United States Patent [19]

Heiss

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[54] **PHOTOMETER APPARATUS**

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[73] Assignee: **Baxter Laboratories, Inc.,** Morton Grove, Ill.

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[21] Appl. No.: **264,188**

[52] **U.S. Cl.** **356/201,** 356/246, 250/218, 356/218

[51] **Int. Cl.** **G01j 1/42,** G01n 1/10

[58] **Field of Search** .....356/218–228, 173; 250/218, 71 R

[56] **References Cited**

UNITED STATES PATENTS

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Assistant Examiner—Conrad Clark
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[57] **ABSTRACT**

A photometer assembly consisting of a basic photometer unit having a photomultiplier tube projecting from its top wall. A reaction chamber is mounted over and receives the photomultiplier tube. The reaction chamber includes a stationary spool-shaped member having a shank consisting of a shell portion which surrounds the photomultiplier tube and is provided with an exposure aperture. A sample tube carrier rotatably surrounds the shank and has a vertical socket receiving a transparent sample tube, the carrier having a light duct leading from the socket to the shell portion, the duct being movable into registry with the exposure aperture so as to expose the sample tube to the photomultiplier tube in a unique position of the carrier, the sample tube being shielded from ambient light by the spool-shaped member and carrier in this position. The top of the spool-shaped member has a vertical guide tube, the guide tube registering vertically with the sample tube when the sample tube is in said unique position. Luminescence-inducing reagent or radiation may be injected into the sample tube through said guide tube, and the resulting luminescence may then be measured by the resultant signal generated by the photomultiplier tube. The top of the spool-shaped member is cut away opposite the guide tube to allow the sample tube to be inserted into and withdrawn from the socket.

