United States Patent [19]

Frank

[11] **3,857,485**

[45] **Dec. 31, 1974**

[54] **FLEXIBLE CONTAINERS FOR LIQUID SAMPLE SPECTROMETRY AND METHODS AND APPARATUS FOR FORMING, FILLING AND HANDLING THE SAME**

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[73] Assignee: **Packard Instrument Company, Inc.,** Downers Grove, Ill.

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[21] Appl. No.: **259,767**

[52] **U.S. Cl.** ..... **206/305,** 53/29, 250/106 SC, 206/84

[51] **Int. Cl.** **B65d 65/16,** G21f 5/00

[58] **Field of Search**... 206/84, 56 AB, 56 AA, 46 P, 206/46 PU, 46 M, 45.34, 78 B; 229/65; 53/29; 250/106 SC

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Primary Examiner—William T. Dixson, Jr.
Attorney, Agent, or Firm—Wolfe, Hubbard, Leydig, Voit & Osann, Ltd.

[57] **ABSTRACT**

Flexible sample containers for liquid scintillation spectrometry analysis of test samples containing one or more radioactive isotopes disposed in a liquid scintillator wherein the flexible sample containers either in individual or strip form are made of layered, flexible, light-transmissive, polyester film and are provided further with means for avoiding light "piping" or optical isolation from respective adjacent sample containers. Apparatus for handling such flexible sample containers is provided with light transmission sealing means for preventing entry of ambient light or escape of light from the photomultiplier tube detection devices. Also disclosed are methods and apparatus for filling, forming, sealing and handling the aforementioned flexible sample containers that readily lends itself to fully automated production line type operations.

4 Claims, 34 Drawing Figures

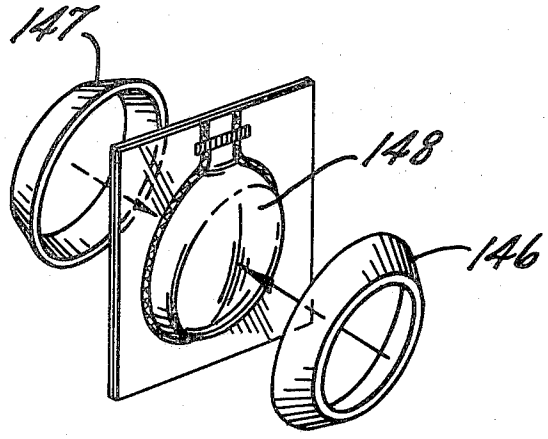
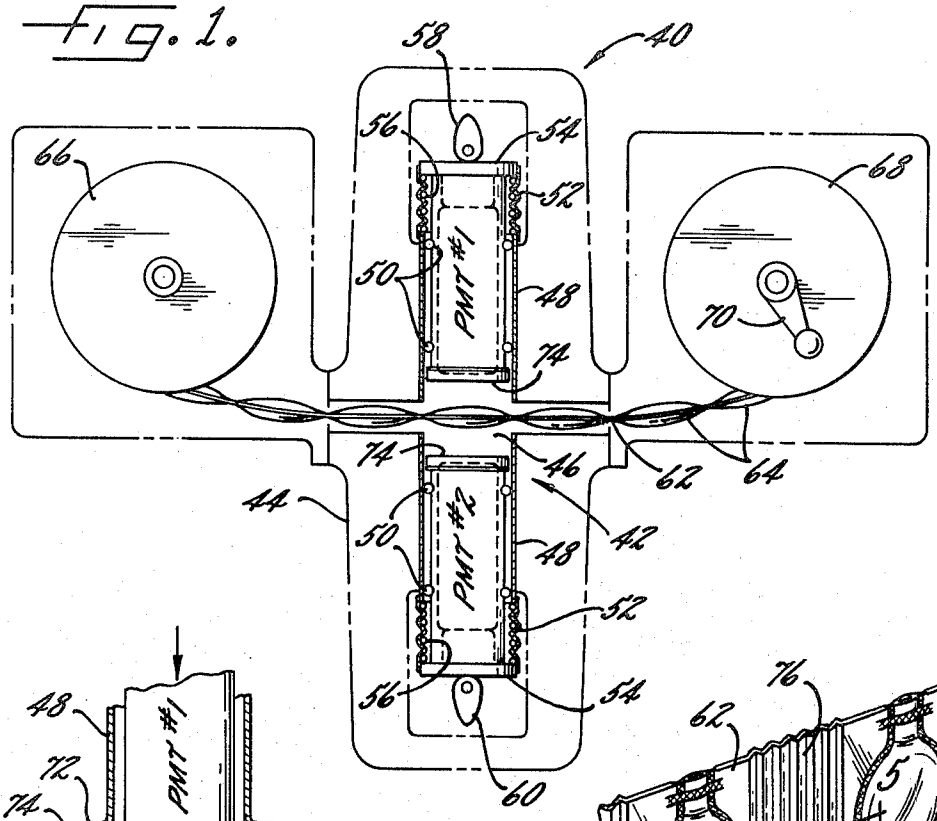


Fig. 1.



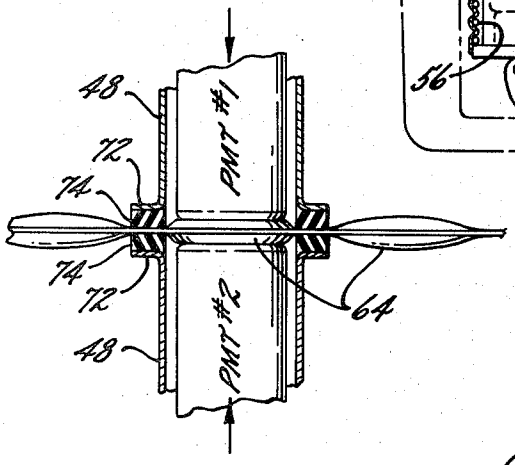


Fig. 2.

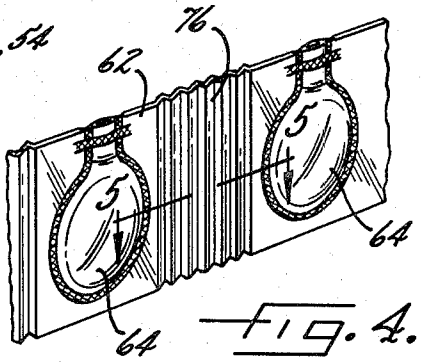


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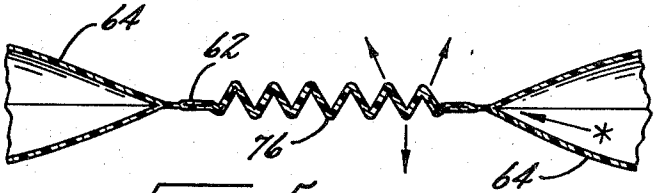


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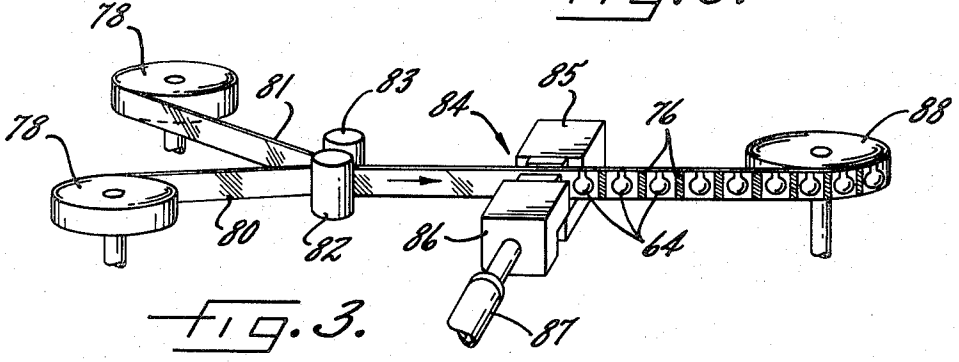


Fig. 3.

Fig. 6.

