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(54) TUBE RACK AND CLAMP SYSTEM

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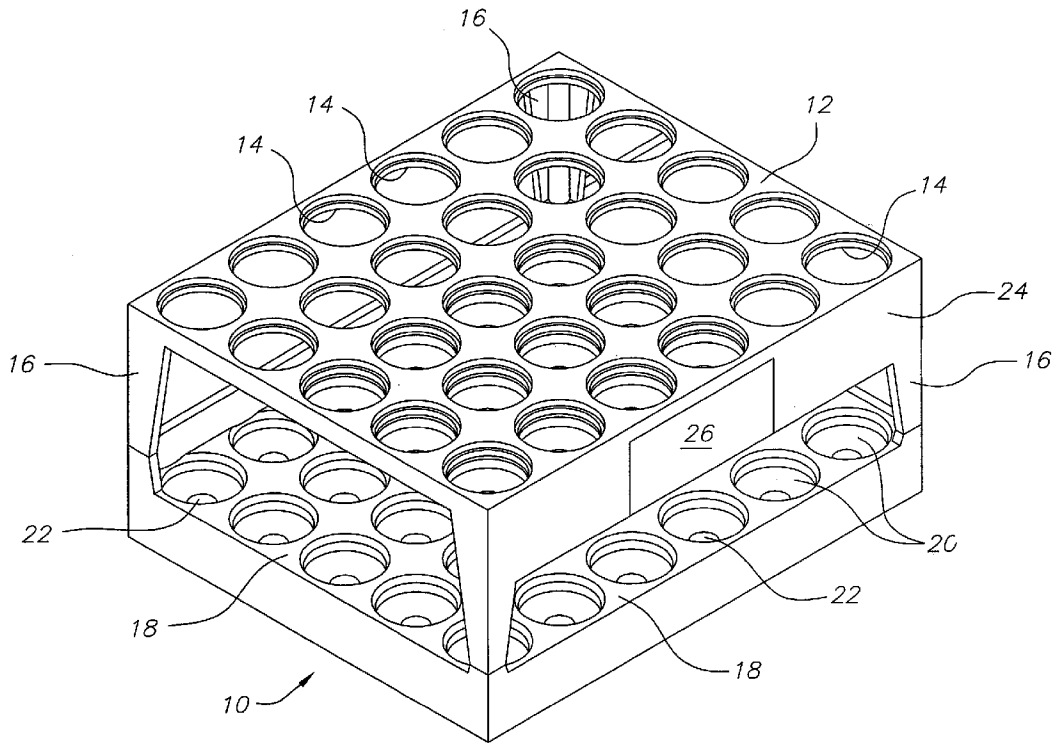
(57) **ABSTRACT**

A test tube rack includes top and bottom plates. Openings in the top plate are aligned with corresponding cavities formed in the bottom plate. The two plates are spaced apart and secured together by legs which are reinforced by internally embedded dowel pins. Respective test tube clamps fit snugly in respective openings in the top plate. The clamp includes a ring section with a first set of downwardly extending fingers which grip a test tube in a first plane substantially parallel to the top and bottom plates. The ring also carries a second set of fingers which grip the test tube in a different plane so the test tube is automatically aligned to be substantially perpendicular to the top and bottom plates.