9 Claims, 13 Drawing Figures

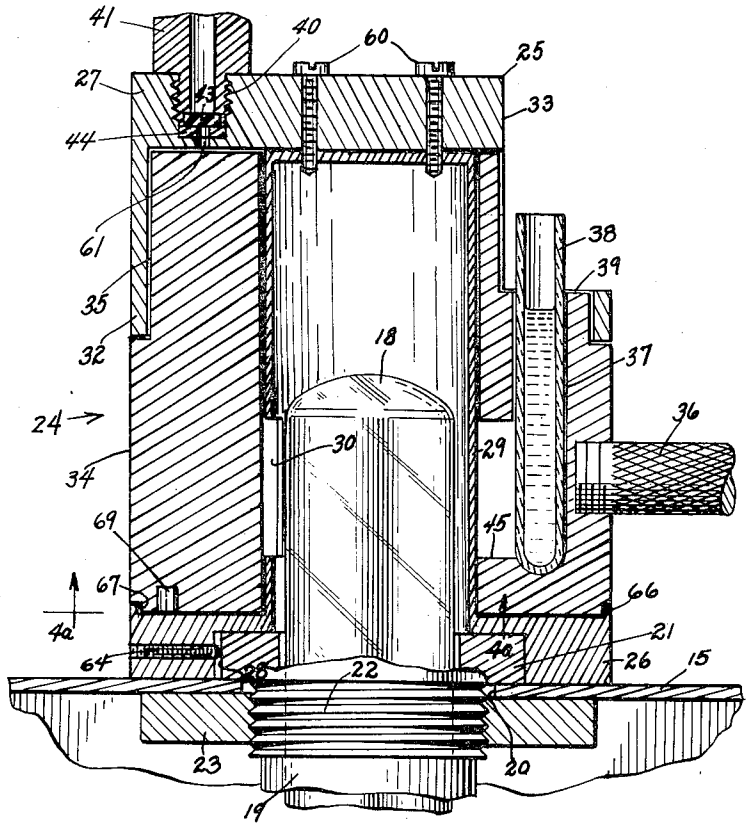


Fig. 1

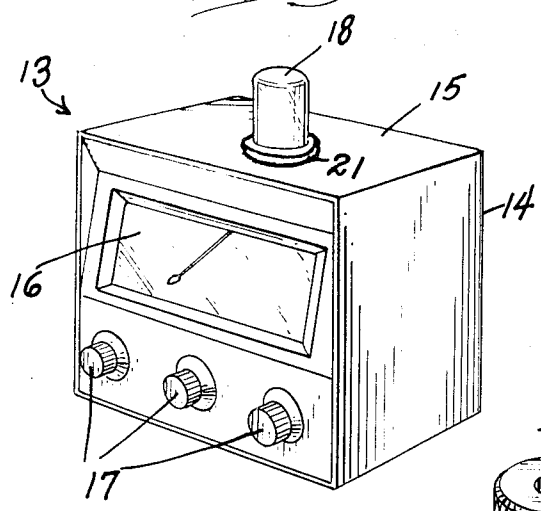
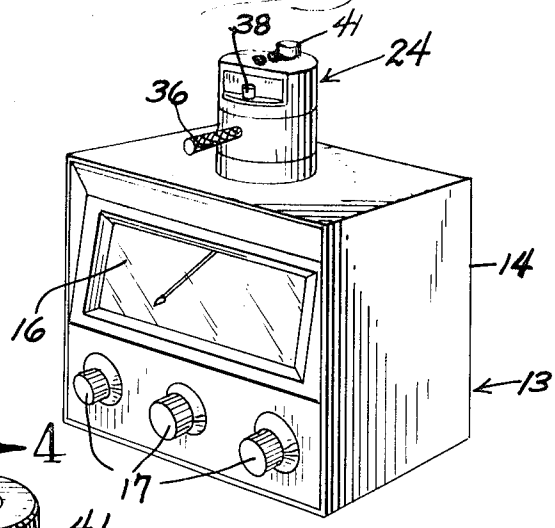