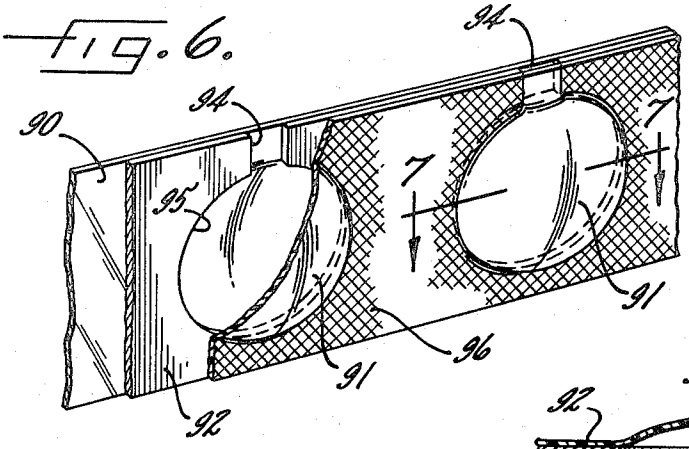
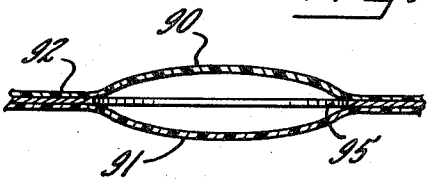


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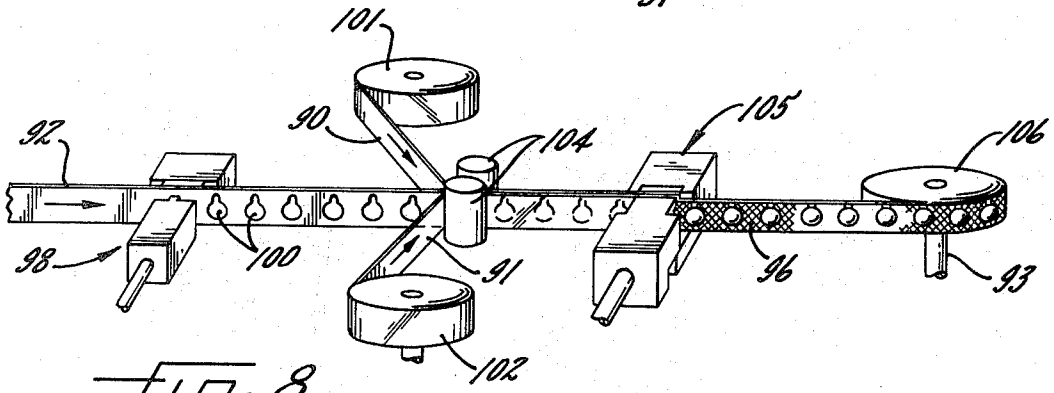


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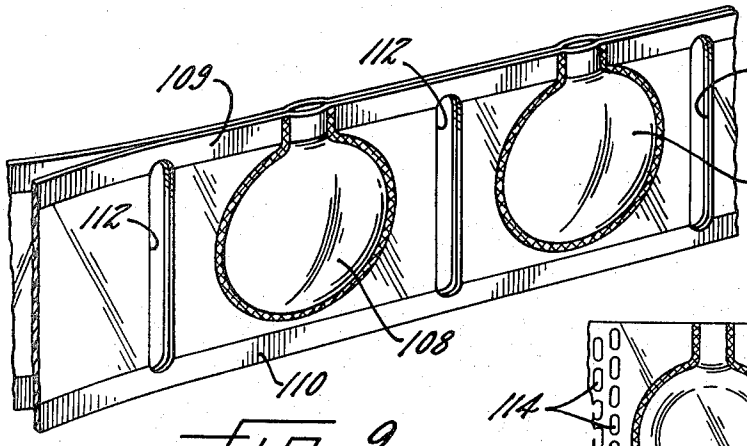


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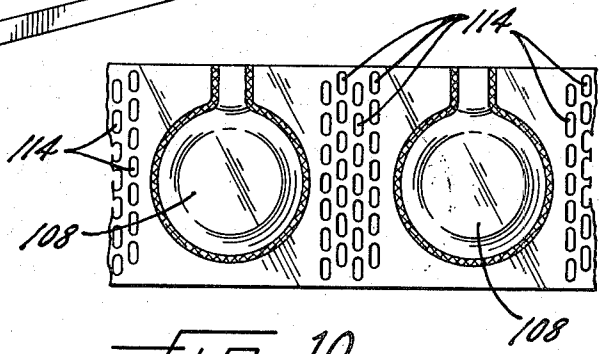


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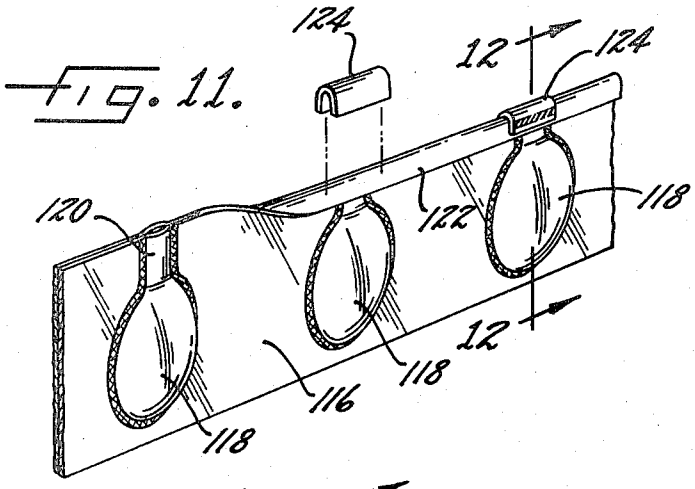


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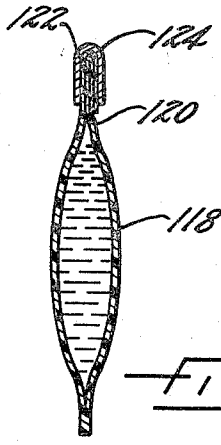


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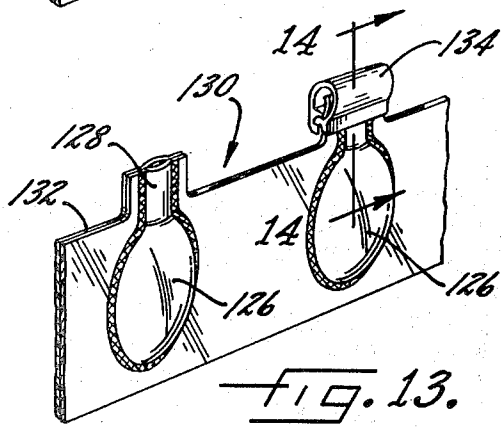


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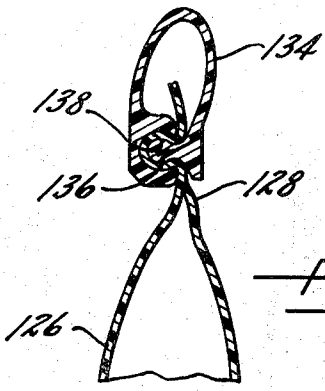


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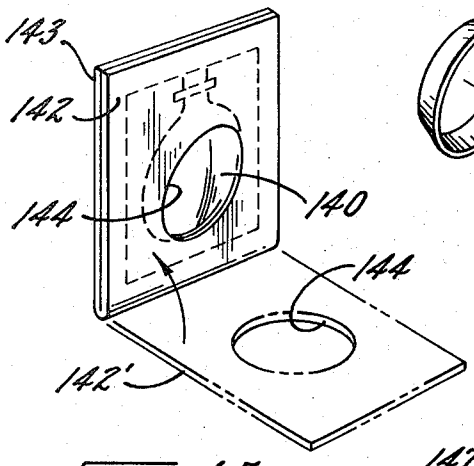


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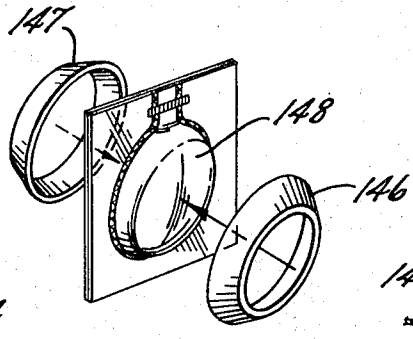


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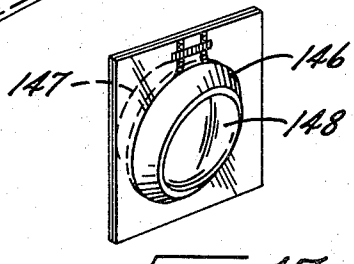


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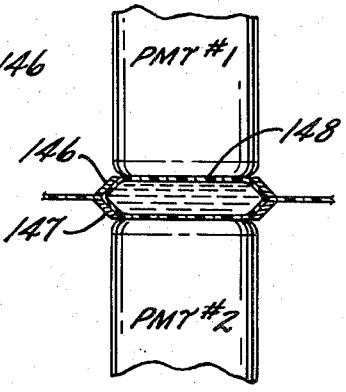