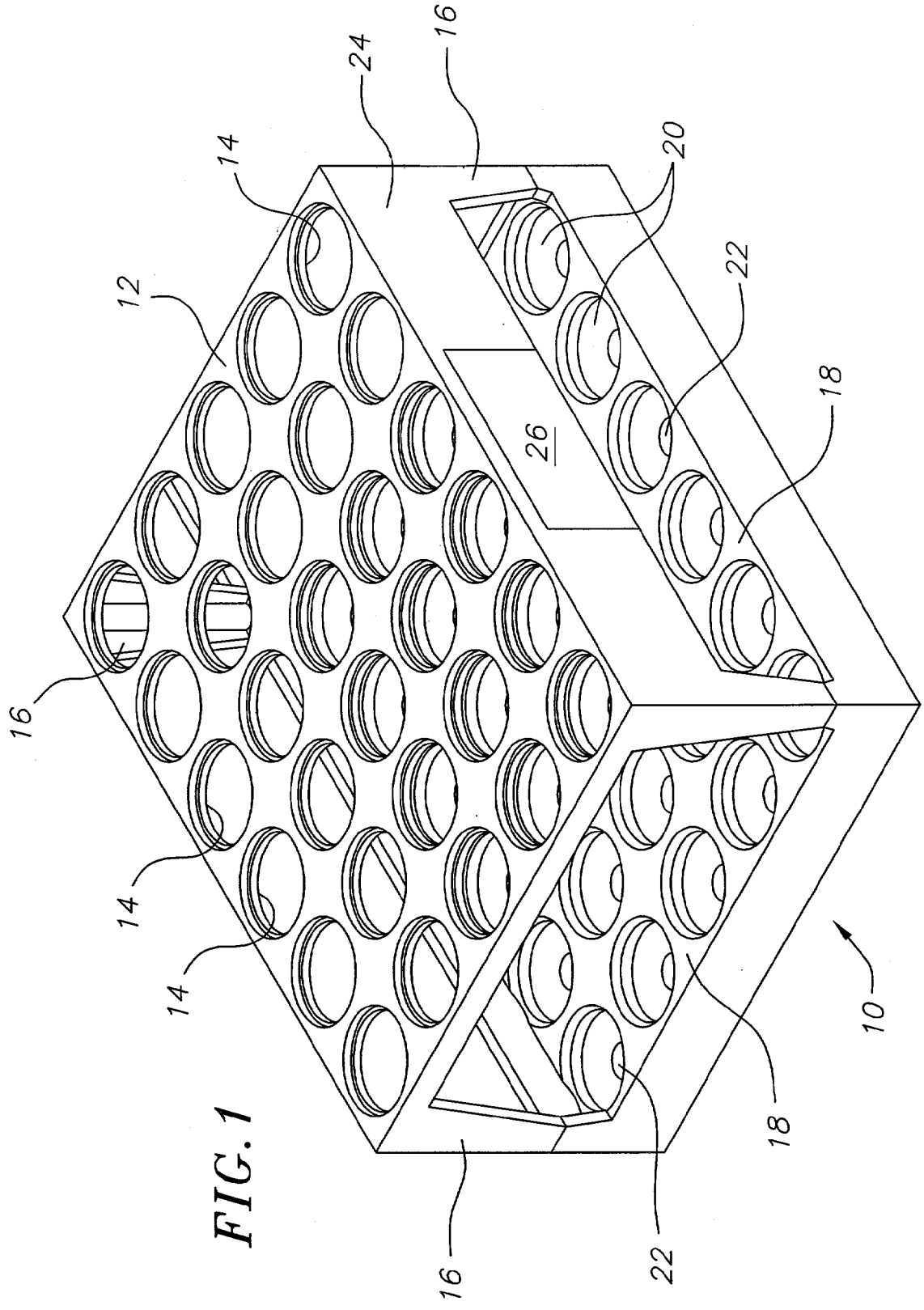


FIG. 1

FIG. 1A