Fig. 2



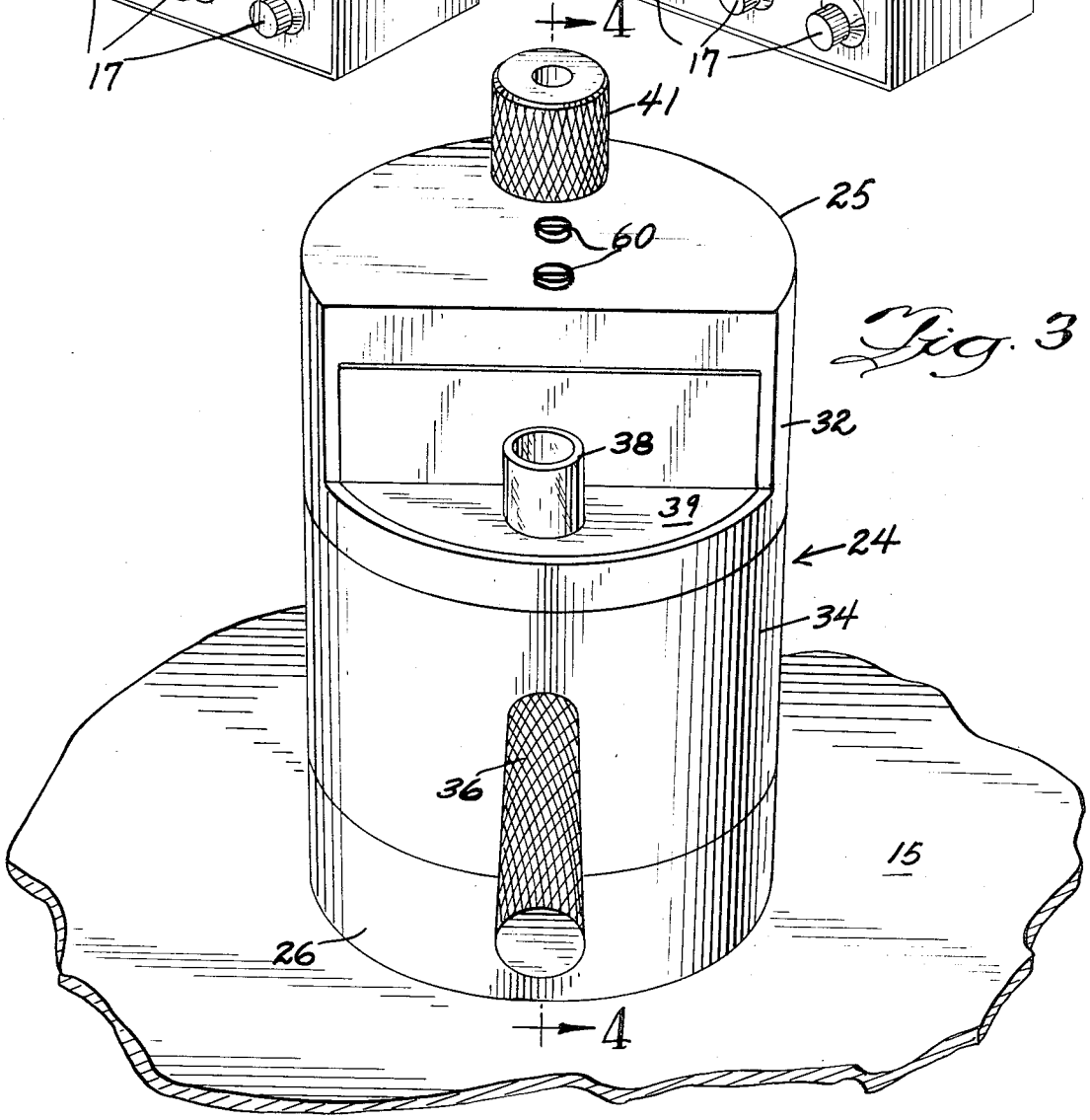


Fig. 3

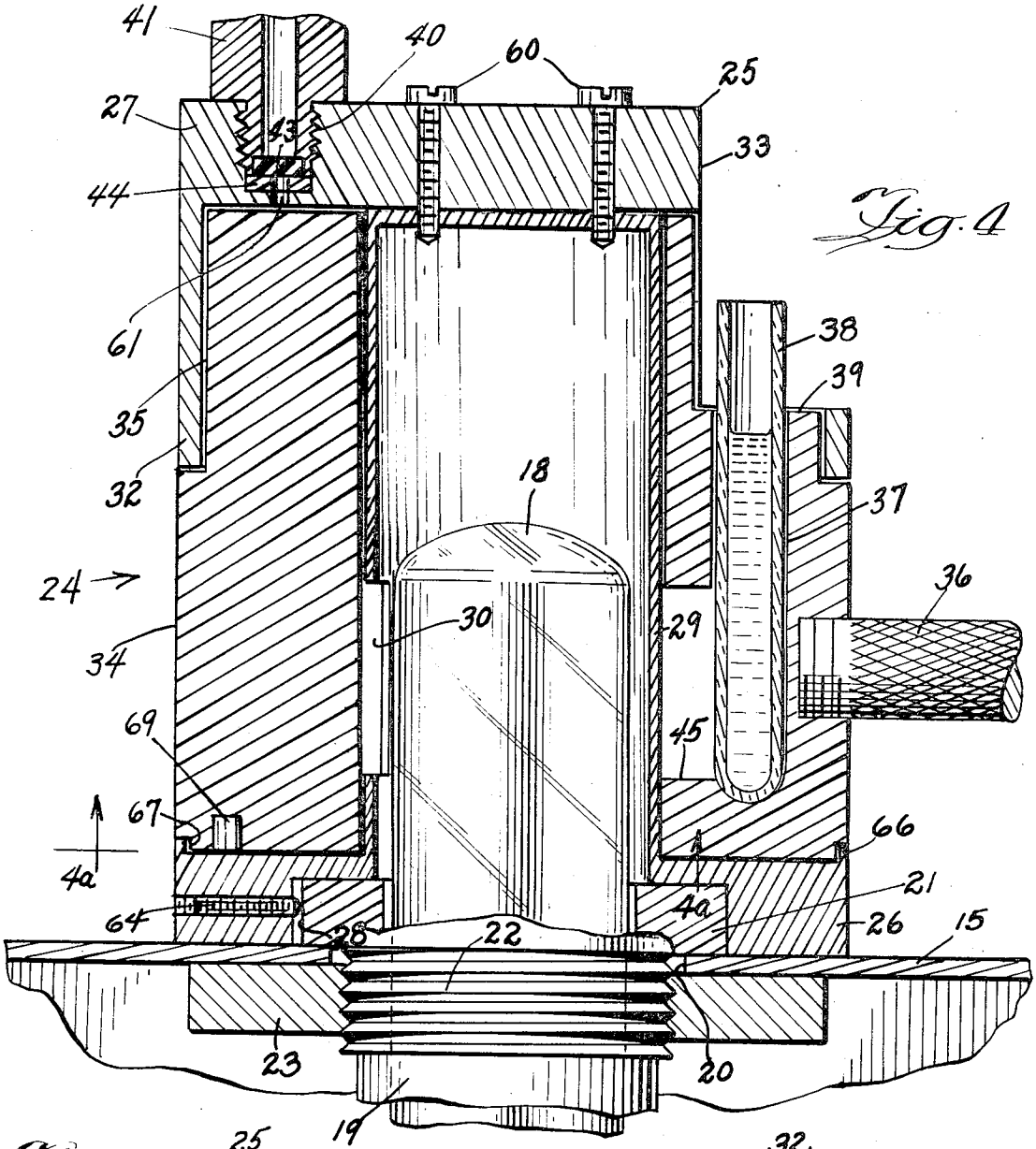


Fig. 4