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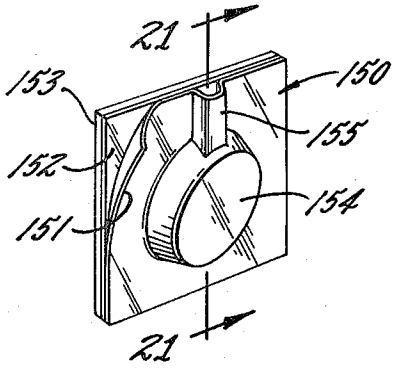


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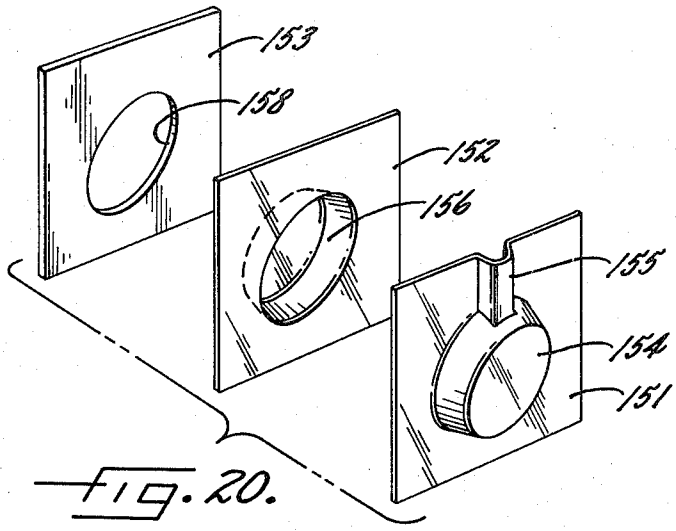


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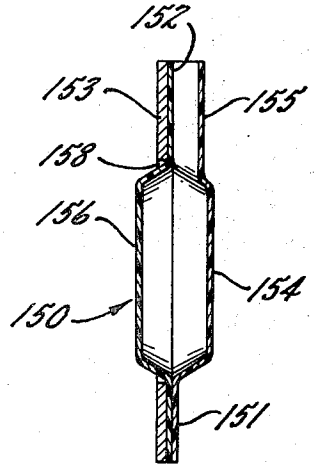


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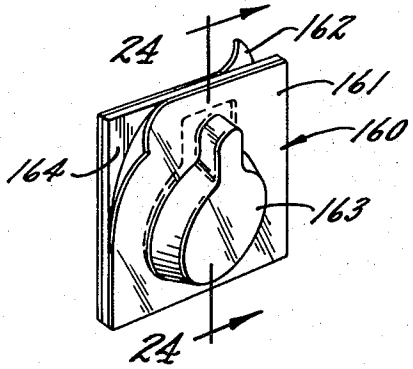


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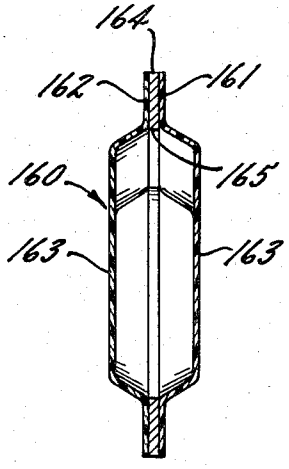


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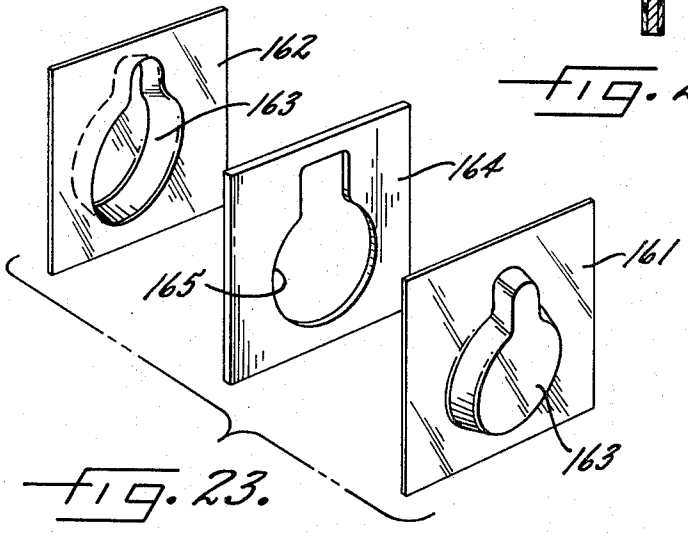


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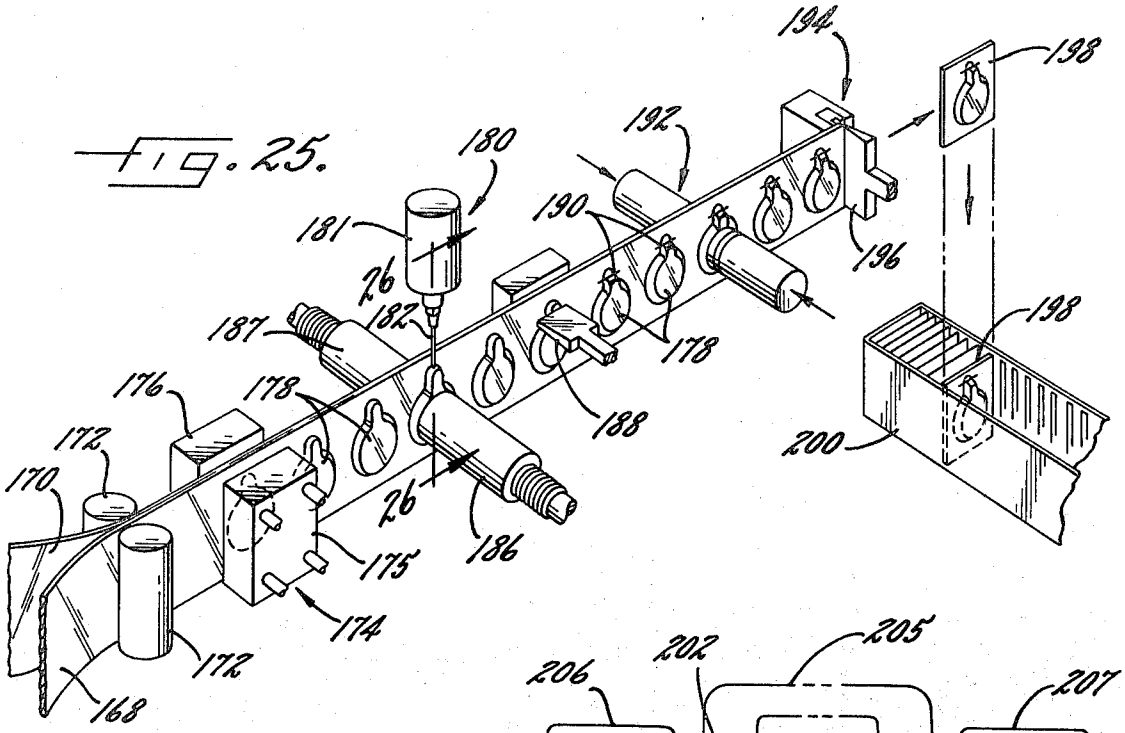


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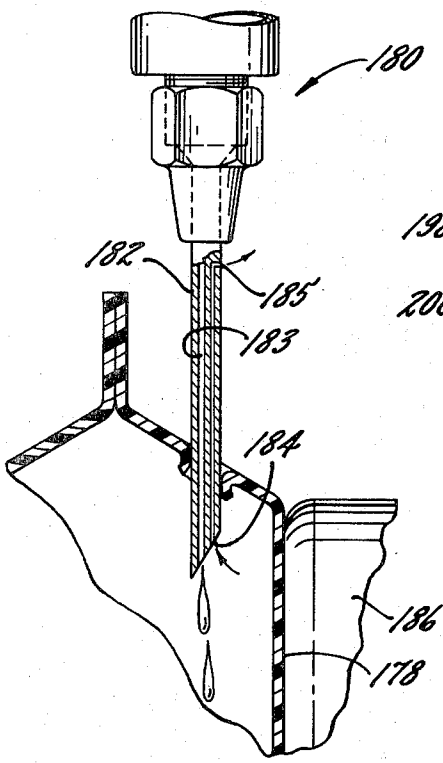


