

Dec. 8, 1970

V. W. DRYDEN ET AL

3,545,934

CHEMICAL PACKAGE

Filed Oct. 3, 1968

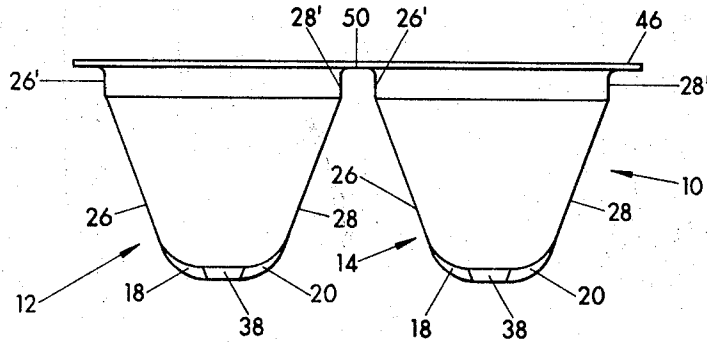


Fig. 1

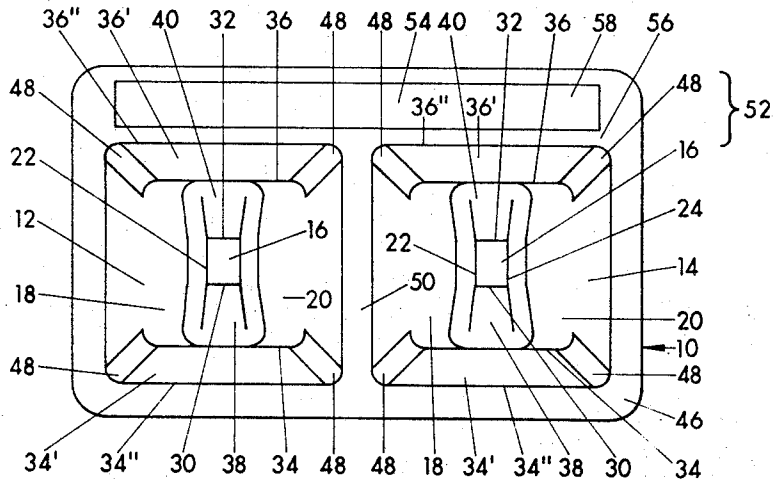


Fig. 2

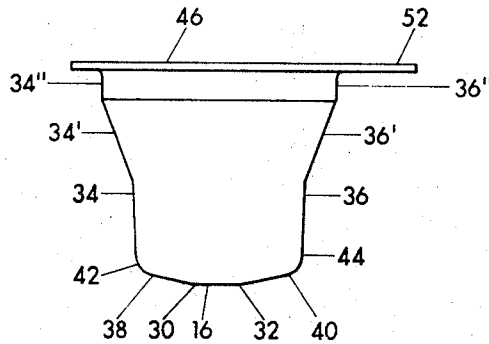


Fig. 3

INVENTORS:

VERNON W. DRYDEN

DONALD L. JOHNSTON

BY:

Joseph Hirsch
ATTORNEY

1

3,545,934

CHEMICAL PACKAGE

Vernon W. Dryden, Pasadena, and Donald L. Johnston, Arcadia, Calif., assignors to Xerox Corporation, Rochester, N.Y., a corporation of New York

Filed Oct. 3, 1968, Ser. No. 764,850

Int. Cl. B011 3/00; G01n 33/16

U.S. Cl. 23—253

47 Claims

ABSTRACT OF THE DISCLOSURE

This application relates to the lower reaction compartment section of a disposable reaction container having a unique configuration adapted to promote coupling of the ultrasonic energy from an ultrasonic generating means adjacent thereto with materials held within the reaction compartment. The unique design includes a flat portion at the bottom of each reaction compartment, and upwardly extending bottom wall portions connecting said flat portion to the four side walls of the reaction compartment whereby said flat portion is positioned as the lowest point within the reaction compartment. Solid materials, especially in tablet form, added to the reaction compartment will be preferentially positioned over the flat portion such that highly effective coupling is attained when the flat portion is properly positioned over the adjacent ultrasonic generating means.

BACKGROUND OF THE INVENTION

This invention relates to automatic chemical analysis and, more particularly, to the automatic chemical analysis of body fluids, such as blood, urine, etc.