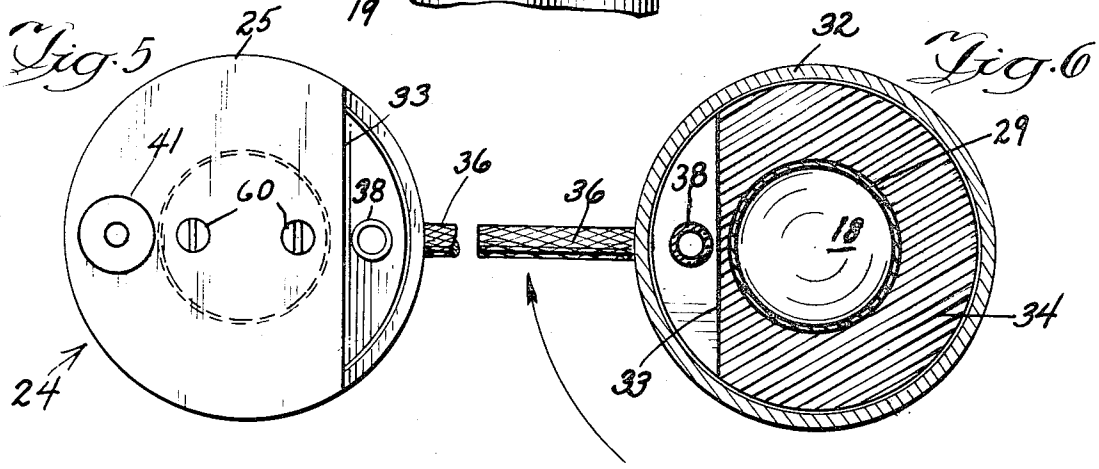


Fig. 5

Fig. 6

Fig. 7

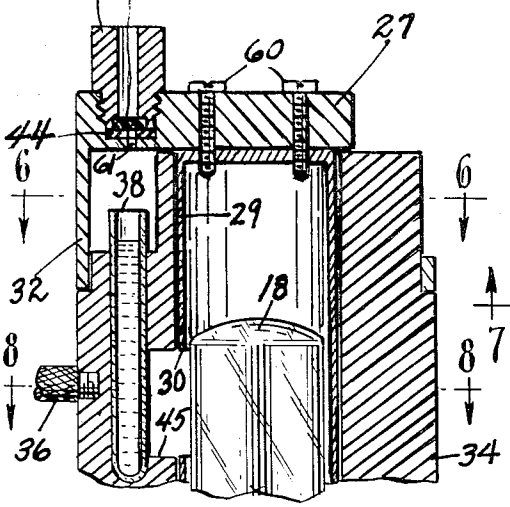
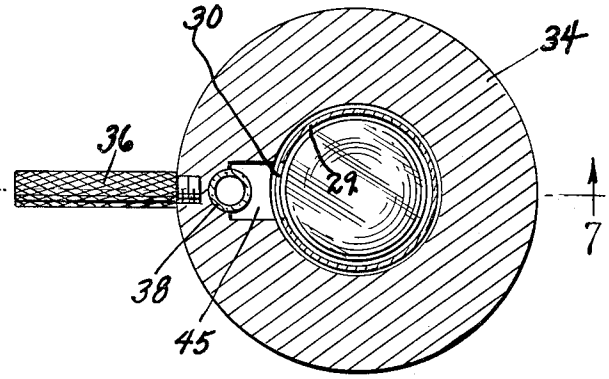