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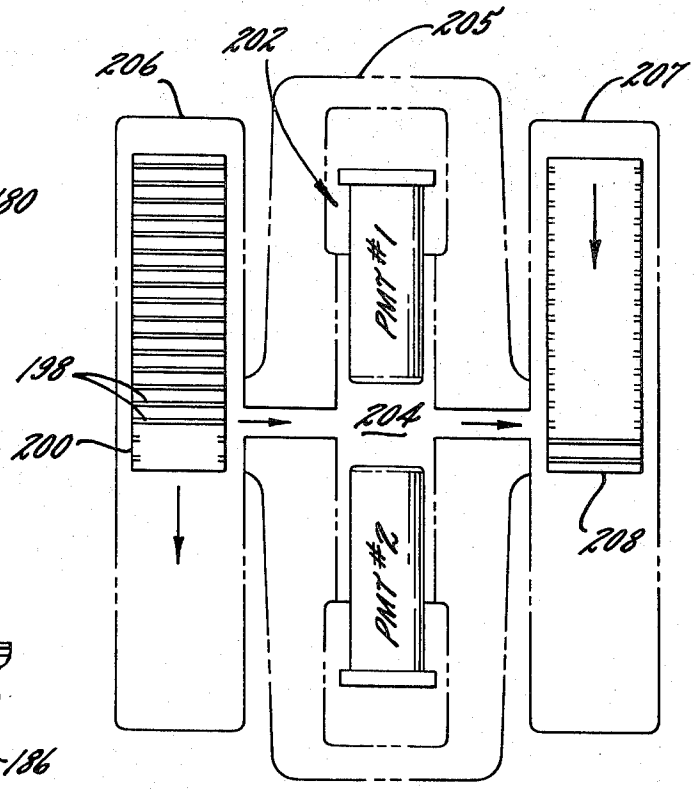


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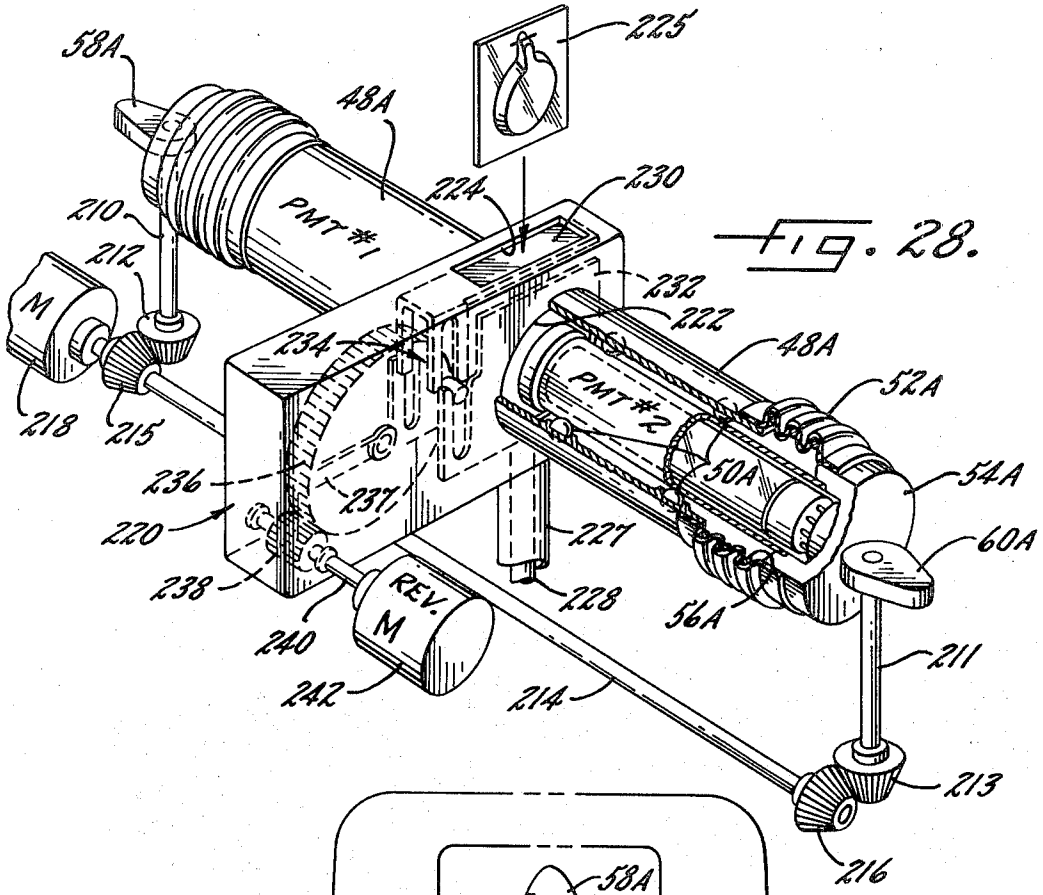

58A
225
48A
224
230
210
PMT #1
212
M
232
222
234
48A
PMT #2
52A
218
215
50A
54A
236
237
220
227
60A
238
REV.
M
228
240
56A
211
242
214
213
216

Fig. 28.

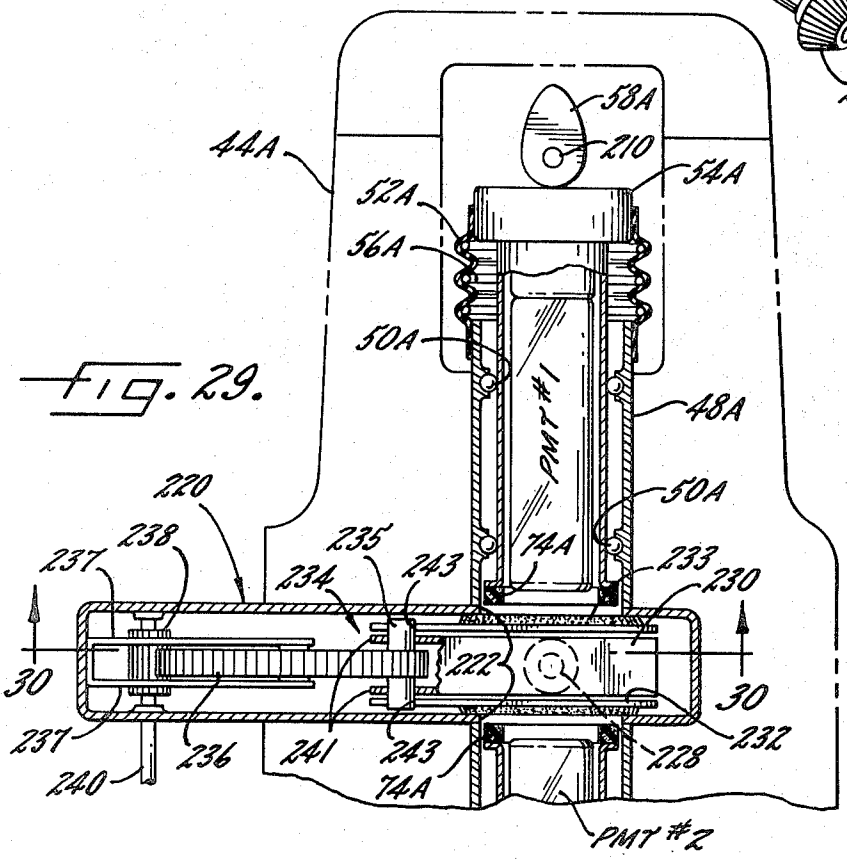

58A
210
44A
54A
52A
56A
50A
48A
PMT #1
220
50A
238
235
237
234
243
74A
233
230
30
222
30
237
236
241
243
228
232
240
74A
PMT #2

Fig. 29.

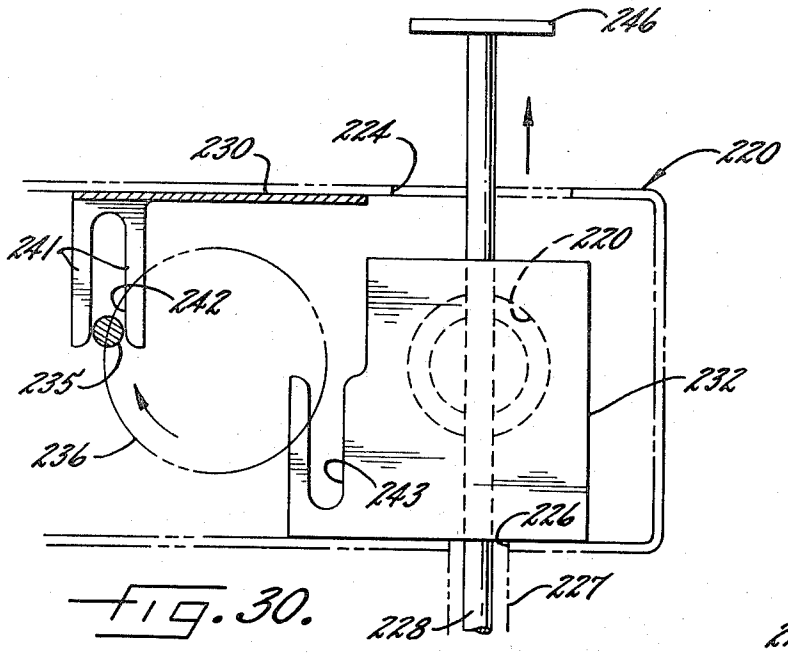


Fig. 30.