In copending application Ser. No. 602,025 filed Dec. 15, 1966, now U.S. No. 3,504,376, there is disclosed an automated chemical analytical system including a plurality of different disposable reaction containers, a magazine for the storage of the plurality of different reaction containers, a station for the addition of sample material to the reaction container, a mixing and incubation station wherein the reaction mixture is maintained in the disposable container for a period of time sufficient to culminate the chemical reaction, a detection station wherein the analytical data is obtained by monitoring one or more of the physical properties of the reaction mixture, a disposal station wherein the disposable reaction container is eliminated from the system, and means to transport the disposable reaction container from its storage area in the magazine through the system to the disposal station. The heart of the system is the disposable reaction container which, in its broad aspects, has at least one lower compartment for the admixing and reaction of reagents and sample, and an upper section having a plurality of reagent storage chambers in communication with each reaction compartment. At least one wall or end portion of the reaction compartment may be optically transparent so that upon completion of the desired chemical reaction the compartment can be utilized as a cuvette for optical analysis. Optionally, none of the walls need be optically transparent as a probe photometer, such as the one disclosed in Gale 3,164,663, may be inserted into the reaction mixture and electromagnetic radiation from a source passed through a radiation conductor, the reaction mixture and back through the radiation conductor to a detection means, without the necessity of passing through the compartment walls.

In copending application Ser. No. 602,018 (also filed Dec. 15, 1966), and now U.S. No. 3,497,320 there is disclosed a similar, though conceptually and structurally different, analytical apparatus and system. The disposable

2

reaction container in this application has a flexible lower compartment, i.e., one having at least one flexible wall, so that during analysis a light source and a detection means pressed against the flexible wall or walls defining the lower cuvette(s) will cause the wall(s) to yield a distance sufficient to define a fixed optical path between the light source and the detection means through the reaction mixture. The automatic analytical apparatus includes monitoring means having a light source and a means responsive to the variations in light transmittance caused by different concentrations of a constituent under analysis in the reaction mixture. The light source and the responsive means are pressed against opposite sides of the reaction compartment or cuvette during analysis to define a fixed optical path through the reaction mixture. Thus, there is provided an automatic analytical apparatus having the optical path defining means built into the detection station.

In the practice of the analytical methods disclosed in either of the aforementioned copending applications, the reaction container can be mass produced and disposed of after use without significant cost.

In copending application Ser. No. 645,665 filed June 13, 1967, and now abandoned, there is disclosed a disposable reaction container of improved design. Specifically, the lower section of the disposable reaction container comprises positioned walls adapted to channel the material added thereto to a portion of the lower compartment defined by a substantially rectangular volume. Optionally, a still lower compartment can be provided for the storage therein of a magnetic stirring bar so that thorough mixing of added materials can be achieved through use of urging means magnetically coupled to said magnetic stirring bar.

In actuality, the provision of a magnetic stirring bar to thoroughly mix all materials added to the reaction compartment has not been totally satisfactory. Initially, the stirring bar has to be inert, or at least inert up to the time for final optical analysis, to the diverse chemical mixtures which will be formed in the disposable reaction containers during the course of analysis. Obviously, since it is contemplated that the automatic analytical system would be utilized in conducting numerous analytical tests, on the order of at least 15 to 20, it can be seen that such stirring bars would be subjected to various chemical mixtures, any of which might have some deleterious effect upon the stirring bar such that the analytical results might not be truly representative. It was, therefore, necessary to encase the magnetic member in an inert envelope. This was most easily achieved by taking a magnetic wire, coating it with an inert material and then cutting it into a plurality of small pieces corresponding to the magnetic stirring bar. This, in itself, was not entirely satisfactory since the ends of the magnetic wire were now exposed. These ends had to be protected thereby adding another operation and increasing the cost involved in the satisfactory production of this particular member.

From the disposable reaction container point of view, the contemplation of the use of the magnetic stirring bar necessitated the provision of a compartment for the storage thereof such that when it was not in use it would settle into that compartment. This would, if properly used, cause the magnetic stirring bar to be out of the optical path during analysis. On occasion, it was found that the stirring bar would not properly position itself in its storage compartment and thus would interfere with the analysis.

In use, it was found that the stirring bar had the tendency to scratch side walls of the reaction compartment thereby marring the optical window through which analysis was made. Among other things, this caused diffusion of the optical beam thereby adversely affecting the analytical results.

Because of these factors, other modes of mixing the materials added to the reaction compartment were investigated. One such mode was the use of ultrasonics which was found to be conceptually compatible though initially erratic in its mixing capabilities. More specifically, it was found that there was insufficient coupling between the ultrasonic transducer and the materials being mixed, normally a liquid and at least one tableted material. This insufficient coupling either increased mixing time to a point considered economically undesirable or prevented complete dissolution of the tableted materials. It has now been found that this coupling problem can be overcome by the proper design of the lower portion of the reaction compartments.

OBJECTS OF THE INVENTION

It is, therefore, an object of this invention to provide a novel disposable reaction container of improved design.