Fig. 8



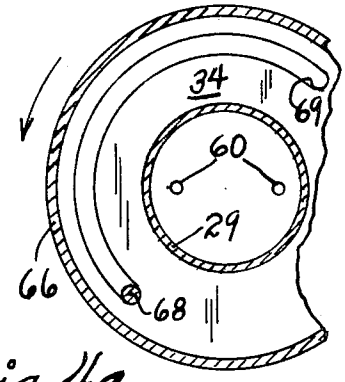


Fig. 4a

Fig. 9

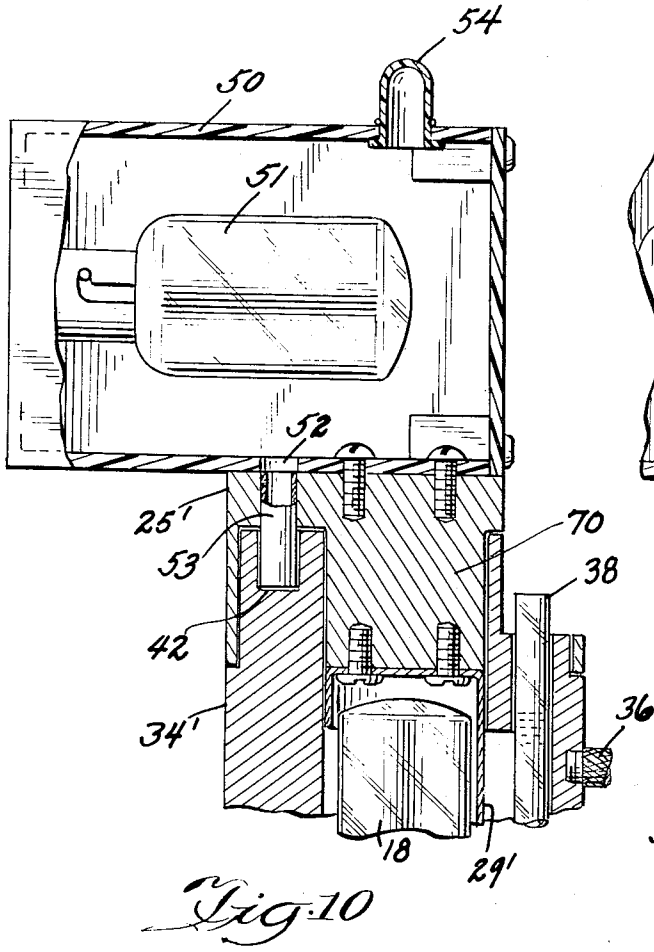


Fig. 10

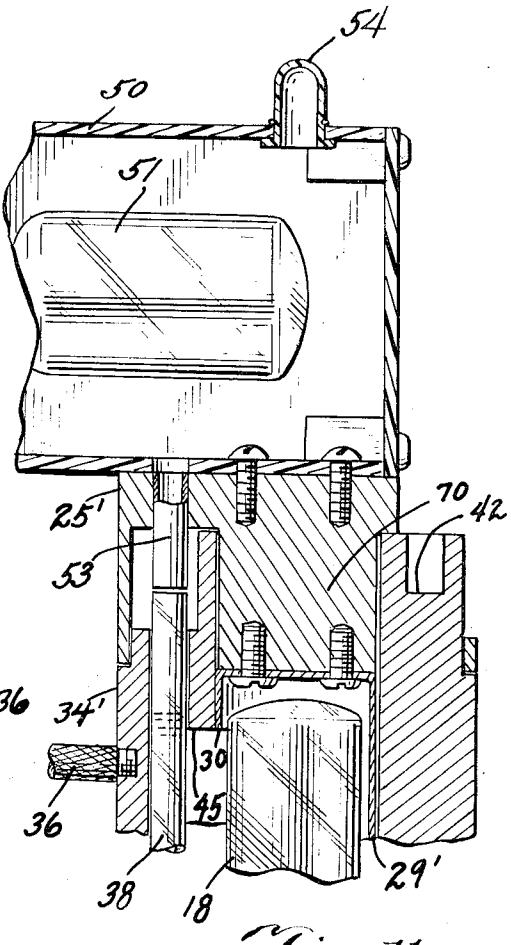


Fig. 11

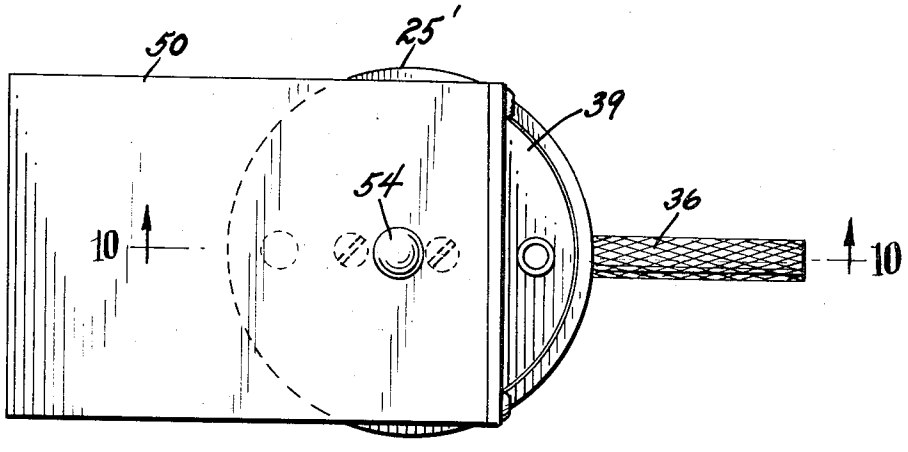


Fig. 12

PHOTOMETER APPARATUS

This invention relates to photometers, and more particularly to apparatus for detecting and measuring luminescence in materials.

A main object of the invention is to provide a novel and improved photometer assembly which is relatively simple in construction, which is easy to operate, and which is readily adaptable for performing a wide range of luminescence-measuring tests.

A further object of the invention is to provide an improved luminescence measuring photometer assembly comprising a basic luminescence-responsive photometer unit and various types of reaction chambers which can be employed with said basic unit for performing different types of luminescence-measuring tests, such as chemiluminescent response to reagents, bioluminescence of organic or other materials, fluorescent response of materials to radiant energy, and the like, the assembly being compact in size, being extremely versatile in operation, and being substantially free from errors caused by ambient light or other disturbing factors.

A still further object of the invention is to provide an improved luminescence-measuring photometer assembly which can be efficiently employed for measuring luminescence in samples induced by the injection of reagents therein, such as the injection of reagents reacting with ATP to produce the "firefly" bioluminescence reaction, or for measuring other types of chemiluminescence reactions, and which may be readily adapted for use for measuring fluorescence or other forms of luminescence in samples induced by excitation with radiant energy.

Further objects and advantages of the invention will become apparent from the following description and claims, and from the accompanying drawings, wherein:

FIG. 1 is a perspective view of a basic photometer unit forming part of the present invention.

FIG. 2 is a perspective view of the basic photometer unit of FIG. 1 on which is mounted a reaction chamber according to the present invention for use in performing chemiluminescence tests.