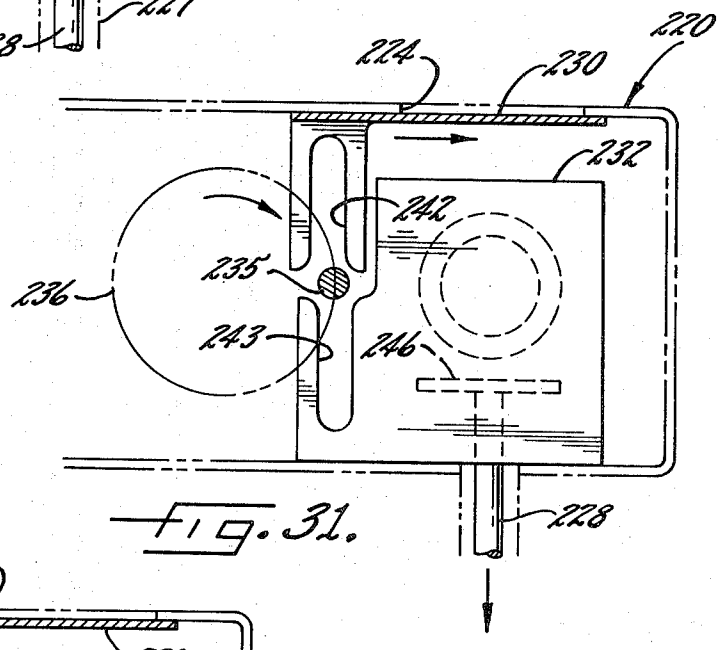


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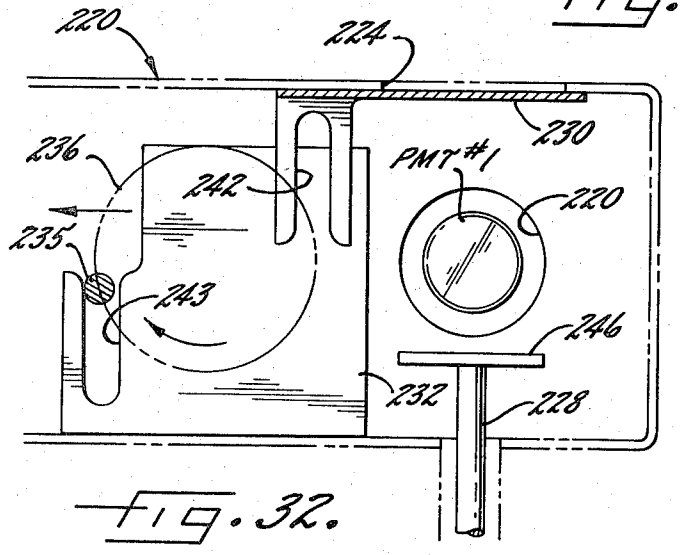


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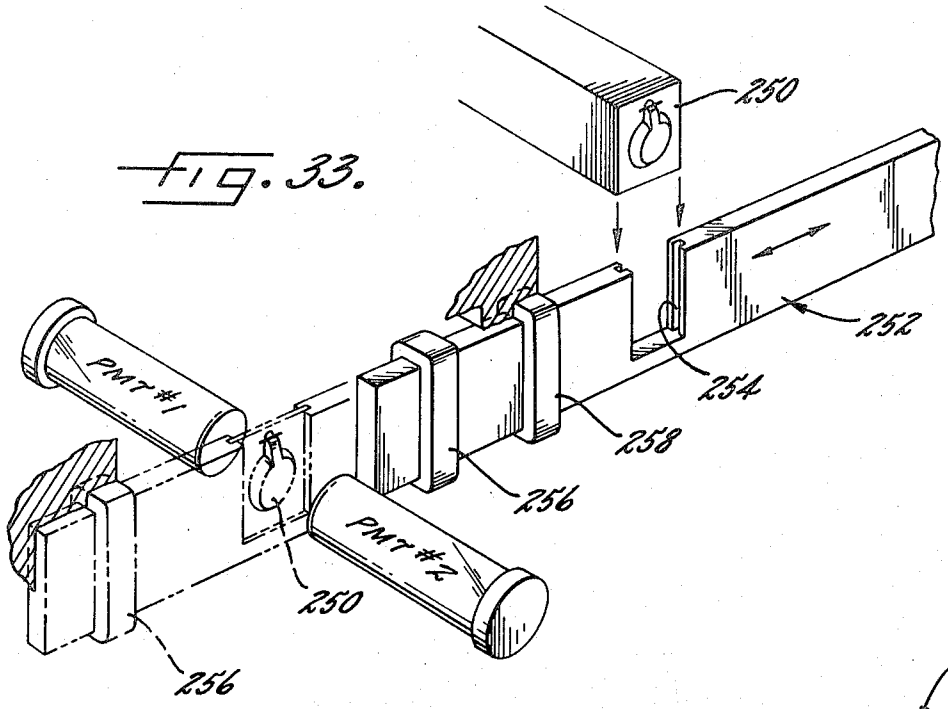

250
252
254
258
256
PMT #1
PMT #2
250
256

FIG. 33.

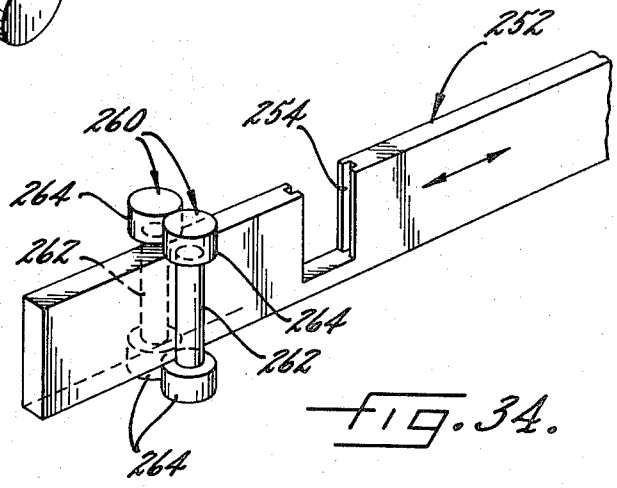

252
254
260
264
262
264
262
264

FIG. 34.

FLEXIBLE CONTAINERS FOR LIQUID SAMPLE SPECTROMETRY AND METHODS AND APPARATUS FOR FORMING, FILLING AND HANDLING THE SAME

DESCRIPTION OF THE INVENTION

This invention relates generally to flexible sample containers and apparatus for filling, forming and handling the same in liquid scintillation spectral analysis of test samples containing one or more radioactive isotopes disposed in a liquid scintillator. More particularly, the invention relates to improved flexible sample containers and filling, forming and handling arrangements for such flexible sample containers in individual or strip form and which readily lend themselves to fully automatic operations.

BACKGROUND AND OBJECTS

Flexible sample containers for liquid scintillation spectral analysis of test samples containing one or more radioactive isotopes disposed in a liquid scintillator and methods and apparatus for handling the same are described and claimed in the copending application of Lyle E. Packard and Ariel G. Schrodt, Ser. No. 192,543 filed Oct. 2, 1971 and assigned to the assignee of the present invention. Such flexible containers comprise a flexible bag formed in layered polyester films which are heat sealed, welded or otherwise joined to define a closed flask between the layers. The aforesaid copending application of L. E. Packard et al. further describes and claims methods and apparatus for utilizing such flexible containers for liquid scintillation detection operations in a wholly automated manner.

It is therefore, the general object of this invention to provide improved flexible sample containers and mechanisms for filling and handling such containers for spectral analysis of test samples confined therein, characterized in that such containers and mechanisms are relatively simple and low in cost of production, yet maintain the high degree of counting efficiency required in liquid scintillation spectrometry. Another objective of the invention is the provision of flexible containers which may be produced in a continuous strip wherein barriers are provided between individual sample holding portions of the strip to prevent light piping between samples during counting.