It is a further object of the present invention to provide a novel disposable reaction container suitable for use in an automated analytical system.

Yet a still further object of the present invention is to provide a novel lower reaction compartment section of a disposable reaction container, said novel lower section being suitable for use with ultrasonic mixing means for enhancing the mixing action of said means.

Yet a still further object of the present invention is to provide a novel disposable reaction container and, in particular, the lower reaction compartment section thereof, of such a design that it effectively couples the transducing action of an ultrasonic mixer thereby aiding in the rapid and substantial dissolution of tableted material into a liquid material held in contact therewith in the reaction compartment(s) defined thereby.

These and still further objects, features and advantages of the present invention will become apparent upon consideration of the following detailed disclosure of specific exemplary embodiments of the present invention.

SUMMARY OF THE INVENTION

Now in accordance with the present invention, there is provided a further improved disposable reaction container for use with the aforementioned analytical apparatus and systems. The improved disposable reaction container has a uniquely configured lower compartment section for the admixing and reaction of reagents and sample materials added thereto, the configuration of said lower section acting to promote enhanced coupling between an ultrasonic generating mixer adjacent thereto and the materials added to the reaction compartments. The unique design includes a flat portion at the bottom of each reaction compartment, and upwardly extending bottom wall portions connecting said flat portion to the four side walls of the reaction compartment whereby said flat portion is positioned as the lowest point within the reaction compartment. Solid materials added to the reaction compartment will be preferentially positioned over the flat portion such that highly effective coupling is attained when the flat portion is properly positioned over adjacent ultrasonic generating means.

At least the lower portion of one pair of opposite side walls are substantially vertical for a sufficient distance to permit the use of said vertical portions as optical windows through which analysis is made. When a plurality of reaction compartments are provided, the substantially vertical side wall portions are preferably disposed parallel to the longitudinal axis of the disposable reaction container. As should be apparent to those skilled in this art, the lower reaction compartment section should be made from an optically transparent material which will not adversely affect optical analysis. Plastic materials are presently preferred since they can be suitably heat sealed to bond the reaction compartment section of the disposable reaction container to an upper reagent storage section suitably positioned thereon, as to be described hereinafter.

The walls of the reaction compartment can be transparent and rigid, the distance between one pair of opposite walls defining a fixed optical path through the reaction mixture. This fixed optical path or fixed distance between the pair of opposite walls is equal, within certain tolerances, for each disposable reaction container representing a single chemical analysis whereby reproducibility and reliability of analytical data and results can be achieved.

In a different embodiment, at least one pair of opposite walls are sufficiently flexible so that a fixed optical path through the reaction mixture can be defined by contacting a light source means against one wall and a detection means against the other wall. The walls yield a distance sufficient to define a fixed optical path between the light source and the detection means through the reaction mixture. Alternately, higher than atmospheric pressure means can be positioned over the upper storage section so that a relatively inert gas, such as nitrogen, can be admitted to each reaction compartment through a hole made in the upper section during sample addition. The side walls will be bowed outwardly and can be made to press up against accurately positioned optical path defining means. Thus, in each instance, there is provided within each detection station means to define an optical path which will be maintained constant for each disposable reaction container representing like chemical testing units.

BRIEF DESCRIPTION OF THE DRAWINGS

The nature of the invention will be more easily understood when it is considered in conjunction with the accompanying drawings wherein:

FIG. 1 is a side view of the lower section of the disposable reaction container of the present invention;

FIG. 2 is a top view of the lower reaction compartment section of FIG. 1; and

FIG. 3 is an end view of the lower reaction compartment section of FIG. 1.

Referring to FIGS. 1-3, there is shown a disposable reaction container lower section 10 having two separate lower compartments 12 and 14 for the admixing and reaction of materials added thereto. Each lower compartment has a small flat portion 16 at the bottom thereof which serves to couple the ultrasonic energy from an adjacent ultrasonic generating means to the materials previously added to the reaction compartment. Flat portion 16 is preferably symmetrical about the nonvertical dimensions of the respective reaction compartment and has dimensions on the order of, for example, about one-third to about one-fifth the dimensions of the opening at the top of the reaction compartment defined by flange 46 and the side walls 26, 28, 34 and 36 (or their extensions most closely adjacent flange 46). From the edges of each flat portion, the walls defining the lower portion of each reaction compartment are slightly rounded and/or, as shown, substantially flat surfaces diverging slightly upwardly toward the remaining side walls further defining the reaction compartment.

The slightly rounded wall portions 18 and 20 which connect opposite edges 22 and 24 of flat portion 16 with upwardly diverging side walls 26 and 28, respectively, can best be seen in FIGS. 1 and 2.