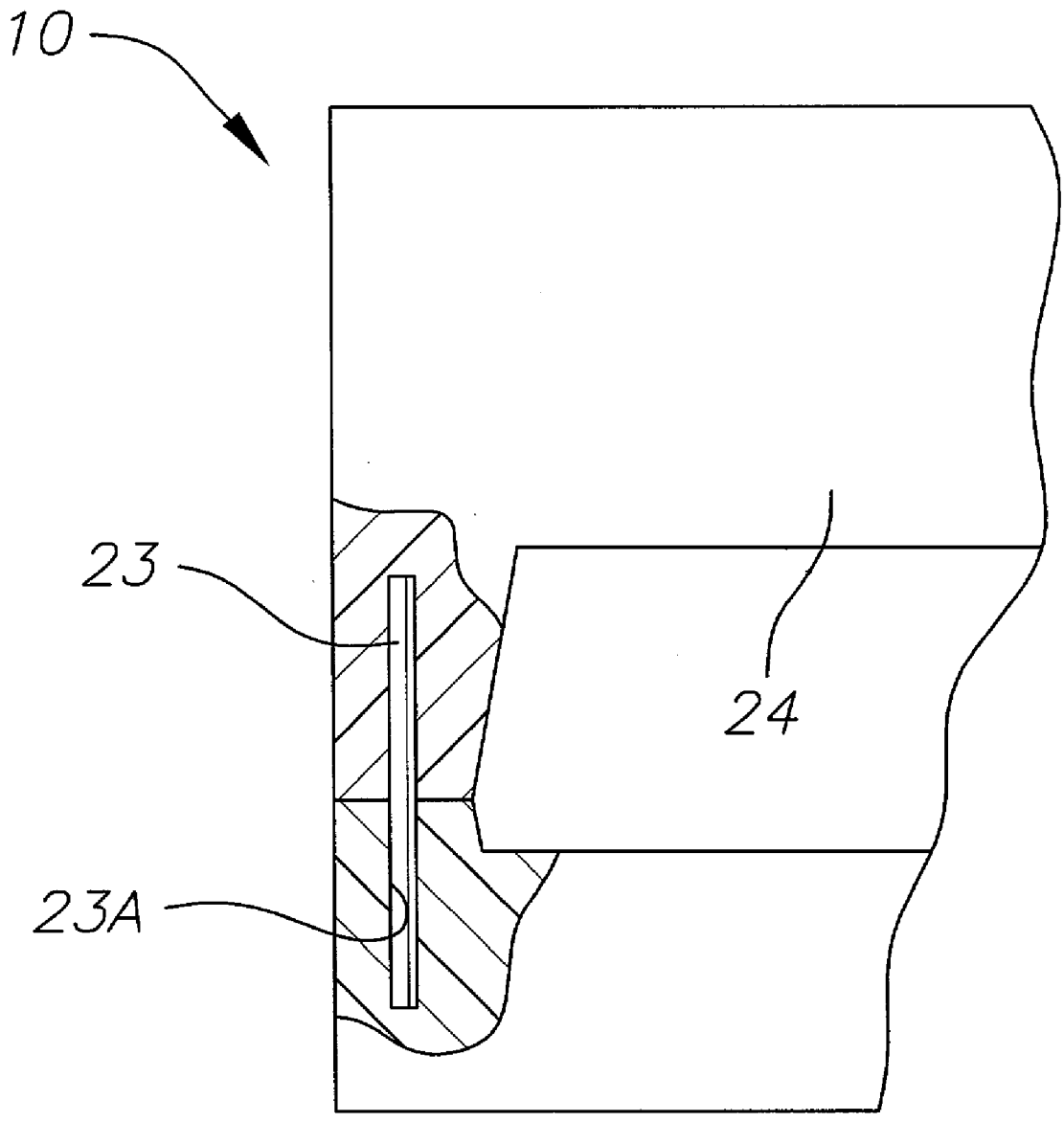
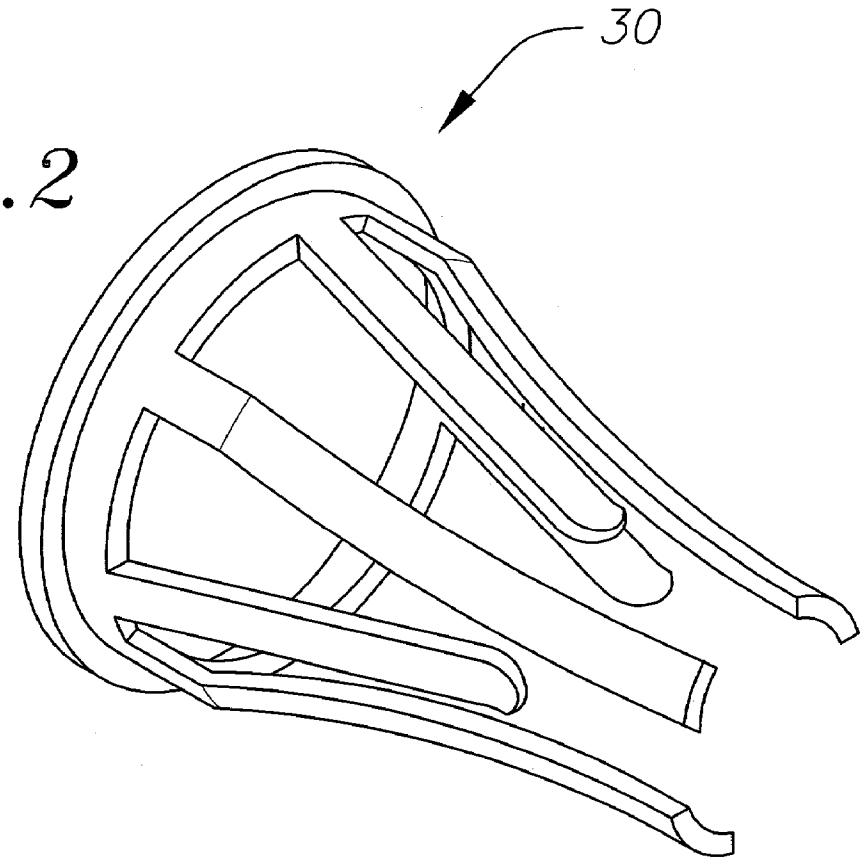