FIG. 3 is an enlarged front perspective view of the assembly of FIG. 2.

FIG. 4 is a vertical cross-sectional view taken substantially on line 4—4 of FIG. 3.

FIG. 4*a* is a fragmentary horizontal cross-sectional view, to a reduced scale, taken substantially on line 4*a*—4*a* of FIG. 4.

FIG. 5 is a top plan view, to a reduced scale, of the reaction chamber shown in FIGS. 3 and 4.

FIG. 6 is a horizontal cross-sectional view of the reaction chamber of FIG. 2 with the sample carrier thereof in luminescence measuring position, said view being taken substantially on line 6—6 of FIG. 7.

FIG. 7 is a fragmentary cross-sectional view of the upper portion of the reaction chamber and the photomultiplier tube taken vertically through the assembly of FIG. 2, with the sample carrier in luminescence measuring position, on line 7—7 of FIG. 8.

FIG. 8 is a horizontal cross-sectional view taken substantially on line 8—8 of FIG. 7.

FIG. 9 is a perspective view of the basic photometer unit on which is mounted a modified reaction chamber according to the present invention for measuring luminescence induced by radiant energy in a sample.

FIG. 10 is an enlarged fragmentary vertical cross-sectional view taken through the reaction chamber of FIG. 9, substantially on the line 10—10 of FIG. 12.

FIG. 11 is a vertical cross-sectional view similar to FIG. 10 but showing the sample carrier in luminescence measuring position.

FIG. 12 is a top plan view of the reaction chamber of FIG. 10, shown in the sample-loading position of FIG. 9.

Referring to the drawings, 13 generally designates a basic photometer unit having a main housing 14 provided with a horizontal top wall 15. The photometer unit 13 has a readout meter 16 and conventional operating controls 17, and employs conventional circuitry. The photosensitive element of the photometer unit 13 comprises a photomultiplier tube 18 which is mounted in a socket 19 engaged through an aperture 20 formed in top wall 15, said socket having a top flange 21 bearing on top wall 15 and having an externally threaded neck portion 22 on which is engaged a clamping ring 23 engaging clampingly beneath the top wall 15, as shown in FIG. 4, whereby the socket is supported so that the photomultiplier tube 18 projects upwardly from top wall 15.