As can best be seen in FIG. 3, and to some extent in FIG. 2, the remaining opposite edges 30 and 32 of each flat portion 16 are connected to substantially vertical side walls 34 and 36, respectively, by substantially flat portions 38 and 40. The actual connection between substantially flat portions 38 and 40 and walls 34 and 36, respectively, is a slightly rounded connection 42 and 44, as can best be seen in FIG. 3. Thus, flat wall portion 16, rounded wall portions 18 and 20 and substantially flat wall portions 38 and 40 define the lower extremity of each compartment such that flat portion 16, when properly positioned over an ultrasonic generating means, effectively couples the ultrasonic energy produced thereby with the materials

previously admixed in the reaction compartment. This is particularly advantageous where tableted materials have been dispensed into the reaction compartment over flat bottom wall portion 16. Effective coupling of the ultrasonic energy to the solid material, which requires additional energy for completely dispersing it into liquid material previously added to the reaction compartment, is thereby achieved.

The wall portions of compartments 12 and 14 terminate in a horizontal flange 46 which encircles the upper perimeter of the two compartments and holds them together as a distinct unit. Each flat wall portion 16 is parallel or substantially parallel with horizontal flange 46. Substantially vertical side walls 34 and 36 do not vertically extend all the way to flange 46 but rather, as shown, diverge outwardly as walls 34' and 36' which terminate in a short leg 34'' and 36'', respectively, just prior to their intersection with flange 46, the legs 34'' and 36'' being substantially perpendicular to the flange. As can best be seen in FIG. 1, walls 26 and 28 also terminate in short legs 26' and 28' just prior to their intersection with flange 46, legs 26' and 28' also being substantially perpendicular to the flange. The short legs 26', 28', 34'' and 36'' define a positive aligning area which can be properly manipulated during manufacture as well as transportation through the aforementioned automatic analyzer. If desired this positive aligning area can be omitted whereby the walls defining each reaction compartment will diverge upwardly and outwardly until they intersect with the encircling flange. Side walls 26, 28, 34 and 36, or their extensions, intersect at rounded corners, for example as shown at 48.

As shown, the walls defining each reaction compartment define a substantially rectangular opening through which materials are added thereto. The shape of the opening is not critical as long as it will not interfere with the introduction of sample material and reagents. The sloping walls in the upper portion of each compartment assist in downwardly channeling all materials toward the bottom of the compartment. A distinct barrier 50 is provided between the compartments such that material from one compartment cannot be mixed with material from the other compartment.

Resting on flange 46 and barrier 50 is a restraining layer (not shown) and an upper storage section (also not shown). A suitable upper storage section can be seen in copending application Ser. No. 645,665 filed June 13, 1967, and assigned to the assignee of the present invention. Other suitable upper storage sections are shown in copending application Ser. Nos. 693,400; 693,401; 693,628; 693,629; all filed Dec. 26, 1967, now U.S. Nos. 3,477,821, 3,480,398, 3,480,399 and 3,477,822 respectively and also assigned to the assignee of the present invention. The particular advantages of the various upper storage sections are indicated in the respective applications.

The common feature of each upper section structure previously disclosed is that they have storage chambers, usually in the form of "top-hats," in which reagents are stored prior to their deposition into the reaction compartment(s) therebelow. The upper section also has a flange extending about the lower perimeter of the plurality of reagent storage chambers. One side of this flange which extends the length of the disposable reaction container is slightly wider than the border that encircles the remainder of the upper storage section. Flange 46 which encircles the lower section of the present invention also has such a wider portion which is indicated at 52. Thus, the rectangles with slightly rounded edges formed by the flange 46 encircling the upper perimeter of lower section 10, the flange encircling the lower perimeter of the upper section (not shown) and, optionally, the restraining layer as shown in aforementioned copending application Ser. No. 645,655, now abandoned, are of equal size and dimension so that the members can be suitably joined to

provide a unitary disposable container. Preferably, each member is formed out of a plastic material which can be heat sealed to the adjacent member to provide an exceptionally strong bond which cannot be broken under normal use. The wider portion of the flange encircling the perimeter of the upper storage section, overlying portion 52 of the lower section, is sufficiently wide so that a code area 54 can be provided between inner bond 56 and outer bond 58. Any suitable type of coding can be placed on the code area to indicate or record any information which desirably should be known during a chemical analysis, such as the actual test which has been pre-stored in the particular disposable reaction container, patient number, instructions for the associated automatic analytical apparatus and system, analytic results, etc. Typical codes include binary coding in the form of light and dark areas, magnetic coding, etc.

