallel to said axis; a recess, including a bottom wall part, defined by said support obverse surface portion, said recess extending radially from said support axis to open through said sidewall portions; a passageway, coextensive with said sidewall portions, defined in said support member and opening through said support reverse surface portion and said recess bottom wall part, said passageway terminating at one end in a port defined by said recess bottom wall part; a strip of translucent material, wettable by said volatile material, adapted to be inserted in said recess; carrier means for inserting said strip in said recess, said carrier means having an obverse surface portion adapted to receive said strip and a reverse surface portion, and defining a port opening between said surface portions, said carrier means also adapted for insertion in said recess to engage said reverse surface portion thereof in slidable surface contact with said recess bottom wall part, whereby to position said carrier means port in coaxial relation with said passageway port; a capping piece for said support member, said piece having spaced, coaxial obverse and reverse surface portions; a passageway defined in said capping piece to open through said respective surface portions, said capping piece being adapted for engagement with said support member so as to dispose said capping piece reverse surface portion in surface contact with said support obverse surface portion, and with said capping piece passageway in coaxial alignment with said support passageway; means, including a light source, for directing a beam of light in a path extending through said respective support member and capping piece passageways, by way of said respective ports defined by said recess bottom wall part and by said carrier means; light-sensitive means disposed in light-receiving relation to said capping piece passageway on said capping piece obverse surface; and means adapted to pass a current of air over said strip of wettable material while said strip is inserted in said recess; said light-sensitive means being adapted to exhibit the changing intensity of light transmitted by said wettable material inserted in said recess and during evaporation therefrom of a sample portion of said volatile liquid material applied thereto.

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