Referring to FIGS. 2 to 8, 24 generally designates a reaction chamber which may be employed in cooperation with the basic photometer unit 13 to perform chemiluminescence or bioluminescence tests. The reaction chamber 24 comprises a generally spool-shaped supporting member 25 having a bottom flange portion 26, a top flange portion 27 and a shank comprising a hollow shell portion 29 adapted to receive photomultiplier tube 18.

Shell portion 29 is integral with bottom flange portion 26, and said shell portion is formed with an exposure aperture 30. The bottom flange portion 26 is recessed to fit over and receive the socket flange 21 and may be detachably secured thereto, as by a set screw 64 engaging in a vertical positioning notch 28 formed in flange 21, as shown in FIG. 4.

The top flange portion 27 is secured to the top wall of shell portion 29 by a pair of fastening screws 60,60. Top flange portion 27 has a depending peripheral skirt 32, and part of said top flange portion and skirt are right-angularly cut away at one side of member 25, as shown at 33, for a purpose presently to be described.

Designated at 34 is a sample carrier which is rotatably mounted on and surrounds the shell portion 29 and which is peripherally recessed at 35 to recive skirt 32. Carrier 34 is provided with the outwardly extending horizontal handle 36 located adjacent a vertical sample tube-receiving socket 37 formed at the cut-away portion 33. Socket 37 is dimensioned to receive a vertical transparent sample tube 38 and to support the tube with a portion thereof projecting above the horizontal floor surface 39 of the cut-away portion 33.

Diametrically opposite the cut-away portion 33 the top portion 27 is formed with a vertical bore 40 having a bottom wall provided with a central aperture 61. Threadedly engaged in bore 40 is a flanged guide tube 41 having a bottom recess in which is seated a rubber septum disc 43 held against a centrally apertured rigid disc member 44 seated in the bottom of bore 40. The rubber septum disc is penetrable to allow a syringe needle to pass therethrough and is self-sealing when the needle is withdrawn.

It will be seen from FIG. 4 that carrier 34 is rotatable, for example, from the position of FIG. 4 about 180° to the position of FIG. 7 to allow sample tube 38 to be rotated from the loading position of FIG. 4 to the injection position of FIG. 7, wherein the sample tube is brought into registry with the injection guide tube 41.

Carrier 34 is formed with a light duct 45 extending from socket 37 to shell portion 29 and located so as to register with aperture 30 when the carrier is rotated to the injection position of FIG. 7. Thus, in this injection position, the lower portion of sample tube 38 is exposed to photomultiplier tube 18, which can thus respond to luminescence in the sample tube.

The internal wall surface of socket 37 opposite the light duct 45 is preferably silvered or otherwise made highly reflective to maximize the intensity of the display provided by luminescence in the sample tube relative to photomultiplier tube 18.

the rim of bottom flange portion 26 is provided with an upstanding peripheral light-shielding rib 66 which is received in a peripheral recess 67 in the bottom portion of carrier 34. Bottom flange portion 26 is provided with an upstanding stop pin 68 (see FIG. 4a) which is received in a substantially semicircular stop groove 69 formed in the bottom of carrier 34 concentrically with shell portion 29 to limit rotation of carrier 34 with respect to support 25 between the positions of FIG. 4 and FIG. 7.

In operation, a sample tube 38 containing material to be tested is inserted in the socket 37 with the carrier 34 in the loading position thereof shown in FIGS. 2, 3 and 4. The carrier is then rotated approximately 180° to the injection position of FIG. 7 and the photometer unit is adjusted to provide an initial reference reading, such as zero, on the meter 16. Suitable luminescence-generating reagent is then injected by means of a syringe through the guide tube 41, the syringe needle being forced downwardly through the penetrable rubber septum disc 43, passing through the central aperture of disc 44 and through aperture 61. The luminescence produced by the reagent is detected by the photomultiplier tube 18 and is indicated on the meter 16.