In operation, a complete disposable container is taken from a supply magazine and passed to a sample addition station where the proper amount of sample diluted with distilled water is aliquoted into the reaction compartment. This addition is accomplished by injecting the sample solution through a needle which has been inserted through the plastic layer(s) forming the upper storage section. Preferably, this insertion is made at a point which will not cause undue rotation of the supported container. For example, with a container having four storage "top-hats" per reaction compartment, such as shown in FIGS. 1-3 of Ser. No. 645,665, now abandoned, the insertion for each compartment can be made at a point approximately equidistant from the centers of the four storage chambers. The sample-holding container is then passed to a reagent addition station wherein reagents stored in the storage chambers are emptied into the appropriate compartments. Reagent addition can be done in one operation or it can be done sequentially as it is necessary to complete the analytical procedure. If done sequentially, the addition can be done during or after incubation. In essence, reagents can be added any time prior to final detection as determined by the particular analytical procedure utilized. The container is passed to a mixing station where it is maintained for a time sufficient to ensure the dissolution of all solid materials in the liquid contained in the lower compartments. The container next passes to an incubation station where appropriate reaction conditions are imposed upon the materials within the container for a time sufficient to complete the desired reaction which is then measured at a detection station. If necessary the package passes to a further reagent addition, mixing and incubation stations as dictated by the analytical procedure. It is not necessary that the mixing and incubation stations be separate and distinct as it is contemplated that these operations may be performed in a single station.

At a detection station, light of appropriate wavelength is passed from a light source through the reaction mixture to detection means situated on the opposite side of the reaction mixture from the light source. The amount of light transmitted (or, conversely, the amount of light absorbed) at the testing wavelength will be representative of the amount of the constituent under analysis in the test solution.

Preferably, the disposable container as shown in the drawings is used in conjunction with a double-beam detection mechanism. In one compartment there is providing a solution of the material being tested with all the reagents which will bring the reaction mixture to the desired point for analysis. The other compartment contains a solution of the material being tested in the absence of reagents. In certain instances, one or more reagents can be added to this latter solution, provided the reagents do not carry the reaction to completion or do not adversely affect, in any other way, the optical analysis. This latter solution is called a "critically incomplete blank" and will enable the analytical system to compensate for the effects of the

sample and the reagents added thereto. To maintain the detection mechanism in calibration, standard solutions are passed through the detection mechanism at intervals so that the latter can adjust for deviations which occur during operation.

To dispense with the necessity of passing standard solutions through the detection mechanism at regular intervals, a disposable container having three compartments, and the plurality of storage chambers associated with each compartment where reagents need be added, is provided for use with a triple-beam detection mechanism. The standard solution can be injected into the disposable container at any point in the system prior to optical analysis and will obviate the need for passing distinct disposable container holding standards through the system. Alternatively, standard solution-producing materials can be stored in the upper section, dispensed into the lower compartment and diluted to give the desired concentration. The detection mechanism will analyze the standard and adjust for deviations from the known value. The analysis of the materials in the other two compartments is conducted in accordance with the teachings above. If one wishes to conduct an extremely precise analysis and take into consideration every possible influencing factor, additional lower compartments can be built into the disposable container for the introduction of such factors and the analysis thereof. Thus, adjustments can be made which will compensate for the effect which these materials have upon the particular analysis.

Optionally, light from the light source and light which has passed through the reaction mixture can be conducted to the disposable container and the detection means, respectively, through light conduits which can be caused to contact an opposite pair of rigid walls which comprise a portion of the lower compartment. Preferably, these conduits contact the substantially vertical walls (i.e., 34 and 36) of each reaction compartment. In this embodiment, the optical path is defined by the distance between the opposite walls of the lower compartment against which the light conduits, or the equivalent thereof, are in contact. This optional form of optical analysis is shown in FIG. 5 of Ser. No. 645,665, now abandoned. Alternatively, higher than atmospheric pressure means can be positioned over the upper storage section so that a relatively inert gas can be admitted to the reaction compartment through the hole made in the upper section during sample addition. The flexible walls will be bowed outwardly and can be made to contact accurately positioned optical path-defining means.

Since it is preferred to maintain the optical path constant for all like analytical procedures, to aid in assuring reproducibility of results, less strict production requirements must be met in the production of disposable containers having semi-rigid lower compartment walls than in the production of disposable container having rigid walls where the walls cannot be deformed by external means. That is, by providing a fixed optical path in this manner, it is easier to mass produce the disposable container as a critical production feature, the optical path, has been eliminated as a strict production standard. The optical path defining means is now built into the detection station and, as would be expected, significantly less detection stations should be produced than disposable containers. Since a fixed optical path is defined by the detection station and will be the same for each container passing therethrough, highly accurate and reliable data can be obtained with this system.

It is also contemplated that this form of optical analysis can be used in a double- or triple-beam detection mode, as described above.