A more specific object of the invention is to provide procedures and apparatus for filling and sealing flexible sample containers which are characterized by their simplicity and reliability and wherein the filling and sealing may be done in a rapid production-like manner.

It is still a further object of the invention to provide low cost flexible sample containers that may be produced as a continuous strip, yet separated into individual containers for storage and handling with sample changing and counting apparatus. In this connection, it is a related object of the invention to provide improved apparatus for spectral analysis of test samples in flexible sample containers of the foregoing type.

DESCRIPTION OF DRAWINGS

Other objects and advantages of the invention will become apparent as the following description proceeds, taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a front sectional view of an exemplary radioactive sample handling and measuring apparatus, housed in a suitable cabinet and depicting the handling of flexible containers in accordance with the present invention;

FIG. 2 is an enlarged fragmentary view taken of the counting station of the apparatus in FIG. 1 illustrating light piping prevention means in the form of annular seals associated with the photomultiplier tubes and here showing the tubes brought into contact with the container in the counting station;

FIG. 3 is a diagrammatic illustration of an exemplary arrangement for preparation of a continuous strip of flexible sample containers;

FIG. 4 is an enlarged perspective view of a portion of a strip of containers shown in FIG. 3, here depicting one form of light piping prevention barrier between the container portions of the strip;

FIG. 5 is an enlarged, fragmentary top plan view of the flexible containers of FIG. 4;

FIG. 6 is a perspective view showing a portion of a strip of another form of flexible containers;

FIG. 7 is a view taken along the line 7—7 in FIG. 6;

FIG. 8 is a diagrammatic illustration of an arrangement for producing the flexible containers of FIGS. 6 and 7;

FIG. 9 is a view in perpective of yet another strip form of flexible containers;

FIG. 10 is a front plan view of still another strip form of flexible containers;

FIG. 11 is a view in perspective of yet another strip form of flexible containers adapted to be closed with closed clips;

FIG. 12 is a transverse sectional view taken along the line 12—12 in FIG. 11 and here depicting a crimp clip in sealing position;

FIG. 13 is a view in perspective of another strip form of flexible containers having a clip for sealing;

FIG. 14 is an enlarged fragmentary sectional view of a container of FIG. 13 sealed with a clip;

FIG. 15 is a view in perspective of an individual flexible sample container shown in a rigid mount and depicting the folding that takes place to complete the mount;

FIG. 16 is an exploded view in perspective of an individual form of flexible container and reflection rings provided therefor;

FIG. 17 is a view of the container FIG. 16 with the rings in place;

FIG. 18 is a fragmentary diagrammatic view showing the flexible sample containers of FIGS. 16 and 17 disposed between a pair of photomultiplier tubes;

FIG. 19 is a view in perspective of yet another form of flexible container construction having rigid support means integrally formed therewith;

FIG. 20 is an exploded view of the components of the flexible container of FIG. 19;

FIG. 21 is an edge view of the flexible container of FIG. 19;

FIG. 22 is a perspective view of yet another form of flexible container with rigid support disposed between a pair of sheets;

FIG. 23 is an exploded view of the container of FIG. 22;

FIG. 24 is a view taken along the line 24—24 in FIG. 22;

FIG. 25 is a diagrammatic view illustrating the process sequence of making, filling and stacking individual flexible containers embodying features of the present invention;

FIG. 26 is a fragmentary view of the filling station of FIG. 23, here depicting the injection means for inserting samples into the container;

FIG. 27 is a diagrammatic representation of an alternative form of detector apparatus adapted to handle individual flexible sample containers;

FIG. 28 is a view in perspective of a detector module, showing the shutter operating mechanism and sample container elevator;

FIG. 29 is an enlarged fragmentary view, partly in section showing the details of an axially shiftable photomultiplier tube mounting;

FIGS. 30, 31 and 32 are diagrammatic representations, respectively, of a cycle of operation of the shutters and elevator for an exemplary detection apparatus; and

FIGS. 33 and 34 are alternative arrangements for shuttering containers into a counting station while sealing against entry of ambient light.

While the invention is susceptible of various modifications and alternative forms, specific embodiments thereof have been shown by way of examples in the drawings and will herein be described in detail. It should be understood, however, that it is not intended to limit the invention to the particular forms disclosed, but, on the contrary, the intention is to cover all modifications, equivalents and alternatives falling within the spirit and scope of the invention as expressed in the appended claims.

GENERAL APPARATUS ARRANGEMENT

Referring to FIG. 1, there is illustrated a liquid scintillation apparatus, indicated generally at 40, which houses a scintillation detector mechanism or apparatus 42. The detection apparatus of FIG. 1 is detailed in the aforementioned copending application of Lyle E. Packard and Ariel G. Schrodt, Ser. No. 192,543 filed Oct. 2, 1971. In brief, the detection apparatus 42 as viewed in FIG. 1, includes a base assembly 44 which houses a pair of photomultipliers PMT No. 1, PMT No. 2 disposed on opposite sides of a counting station 46.

The photomultipliers PMT No. 1, PMT No. 2 are preferably mounted so as to permit controlled simultaneous movement toward and away from the counting station 46. To this end, in the present exemplary arrangement the photomultiplier tubes are slidably carried in tubular guides 48 with ball bearing mounts 50. Light-tight bellows 52 interconnect the guides 48 with the photomultiplier tube sockets 54. The bellows contain compression springs 56 to normally bias the tubes outwardly from the counting station 46.

In order to effect the controlled simultaneous movement of the photomultiplier moves toward one another along a common axis, there is provided a pair of cams 58, 60 acting respectively upon the sockets 54 of photomultiplier tubes PMT No. 1 and PMT No. 2. A suitable actuating mechanism (not shown) rotates the cams 58,60 to act upon the sockets and drive the photomultiplier tubes toward each other which, as more fully discussed below, permits close optical coupling with sample containers in the counting station 46.

FLEXIBLE CONTAINER ARRANGEMENT

As shown in conjunction with FIG. 1, the sample containers utilized with the apparatus 40 are in the form of a continuous strip 62 of flexible bags 64. For details of the flexible sample container construction, reference is made to the aforementioned copending L. E. Packard et al. application Ser. No. 192,543. For the purposes of this application it should suffice to say that the flexible sample containers 64 are produced from layered light-transmissive polyester film strips which are heat sealed, welded or otherwise suitably joined to define a closed flask-like portion between the layers. The flask-like portion has provision for injecting test samples into the closed chamber therein and is sealable to confine the sample in the bag portion without leakage.

In its preferred form, the bag is circular in the plane of the layers with a diameter closely approximating the diameters of the photomultiplier tubes so that there is comformity with the round photomultiplier tubes to provide the optimum counting geometry for the container structure.

FLEXIBLE CONTAINER TRANSFERENCE AND HANDLING

With the provision of a continuous strip of flexible containers, compact storage on a reel 66 (FIG. 1) is possible and the transference of the sample through the detector apparatus involves a passing of the strip from reel 66 to reel 68, the latter being shown as manually operated through crank handle 70. During the time when the containers are being shifted into and out from the counting station 46, the photomultiplier tubes PMT No. 1 and PMT No. 2 are in the retracted, axially spaced apart position. When the particular container 64 holding the test sample to be analyzed is in the counting station, the photomultiplier tubes are then moved axially together until they are in intimate contact with the outer faces of the container (FIG. 2).

The photomultiplier tubes are brought together with sufficient pressure so as to "squeeze" the flexible container therebetween causing the outer walls of the container to conform with the faces of the photomultiplier tubes. With this arrangement, an extremely close optical coupling results which minimizes lost light at the contact surfaces of the container and tubes and high quantitative accuracy of liquid scintillation counting results.

OPTICAL ISOLATION

In accordance with one of the aspects of the present invention, provision is made in respect of the apparatus and the flexible sample container bags or both to avoid light "piping" (transmission of light through the film material) and to provide optical isolation from sample containers adjacent to the containers in the counting station. To this end, the photomultiplier tube guides 48 are provided with flanged ended portions 72 to which there is mounted soft annular sealing rings 74 which coaxially contact opposite sides of the interconnecting strips or borders between the container bags. The sealing rings exclude outside light from entering the detector counting station when the tubes are in the axially together position as shown in FIG. 2, in addition to confining light generated with the photomultiplier tubes from passing through the film layers themselves into

the sample storage enclosures on either side of the counting station.

Elimination or reduction to tolerable minimums of light "piping" through the interconnecting strip material of the containers is accomplished by the provision of light piping prevention means formed on the container strip web or border which may act in cooperation with the soft sealing rings. To this end, referring to FIGS. 4 and 5, conjointly, there is illustrated one form of light piping prevention means which comprises an embossed area 76 on web 62 between respective adjacent sample containers 64.