FIG. 2



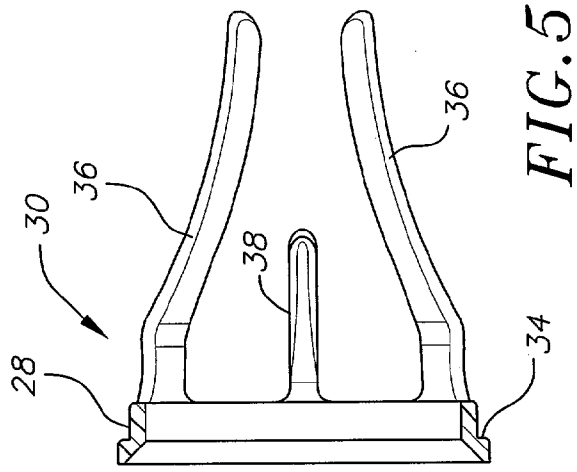


FIG. 5

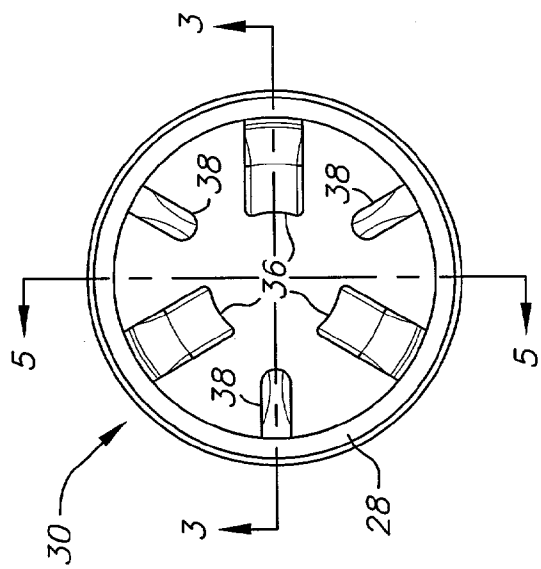


FIG. 4

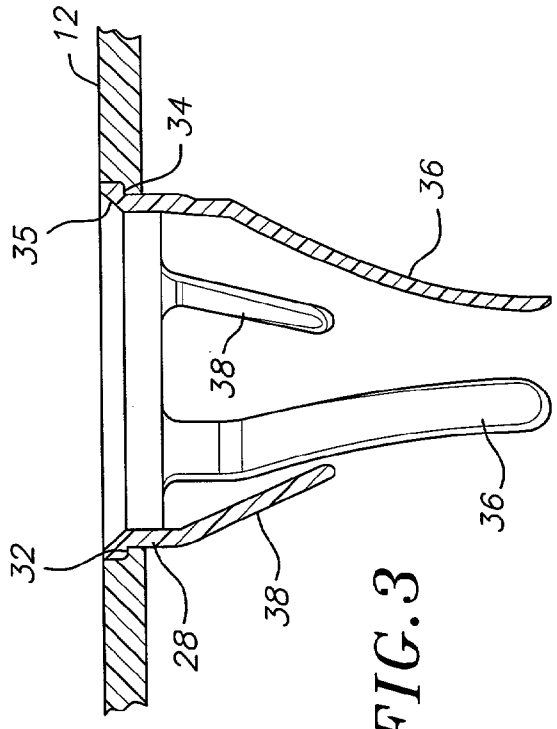


FIG. 3

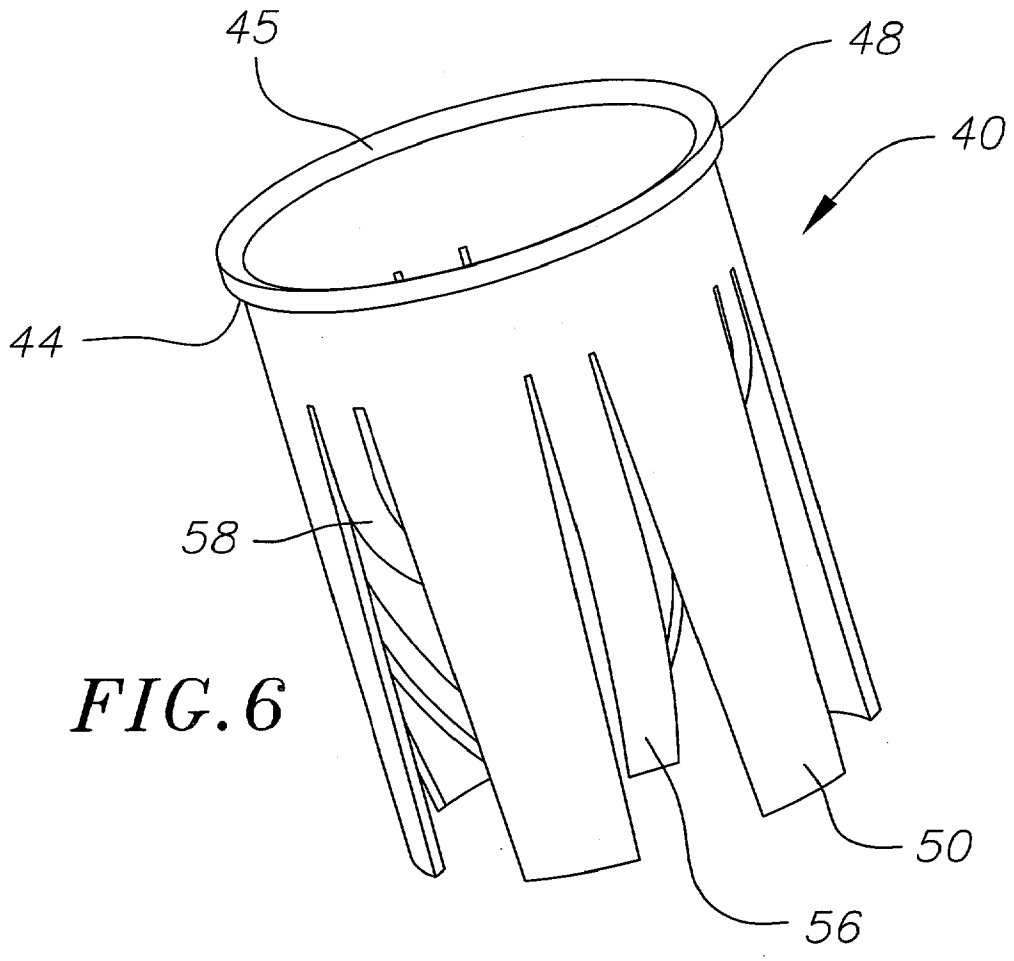


FIG. 6

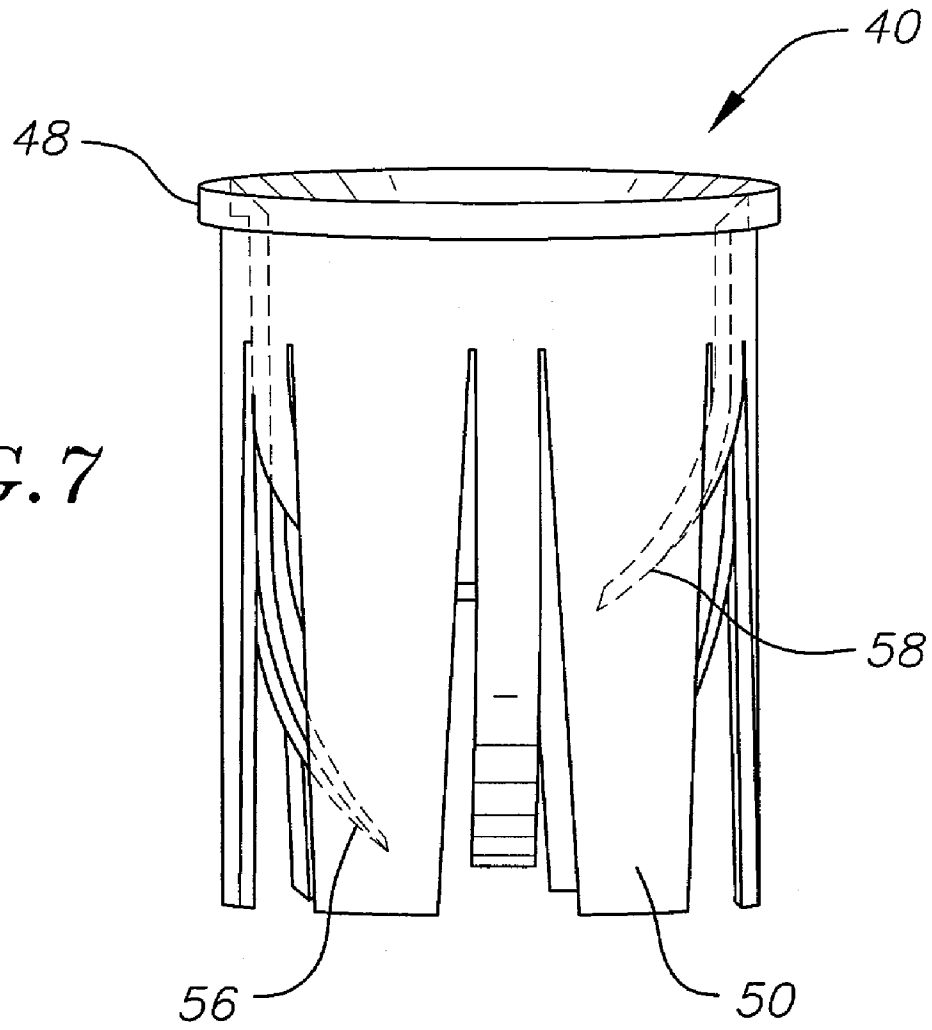


FIG. 7

TUBE RACK AND CLAMP SYSTEM

CROSS-REFERENCE TO RELATED APPLICATION(S)

[0001] This application claims the benefit of U.S. Provisional Patent Application No. 60/262,029 filed Jan. 15, 2001 which is hereby incorporated by reference as if set forth in full herein.

BACKGROUND OF THE INVENTION

[0002] Many laboratories use automated equipment for handling and transporting test tubes for analytical procedures. Such equipment requires precise location of multiple test tubes in a rack used with the automated equipment. Conventional racks for accurately positioning and securing test tubes typically contain multiple plates or vertical channels to align and secure the test tubes. This invention