Alternatively, higher than atmospheric pressure means can be positioned over the upper storage section so that a relatively inert gas, for example nitrogen, can be admitted to the reaction compartment through holes made in the upper section during sample addition. The

side walls will be bowed outwardly and can be made to press up against accurately positioned optical path defining means. Thus, in this embodiment as in the preceding embodiment, there is provided within each detection station means to define an optical path which will be maintained constant for each disposable reaction container representing like chemical testing units.

The number of reagent tablets necessary will depend upon the particular analysis being pre-packaged into the disposable container as well as the compatibility of the different reagents. In certain instances, it is possible to tablet more than one reagent in a single tablet. However, where it is contemplated that the disposable containers will be prepared long before their actual use, the compatibility of the reagents over this long period of time must clearly be established. If this cannot be done, then it is desirable to tablet the reagents separately. In turn, the number of storage chambers will depend upon the number of reagent tablets utilized. It will also depend upon the particular storage section design chosen.

A more complete discussion of further modifications in the disposable storage techniques, the automatic analytical apparatus and system with which the disposable reaction containers of the present invention are to be utilized, etc., is given in Ser. Nos. 602,018, now U.S. No. 3,497,320 and 602,025, now U.S. No. 3,504,376. Reference is made thereto for said complete discussion and such portions of those applications, and other previously mentioned applications, which are necessary to a complete understanding of the present invention are incorporated herein by reference.

The flat portion and the upwardly diverging wall portions connecting the flat portion to the vertical or substantially vertical side walls are substantially thinner than the side walls in order to allow ease of transmission of the ultrasonic energy through the lower surfaces (i.e., the flat portion and the upwardly diverging wall portions) and to minimize ultrasonic motion of the remaining portions of the reaction container. For example, the reaction containers can be manufactured in a thermo-forming operation where the adjustment of various operating parameters, such as temperature, pressure, mold surface spacing, etc., will promote the production of reaction containers where the thickness of the lower surfaces are on the order of one-third to one-half as thick as the side walls or other wall portions of the reaction container. This ratio is sufficient to permit the lower surfaces to act in a more flexible nature thereby enhancing coupling of the material within the reaction compartment to the ultrasonic radiator. In any event, however, the flat portion and, preferably, the upwardly diverging wall portions are sufficiently thin so as to promote this enhanced coupling, even though, in other embodiments, they may be of the same thickness as the side wall or other reaction container wall portions.

Presently, bottom wall portions 38 and 40 are inclined at an angle of 12° to the plane of flat portion 16. With the present dimensions of the disposable container, this has been found to insure that tableted materials added to the liquid in the reaction compartment will be positioned over flat portion 16 while not adversely limiting the vertical dimension of the optical window. These latter two features, along with the widths of the flat portion and the reaction compartment and other dimensions of the container, are the essential factors in determining an acceptable angle at which bottom wall portions 38 and 40 can be inclined to flat portion 16.

As previously indicated, the short legs 26', 28', 34" and 36" define a positive aligning area which can be suitably manipulated during manufacture as well as transportation through an automatic analyzer. While positioning is important in all stages of its passage through the analyzer, it is most important in the photometer where the disposable container must be precisely positioned so optical analysis can be made through the optical window

(i.e., through walls 34 and 36). The positive aligning area thusly defined by the four short legs above is therefore highly desirable to achieve accurate and precise positioning.

From FIG. 1 it can be seen that side walls 26 and 28 slope inwardly from their point of intersection with short legs 26' and 28', respectively, until their intersection with bottom wall portions 18 and 20, respectively. It was found that this reduced imperfections inherent in the optical window which were created during the thermo-forming operation by the provision of slanted wall 32' and substantially vertical wall 32, as can best be seen in FIG. 1 of Ser. No. 645,665, now abandoned. The imperfection is a curved line through the optical window from the intersection of walls 32 and 32' to the intersection of walls 36 and 36' (once again, see FIG. 1 of Ser. No. 645,665, now abandoned, for identification of the aforementioned walls and their respective intersections). This imperfection is caused by the stretching of the plastic material during the thermo-forming operation and is undesirable since it can adversely affect optical analysis. This has been reduced by eliminating the aforementioned intersections so that the non-optical window containing side walls slope gradually towards and intersect with their respective bottom wall portions.

While the invention has been described with reference to its preferred embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the true spirit and scope of the invention. For example, other methods and means can be used to bond the lower reaction compartment section of the present invention to the restraining means or the reagent storage section. Adhesives, cold sealing or the use of ultrasonics or radio frequency to bond the adjacent members are but a few examples of suitable techniques. In addition, many modifications may be made to adapt a particular situation or material to the teaching of the invention without departing from its essential teachings.