The embossment 76, whqch may be achieved by conventional embossing rolls or dies provides a zig-zag, non-planar path that prevents light from being transmitted directly through the web into adjacent sample containers by portions of the continuous strip. The soft annular sealing rings, discussed above, in connection with the photomultiplier tube sleeves will conform themselves with the raised and indented portions of the embossments to provide a more effective seal against entry or loss of light.

a. Fabrication of bi-layered Containers

In order to generate a continuous strip of sample containers of the type described above, a system such as that illustrated in FIG. 3 may be utilized. The arrangement is such that a pair of rolls 78 of wound polyester film strip supply the strips as they are unwound. The strips 80,81 are flattened against each other as they pass through gathering rolls 82,83 before passing into the heat sealing and embossing apparatus 84.

The exemplary heat sealing and embossing apparatus 84 is shown in the form of a pair of cooperating heated dies 85, 86, the latter of which is shiftable by a servo mechanism 87 or the like to clamp the film strip layers between the dies for simultaneously effecting the heat sealing and embossing operations. Controlled intermittent movement of the film strips and actuation of the heat sealing apparatus produces a plurality of the flask-shaped containers 64 separated by embossments 76 and the strip of containers is then wound into a roll 88 for compact storage in readiness to be filled with test samples.

b. Multi-layered Containers

Referring now to FIG. 6, there is shown a slightly modified form of flexible container arrangement for handling liquid samples for scintillation spectrometry wherein instead of two film layers being provided, the container strip is formed from three layers. The layers include a pair of outer transparent or light transmissive layers 90,91 bonded or sealed to an inner opaque layer 92 (FIG. 7). The flask or bag portion 91 defining the sample containers is formed from a cut-out in the central opaque strip such as that defined by the centrally disposed circular cut-out 95 and the filling opening cut-out 94.

The surface area of the outer strips surrounding the defined container portions 91 being heat sealed or bonded to the inner opaque strip are left with a roughened surface 96 which renders them opaque to prevent light piping between the sample container bag through interconnecting material of the strip.

c. Fabrication of Multi-layered Containers

Referring to FIG. 8, there is shown exemplary forming system arrangement for producing the continuous flexible container strip of FIGS. 6 and 7. As shown in FIG. 8, the opaque strip 92 is moved intermittently along a straight path from a source (not shown) to a take up shaft 93. During its movement, the strip 92 first passes through a punch 98 which cuts out the key-hole shaped opening 100 at predetermined spaced intervals along the strip. Next, the strip 92 is sandwiched between strips 90,91 supplied from rolls 101,102, respectively prior to passing between gathering rollers 104. The tri-layered strip after emergence from the gathering rolls passes through a sealing and cutting apparatus 105 which joins the outer strips 90,91 to the opaque strip 92 and trims the top border leaving a neck-like opening in the flasks.

d. Alternative Optical Isolation Arrangements

Turning now to FIG. 9, there is illustrated another form of light transmission or light piping prevention means for the flexible sample container arrangements similar to those shown in FIG. 4 and FIG. 6. In the present instance, the sample containers are again in the form of flexible bags made up of layered, light-transmissive polyester film joined to define closed flasks between the layers. The top and bottom borders 109, 110 are opaque through the provision of embossments, metallized strips, or magnetizable strips such as that described in copending application Ser. No. 192,543.

In order to prevent light transmission through the layered film borders on opposite sides of the sample bag portion, elongated transverse slots 112 are formed in the layered borders adjacent to the bags 108. The slots 112 provide discontinuities in the path of light travel through the film layers.

A still further modification is illustrated in FIG. 10 where instead of one slot, there is provided a plurality of rows of spaced slots 114. The slots of each row are staggered with respect to the slots of an adjacent row or rows so that a straight path of travel for light is avoided. The slots also add more flexibility to the strip for handling and storage in a rolled form.

e. Container Sealing

Referring now to FIG. 11, there is illustrated a portion of a continuous strip of flexible sample containers 116 having a plurality of flask-shaped bag portions 118 therein and provided with neck filling openings 120. After the bag portions have been filled with the test samples, the neck portions may be heat sealed or otherwise joined to provide a liquid tight seal against escape of the test samples. However, in FIGS. 11 and 12 there is shown an alternative arrangement for sealing the containers which provides an effective seal yet allows the containers to be easily unsealed for removal of the samples therefrom.

To this end, the edge portion 122 of the strip containing the necks 120 is folded over and a crimp clip 124 is clamped over the folded portion overlying the container filling neck. The clip 124 may be made of any suitable material such as a soft metal which is sufficiently ductile to tightly clamp the bent over film portions of the container with crimping operations or the like.

Referring to FIGS. 13 and 14, conjointly, there is illustrated another form of removable clip adapted to seal the filling neck portion of flexible sample containers such as those indicated at 126 in FIG. 13. In the present instance, portions of the film border material intermediate that containing the neck portions 128 of the containers 126 have been cut away, as indicated generally at 130, so that the neck portions 128 project

outwardly from the top edge **132** of the container strip. The clip **134** is formed of a resilient material such as plastic and has a generally U-shape with a corresponding protuberance **136** and socket **138** on the inside of the leg portions thereof. The arrangement is such that when the clip is placed over the protruding meck portion **128** and the protuberance **136** is snapped into the socket **138** it tightly clamps the container neck portion **128** between the protuberance and socket to prevent escape of the liquid sample in the container bag portion.

f. Mounted Flexible Sample Container

It will be appreciated that the flexible sample containers as discussed above may be handled individually as well as on a continuous strip. Thus, in accordance with another aspect of the present invention, provision may be made for mounting an individual flexible sample container in a rigid frame which offers yet another mode of storing, handling and transporting the containers. In the exemplary arrangement shown in FIG. **15**, an individual flexible container **140** is sandwiched between a pair of rigid layers **142, 143** that may be made of a single piece of stock folded over such as indicated at **142'**. The rigid material may be polyethylene coated cardboard or the like with cut-out openings **144** (only one being shown) to permit the bag portion **140** to protrude through the opening after assembly.

g. Increased Light Collecting Efficiency

In carrying out another aspect of the present invention provision may be made with respect to the flexible container bag portions for further increasing the light collecting efficiency with the use of the containers. In carrying out this aspect of the invention, annular members **146, 147** or the like of light reflective material are placed about the peripheries of the bag portions **148** (FIGS. **16** and **17**). The annular members may be any suitable light reflective material such as aluminized film or opaque white film. In the alternative it will be appreciated that instead of using separate members a reflective coating may be applied about the periphery of the bag portion so that the reflective surface is formed in situ.

Referring to FIG. **18**, it will be seen that when the sample container of FIG. **17** is disposed between a pair of photomultiplier tubes PMT No. **1**, PMT No. **2** the tube faces engage the outer surfaces of the container bag portion and the peripheral portions thereof containing the light reflective members **146** cover the sides of the bag and provide sloped reflective surfaces which serve to reflect light emitted by the photomultiplier tubes back into the liquid sample rather than allowing it to pass out through the side wall of the container.

h. Formed Containers

In the prior described flexible container arrangements, the bag portion which holds the liquid sample was simply defined by a joining or sealing of the layered polyester film leaving the enclosed flask-like chamber between the layers for holding the sample. Ordinarily, this arrangement provides a sufficient volume for liquid test sammples according to the area between the joint formed in the layers. Where it is desired to have a sample container which will carry a still larger volume of test sample but without increasing the lateral dimension of the bag portion, and in accordance with still another aspect of the present invention, the flask portion may be bulge formed in the direction perpendicular to one or both of the film layers.

As illustrated in FIG. **19**, sample container **150** includes polyester film layers **151,152** and a rigid mount layer **153.** A portion of the flask **154** and filling neck **155** are bulge formed in the layer **151** (FIG. **20**) and the rigid layer **153** is provided wiith an opening **158** to permit protrusion of the bulged portion **156** of layer **152** therethrough (FIG. **21**).

Referring to FIGS. **22,23,** and **24,** conjointly, there is shown another form of molded flexible container arrangement **160** wherein outer layers **161,162** include bulged flask portions **163** and an intermediate rigid layer **164** is sandwiched between inner and outer layers **161,162.** The rigid layer **164** disposed between the film layers is provided with a cut-out **165** corresponding in shape to the flask-shaped bulged portions **163** of the outer layer.