provides an improved rack and clamps for holding test tubes in precise alignment with respect to each other and the rack in which the tubes are mounted. The rack includes a top plate and a bottom plate and insertable test tube clamps for positioning and securing the test tubes into position.

SUMMARY OF THE INVENTION

[0003] The present invention provides an apparatus including a rack having a top plate and a bottom plate with openings in the top plate vertically aligned with corresponding cavities formed in the bottom plate. The plates are spaced apart and secured together by legs. A test tube clamp which fits securely in the opening formed in the top plate of the rack is also provided. The clamp includes a ring section and a shoulder as well as a plurality of downwardly extending fingers to secure the test tube securely in position and aligned with the vertically aligned cavity in the bottom of the rack. The fingers include at least one set of fingers extending to a first depth and a second set of fingers extending to a second depth so the tube is contacted and held in two planes. The clamp can secure test tubes having various diameters centrally within the opening.

BRIEF DESCRIPTION OF THE DRAWING

[0004] **FIG. 1** is a perspective view of an exemplary rack;

[0005] **FIG. 1A** is a fragmentary elevation, partly in section of a leg which secures the rack plates together;

[0006] **FIG. 2** is a perspective view of an exemplary clamp;

[0007] **FIG. 3** is a fragmentary view of an exemplary clamp mounted in an opening of the top plate of a rack;

[0008] **FIG. 4** is a top view of an exemplary clamp;

[0009] **FIG. 5** is a cross-sectional view of the exemplary clamp taken along line **5-5** of **FIG. 4**;

[0010] **FIG. 6** is a perspective view of another exemplary clamp; and

[0011] **FIG. 7** is a side view including fragmentary cross sections of the exemplary clamp shown in **FIG. 6**.