FIGS. 9, 10, 11 and 12 illustrate a modification wherein the apparatus may be employed for testing a sample for photoluminescence. In this embodiment, a lamp housing 50 is secured on the top of the reaction chamber top support member, shown at 25', the housing 50 containing a horizontally mounted excitation lamp 51 overlying an aperture 52 in the bottom wall of housing 50, said aperture registering with a vertical guide tube 53 secured in the top portion of member 25' and depending into an arcuate channel 42 formed in the top rim portion of the sample carrier, shown at 34'. The top support member 25' has a depending solid center portion 70 flush with the shell portion, shown at 29', to which the top wall of said shell portion is rigidly secured. The sample tube 38 may be brought into vertical registry with guide tube 53 in the manner previously described, and luminescence generated in the material contained therein in response to excitation from lamp 51 may be detected by photomultiplier tube 18 and indicated on meter 16 in a manner similar to that described in connection with the embodiment of the invention shown in FIGS. 2 to 8.

Housing 50 is preferably provided at its top portion with a suitably tinted transparent indicating dome 54 to indicate visually that lamp 51 is energized when carrier 34' is in its injection position.

Suitable convertional stop means, such as ball detents, or the like, may be employed to positively establish the respective loading and injection positions of the rotatable sample tube carrier 34 or 34' relative to its stationary associated spool-shaped supporting member.

In the embodiment of FIGS. 9 to 12 suitable primary and secondary filters may be employed respectively between lamp 51 and aperture 52 and between the sample tube 38 and the light duct 45 for specific applications of the instrument. In certain applications wherein ultra violet light is employed as the excitation means this eliminates the need for employing expensive quartz sample containers and permits the use of inexpensive disposable sample containers.

While certain specific embodiments of an improved photometer apparatus have been disclosed in the foregoing description, it will be understood that various modifications within the spirit of the invention may occur to those skilled in the art. Therefore it is intended that no limitations be placed on the invention except as defined by the scope of the appended claims.

I claim:

1. In combination, a photometer including a housing and having a photosensitive element projecting from an outer wall of said housing, a reaction chamber mounted on said outer wall and having a recess receiving said photosensitive element, said reaction chamber comprising a support, means on the support to receive a sample container, said sample container-receiving means comprising a carrier rotatably mounted on said support for rotation around an axis containing said photosensitive element and having a socket for the sample container and means to expose the socket to the photosensitive element at a selected position of rotation of the carrier, and means to shield the sample container and photosensitive element from ambient light when said sample container is exposed to the photosensitive element.

2. The structural combination of claim 1, and wherein said recess is substantially coaxial with the rotational axis of the carrier, wherein the carrier has a light duct extending from said socket toward said recess, and wherein said recess has a wall formed with an aperture registrable with said light duct at said selected position of rotation of said carrier.

3. The structural combination of claim 2, and wherein said shielding means is provided with passage means registrable with said socket at said selected position of rotation of said carrier for transmitting excitation means to a sample container in said socket.

4. The structural combination of claim 3, and wherein said shielding means is cut away opposite said passage means sufficiently to provide access to said socket for inserting a sample container in or removing a sample container from said socket.

5. In combination, a photometer having a photosensitive element, a support mounted on the photometer and having means defining a cavity receiving said photosensitive element, and a sample carrier rotatably mounted on said support for rotation around an axis containing said photosensitive element and having means to support a sample container in a position wherein it extends adjacent said cavity-defining means, said cavity-defining means overlying said photosensitive element and having an exposure aperture located

so as to expose the sample container to the photosensitive element at a selected position of rotation of said carrier.

6. The structural combination of claim **5**, and means on the support defining a passage to transmit excitation means to the sample container when the carrier is in said selected position of rotation.

7. A reaction chamber assembly for use with a photometer of the type having an upstanding exposed photosensitive element, comprising a support engageable on the photometer and having means defining a cavity for receiving the photosensitive element, and a sample carrier rotatably mounted on said support for rotation around an axis containing said photosensitive element and having socket means to support a sample container in a position wherein it extends adjacent said cavity-defining means, said cavity-defining means having an exposure aperture located to expose the sample container to the photosensitive element at a selected position of rotation of said carrier.

8. The reaction chamber assembly of claim **7**, and means on the support defining a passage to transmit an excitation means to the sample container when the carrier is in said selected position of rotation.

9. The reaction chamber assembly of claim **8**, and wherein said support is substantially spool-shaped and is cutaway opposite said passage-defined means sufficiently to provide access to said socket means for inserting or removing a sample container.

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