FORMING, FILLING AND HANDLING INDIVIDUAL FLEXIBLE SAMPLE CONTAINERS

Turning now to FIG. **25,** there is illustrated an exemplary system for forming, filling and arranging individual flexible sample containers in a continuous production-like manner. In the system, a pair of polyester film strips supplied from respective sources (not shown) are merged together through the nip of gathering rolls **172** and then passed through a heat sealing forming station and which effects the formation of the flask-like containers **178** in the strip. The forming unit **174,** for example, includes vacuum forming dies **175,176** that bulge the container walls outwardly at the same time that the heat seal joint is formed. The layered strip moves intermittently so that each of the operations takes place while the strip is at rest.

After formation, the containers **178** are advanced to a filling station **180** wherein liquid sample from a source **181** is injected into the container with a hollow needle **182.** As best shown in FIG. **26,** the needle **182** is adapted to penetrate the neck portion of the container **178** and inject the liquid sample through a hollow opening **183.** In order to permit air inside the container **178** to escape during filling, the needle is provided with a vent including an opening **184** disposed longitudinally within the needle and an interconnecting transverse outlet port **185** which permits the escaping air to pass to the atmosphere.

In the production line filling station, a pair of reciprocatingly actuated plungers **186,187** are provided on opposite sides of the container strip and arranged to apply a pressure to the container faces that stiffens the flask portions to allow for penetration of the needle.

Following the filling operation, the filled containers advance to a heat sealing station wherein a heat sealing head **188** transversely oriented with respect to the neck of the flask shaped container seals the neck as indicated at **190** beneath the opening left by the filling needle.

The filled, sealed, sample containers are then moved to a pressure test station **192** wherein a predetermined compressive pressure load is applied to test for leakage and the ability to withstand pressures which correspond substantially to that of the load applied by the photomultiplier tubes when they compress the flask during counting.

The container strip then moves to a cutting station **194** wherein a cutter **196** severs the layered film between filled flasks to form individual containers **198**

which are then placed in proper order in a compartmentalized holding tray **200** or the like.

Turning to FIG. **27**, there is illustrated diagrammatically a liquid scintillation apparatus, indicated generally at **202**, which may be utilized for spectral analysis of the test samples stored in containers **198** held within tray **200**. The detection apparatus **202**, as that described in connection with FIG. **1** above, includes a pair of axially shiftable photomultiplier tubes PMT No. **1**, PMT No. **2** disposed on opposite sides of a counting station **204** within a light tight housing **205** (shown in phantom). The loaded tray **200** is inserted within a sealed sample source supply chamber **206** adjacent the input side of the detector and a sealed sample receiving chamber **207** attached to the housing **205** adjacent the output side of the detector holds a tray **208** which is initially empty and receives the sample containers after testing.

The trays **200** and **208** are mounted so as to move transversely with respect to the axis of the detector counting station so that the supply tray **200** places the sample containers in position for transference to the counting station and the receiving tray **208** provides an empty space for receipt of the sample container which has been tested.

Instead of passing the sample containers from a tray in the source chamber completely through the detector apparatus to the receiving tray, provision may be made for transferring containers individually to the counting station and returning the container after counting to the tray from which it came. Referring to FIG. **28**, there is shown an exemplary detector counting station and transfer arrangement with photomultiplier tubes mounted for axial shifting toward and away from the counting station similar to that described in connection with FIG. **1**. For convenience, the corresponding components previously described in connection with FIG. **1** have been indicated by the same reference numerals followed by the letter "A."

In order to shift the photomultiplier detection device axially toward the counting station, cams **58A**, **60A** are driven by their respective shafts **210**, **211** and geared to **212**,**213** through drive shaft **214** carrying gears **215**,**216** from a motor **218**.

A rectangular box-like housing transversely disposed between the photomultiplier tube guides **48A** and secured thereto define the counting station. As best shown by references to FIGS. **28**,**29**, and **30**, conjointly, the housing **220** has side openings **222** to permit entry of the photomultiplier tubes, a top opening **224** for entry of the sample container **225** and a bottom opening **226** coupled to a tube or sleeve **227** through which an elevator shaft **228** passes. For details of an elevator operating arrangement and control therefor, reference is made to L. E. Packard U.S. Pat. No. 3,188,468 issued June 8, 1965.

Pursuant to the invention, the counting station housing **220** is provided with a shutter arrangement to permit entry of a sample container while excluding light from the photomultiplier tubes and after the sample has entered the counting station to close off the top opening to exclude ambient light, and then open the side openings permitting entry of the photomultiplier tubes into the counting station.

To this end, a slidable sample entry opening shutter **230** is positioned beneath the sample entry opening **224** and a pair of shutters **232**,**233** are positioned adjacent the photomultiplier tube entry openings **222**. The entry opening and tube opening shutters are alternately shifted between their open and closed positions by means of a pin and slot leakage arrangement, indicated generally at **234** (FIG. **29**). The pin **235** is transversely carried adjacent the periphery of a gear **236** mounted on brackets **237** connected to the box **220**. To drive the gear **236**, a pinion gear **238** meshed therewith is carried by shaft **240** journaled in the box **220** and rotated from the outside of the box by a reversible motor **242** (FIG. **28**).

The shutter **230** includes depending legs **241** with slots **242** therein arranged perpendicular to the axis of pin **235** carried by gear **236**. Similarly, the shutters **232** include slots **243** arranged perpendicular to the axis of pin **235**.

In order to more fully understand the operation of the shutter operating mechanism reference is made to FIG. **30** wherein it is shown in a cycle "start" position in that shutter **230** is retracted and elevator **246** is in its upward position for receipt of the sample container to be counted. Gear **236** is rotated to a position wherein pin **235** enters the slot **242** of top opening shutter **230** depending legs **241**. The side opening shutters **232** are in a closed position to the right as viewed in FIG. **30** so that they cover the photomultiplier tube entry openings.

The elevator carrying the sample container (not shown) at this point moves downwardly until the sample container is positioned within the box **220** between the photomultiplier tubes. Gear **236** with pin **235** continues to rotate clockwise through an angle of approximately 180° driving shutter **230** to the right to where it is shown in FIG. **31**. At this point the top entry opening is sealed with the container held in position in the counting station by elevator **246**.

Gear **236** with pin **235** still continues to rotate clockwise with pin **235** entering slots **243** of shutters **232** and after approximately 180° rotation the shutters **232** are moved to the left as shown in FIG. **32** and the photomultiplier tubes may then be moved axially toward the container in the counting station.

After counting has been completed the tubes retract and gear **236** with pin **235** rotate in the opposite or counterclockwise direction first closing shutters **232** and then opening shutter **230** in successive 180° angles of rotation. When shutter **230** has been opened, elevator **246** may then move upwardly and the shutters and elevator are back in the positions shown in FIG. **30** in readiness for another cycle.

Turning to FIG. **33**, there is shown another modified arrangement for transferring individual sample containers **250** into a counting station between a pair of axially shiftable photomultiplier tubes PMT No. **1**,PMT No. **2**. In the present instance, there is provided a sliding shuttle bar **252** having a slotted opening **254** therein adapted to receive a sample container. The shuttle has a first sealing ring **256** which may be made of felt or the like fixedly mounted adjacent the end toward the counting station and a second sealing ring **258** which may be slidable with respect to the shuttle so that when the shuttle moves a sample container into the counting station as shown in phantom in FIG. **33**, the sealing rings are disposed on opposite sides thereof to prevent entry of ambient light.

As an alternative to the sliding, sealing ring, there is shown in FIG. **34** a pair of resilient rollers **260** which

provide a rotatable seal permitting the shuttle to pass between the nips thereof while preventing entry of light to the counting station. The rollers include a shaft-like central portion **262** of a first diameter and end portions **264** of a larger diameter. The central portion rollers are of a length corresponding to the height of the shuttle along the vertical axis as viewed in FIG. **34** while the end portions **264** overlap and engage one another approximately at the middle of the width of the shuttle along the horizontal axis.

I claim as my invention:

1. In a sample container for liquid scintillation spectrometry analysis including at least a pair of layers of flexible, light-transmissive, polyester film,

means defining a joint between said layers to form an enclosed bag portion for holding said liquid sample,

means for filling said bag portion,

the filling means being sealable when the bag portion is filled with sample to form the liquid tight seal with said sample within the container bag portion, the improvement comprising,

annular light reflective means disposed about the periphery of said bag portion and the central portion of said bag remaining light-transmissive.

2. A flexible sample container as claimed in claim **1** wherein said light reflective means is disposed on both sides of the bag portion.

3. A flexible sample container as claimed in claim **1** wherein said light reflective means is an aluminized film member secured to said bag portion.

4. A flexible container as claimed in claim **1** wherein said reflective means comprises an opaque white film member secured to said bag portion.

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