What is claimed is:

1. A lower reaction compartment section of a disposable reaction container comprising a unitary member formed into at least one reaction compartment having a flange encircling the upper perimeter thereof, each reaction compartment comprising at least one side wall and a bottom wall, said bottom wall having a flat portion substantially parallel to said flange and substantially symmetrical about the non-vertical dimensions of said compartment, said flat portion connected to each of said side walls by upwardly and outwardly diverging bottom wall portions adapted to define said flat portion as the lowest point within said compartment.

2. The lower reaction compartment section of claim 1 wherein said unitary member is formed from a plastic material.

3. The lower reaction compartment section of claim 1 wherein said section has a plurality of side walls and at least the lower portion of a pair of opposite side walls are substantially vertical.

4. The lower reaction compartment section of claim 3 wherein at least said substantially vertical wall portions are optically transparent so that upon completion of the desired chemical reaction each compartment can be utilized as a cuvette for optical analysis.

5. The lower reaction compartment section of claim 4 wherein said substantially vertical wall portions of each reaction compartment are sufficiently flexible so they will yield when contacted by cooperating members in a detection station adapted to define a fixed optical path between a light source and a detection means through a reaction mixture within each of said reaction compartments.

6. The lower reaction compartment section of claim 1 wherein said section has a plurality of separate reaction compartments separated by a portion of said flange

acting as a barrier to prevent the admixing of materials added to different reaction compartments.

7. The lower reaction compartment section of claim 6 wherein at least the lower portion of the side walls of each reaction compartment disposed parallel to the longitudinal axis of said section are substantially vertical.

8. The lower reaction compartment section of claim 1 wherein each of said side walls terminates in a short leg immediately adjacent and perpendicular to said flange.

9. The lower reaction compartment section of claim 8 wherein said non-vertical portion containing said walls slopes inwardly from their intersection with said short legs toward said upwardly diverging wall portions.

10. The lower reaction compartment section of claim 1 wherein said flange and said side wall or walls define an opening in said flange through which materials are added to said reaction compartment.

11. The lower reaction compartment section of claim 10 wherein said flat portion comprises a rectangle whose planar dimensions are significantly less than the dimensions of said opening.

12. The lower reaction compartment section of claim 10 wherein said flat portion is a rectangle, each planar dimension of which is about one-half to about one-fifth the corresponding dimension of said opening.

13. The lower reaction compartment section of claim 1 wherein said flat portion and said upwardly and outwardly diverging bottom wall portions are substantially thinner than said side wall or walls.

14. The lower reaction compartment section of claim 1 wherein said flat portion and said upwardly and outwardly diverging bottom wall portions are about one-third to about one-half the thickness of said side wall or walls.

15. The lower reaction compartment section of claim 1 having an upper reagent storage unitary member positioned on said flange.

16. The combination of claim 15 wherein said reagent storage unitary member has a plurality of reagent storage chambers associated with each reaction compartment.

17. The combination of claim 16 further including restraining means adapted to prevent the premature movement of prepackaged reagents from said plurality of said storage chambers.

18. The combination of claim 17 wherein said restraining means comprises a thin plastic layer positioned between said upper reaction storage member and said lower reaction compartment.

19. The combination of claim 18 wherein said upper reagent storage unitary member, said restraining layer and said lower reaction compartment section are bonded together.

20. The combination of claim 18 wherein said upper reagent storage unitary member, said restraining layer and said lower reaction compartment section are heat sealed together.

21. The lower reaction compartment section of claim 9 having an upper reagent storage unitary member positioned on said flange.

22. A lower reaction compartment section of a disposable reaction container comprising a unitary member formed into a plurality of reaction compartments having a flange encircling the upper perimeter thereof and separating each reaction compartment from an adjacent compartment, each reaction compartment comprising four side walls and a bottom wall, said flange and said four side walls of each reaction compartment defining an opening in said flange through which materials are added to each reaction compartment, said bottom wall having a first flat portion substantially parallel to said flange and symmetrical about the non-vertical dimensions of said reaction compartment, at least the lower portion of the side walls of each reaction compartment disposed parallel to the longitudinal axis of said section being

substantially vertical, said first flat portion being connected to each of said substantially vertical wall portions by upwardly and outwardly extending substantially flat bottom wall portions, all of said flat bottom wall portions being connected to the other pair of side walls by upwardly rounded wall portions whereby said first flat portion is positioned as the lowest point within said compartment.

23. The lower reaction compartment section of claim 22 wherein said other pair of side walls diverge upwardly toward said flange.

24. The lower reaction compartment section of claim 23 wherein the upper portion of said pair of side walls disposed parallel to the longitudinal axis of said section diverge upwardly toward said flange.

25. The lower reaction compartment section of claim 22 wherein the substantially vertical wall portions are vertical for a sufficient distance to permit the use of said substantially vertical portions as optical windows through which analysis is made.

26. The lower reaction compartment section of claim 22 wherein said flat portion and said upwardly and outwardly diverging bottom wall portions are substantially thinner than said side walls.

27. The lower reaction compartment section of claim 22 wherein said flat portion and said upwardly and outwardly diverging bottom wall portions are about one-third to about one-half the thickness of said side walls.

28. The lower reaction compartment section of claim 22 wherein said first flat portion comprises a rectangle whose planar dimensions are significantly less than the dimensions of said opening.

29. The lower reaction compartment section of claim 22 having an upper reagent storage section positioned on said flange.

30. The combination of claim 29 wherein said reagent storage section has a plurality of reagent storage chambers associated with each reaction compartment.

31. The combination of claim 30 further including restraining means adapted to prevent the premature movement of prepackaged reagents from said plurality of said storage chambers.

32. The combination of claim 30 further including restraining means comprising a thin plastic layer positioned between said upper reaction storage section and said lower reaction compartment section for preventing the premature movement of prepackaged reagents from said plurality of said storage chambers, said upper reagent storage section, said restraining layer and said lower reaction compartment section being bonded together.

33. The combination of claim 31 wherein each of said side walls of said lower reaction compartment section terminates in a short leg immediately adjacent and perpendicular to said flange, said short legs defining positive aligning surfaces for the precise positioning of said combination.

34. A lower reaction compartment section of a disposable reaction container comprising a unitary member formed into at least one reaction compartment having a flange encircling the upper perimeter thereof, each reaction compartment comprising at least one side wall and a bottom wall, said bottom wall being of a non-planar configuration and adapted to effectively couple the transducing action of an ultrasonic mixer adjacent thereto whereby materials added to each of said reaction compartments can be thoroughly mixed.

35. The lower reaction compartment section of claim 34 wherein said unitary member is formed from a plastic material.

36. The lower reaction compartment section of claim 34 wherein said section has a plurality of side walls and

at least the lower portion of a pair of opposite side walls are substantially vertical.

37. The lower reaction compartment section of claim 36 wherein at least said substantially vertical wall portions are optically transparent so that upon completion of the desired chemical reaction each compartment can be utilized as a cuvette for optical analysis.

38. The lower reaction compartment section of claim 34 wherein said section has a plurality of separate reaction compartments separated by a portion of said flange acting as a barrier to prevent the admixing of materials added to different reaction compartments.

39. The lower reaction compartment section of claim 38 wherein at least the lower portion of the side wall or walls of each reaction compartment disposed parallel to the longitudinal axis of said section are substantially vertical and optically transparent so that upon completion of the desired chemical reaction each compartment can be utilized as a cuvette for optical analysis.

40. The lower reaction compartment section of claim 39 having an upper reagent storage unitary member positioned on said flange.

41. The combination of claim 40 wherein said reagent storage unitary member has a plurality of reagent storage chambers associated with each of said reaction compartments.

42. The combination of claim 41 further including restraining means adapted to prevent the premature movement of prepackaged reagents from said plurality of storage chambers.

43. The combination of claim 42 wherein said restraining means comprises a thin plastic layer positioned between said upper reagent storage member and said lower reaction compartment section.

44. The combination of claim 42 wherein said upper reagent storage member, said restraining layer and said lower reaction compartment section are bonded together.

45. A lower reaction compartment section of a disposable reaction container comprising a unitary member formed into at least one reaction compartment having a flange encircling the upper perimeter thereof, each reaction compartment comprising side wall or walls and a bottom wall, said bottom wall having a flat portion substantially parallel to said flange and substantially symmetrical about the center point of said compartment along at least one of the non-vertical dimensions of said compartment, said flat portion connected to said side walls by upwardly and outwardly diverging bottom wall portions adapted to define said flat portion as the lowest point within said compartment.

46. The lower reaction compartment section of claim 45 wherein said flat portion and said upwardly and outwardly diverging bottom wall portions are substantially thinner than said side wall or walls.

47. The lower reaction compartment section of claim 45 wherein said flat portion and said upwardly and outwardly diverging bottom wall portions are about one-third to about one-half the thickness of said side wall or walls.

References Cited

UNITED STATES PATENTS

3,476,515	11/1969	Johnson	23—230
3,477,821	11/1969	Hamilton	23—230X
3,477,822	11/1969	Hamilton	23—230X
3,480,398	11/1969	Hamilton	23—230X

MORRIS O. WOLK, Primary Examiner

R. E. SERWIN, Assistant Examiner

U.S. Cl. X.R.

23—230, 259, 292; 206—47; 220—23, 23.8