DETAILED DESCRIPTION

[0012] Referring to the drawings, **FIG. 1** is a perspective view of a rack **10**, which includes a horizontal rectangular top plate or shelf **12** with a plurality of circular openings **14**. Top plate **12** is molded integrally with four downwardly extending legs **16** at each corner of the top plate. If necessary, say to resist deformation when subjected to high temperatures of about 130° C. and low temperatures of about −70° C., one or more additional downwardly extending legs or pillars (not shown) are molded integrally with the bottom surface of the top plate, and are spaced from the edges of the top plate by distance at least equal to about the elements of the holes. The rack is preferably formed of a plastic material such as polysulfone but other materials may be used alternatively. Materials of formation are chosen for durability and high and low temperature tolerance.

[0013] The lower end of each leg **16** is secured to a respective corner of a rectangular bottom plate **18** of the same size as the top plate. Leg **16** may optionally be internally reinforced with steel or other rigid metals.

[0014] Bottom plate **18** is preferably molded of the same material as top plate **12**, and includes a plurality of upwardly opening conical cavities **20** molded in the top surface of bottom plate **18**. Each cavity **20** is a frustro-conical shape to receive the lower end of a test tube, and has a respective opening **22** extending through the bottom plate to facilitate cleaning. Each cavity **20** is vertically aligned with a corresponding circular opening **14** formed in top plate **12**. As shown in **FIG. 1**, the top and bottom plates each define a respective substantially flat plane, and are substantially parallel.

[0015] As shown in **FIG. 1A**, each leg of the top plate includes a downwardly extending dowel pin **23** which fits into a matching bore **23A** at each corner of the bottom plate so that the top plate **12** and bottom plate **18** are precisely aligned to ensure that each circular opening **14** formed in top plate **12** directly overlies a corresponding cavity **20** in bottom plate **18**. The dowel may be formed of steel or other rigid materials. If additional legs are used at intermediate locations on the top plate (as referred to above), each such leg carries a downwardly extending dowel pin which makes a snug fit in a matching base in the bottom plate.

[0016] A downwardly extending broad flange **24** is molded integrally with one of the long edges of top plate **12** and with two adjacent legs. The vertical dimension of the flange is about one half the distance between the top and bottom plates but other dimensions may be used alternatively. Rectangular recess **26** is an alignment marker formed in the outer face of flange **24** and is shaped to receive a label (not shown) for identifying the rack. The opposite edge of the top plate does not have a broad flange. This insures that the label is always placed on the correct side of the rack for proper orientation in automated handling. This feature is especially useful in automated pick and place equipment for positioning the rack and for removing and inserting the test tubes into and from the rack. According to another exemplary embodiment, the flange with the formed recess may extend from leg to leg along a side of the rack and be located superjacent an edge of bottom plate **18** and extend upward when the rack is assembled.

[0017] Another aspect of the present invention is the clamp for positioning and securing a test tube centrally within openings such as circular openings **14** of top plate **12**. FIGS. **2-5** show an exemplary clamp **30** which is constructed to be inserted to make a pressed fit in circular opening **14** of

top plate **12**. **FIG. 2** is a perspective view of clamp **30** according to an exemplary embodiment of the invention. The clamp may be formed of a copolymer material chosen to have the following characteristics: ease of manufacture, strength, durability, flexibility, high and low temperature tolerance and low surface friction. In an exemplary embodiment, a copolymer such as DuPont Celcom 90 may be used. Clamp **30** is constructed such that a single clamp may secure test tubes of various diameters within an opening such as circular opening **14** such that, regardless of test tube diameter, the longitudinal axis of the grasped tube is coaxial with the axis passing through the center of the hole in which the clamp is inserted. With respect to exemplary rack **10**, clamps **30** retain test tubes, regardless of diameter, such that the longitudinal axis of the gripped test tube is coaxial with the axis passing through the center of circular opening **14** and the respective underlying cavity **20** to which circular opening **14** is aligned. This ensures accurate alignment and permits reliable handling of test tubes of different sizes with automated equipment. The openings may preferably be formed in compliance with NCCLS (National Committee for Clinical Laboratory Standards) and may include a pitch on the order of 22 mm, but other configurations may be used alternatively. Clamp **30** fits securely in circular opening **14** when inserted therein but may be removed after use.

[**0018**] Clamp **30** includes a plurality of downwardly and inwardly extending fingers to align and secure the test tube securely into position. The fingers and ring of the clamp are integrally molded of any suitable plastic which provides rigidity around the ring portion and flexibility and resiliency for the fingers as well as the other characteristics described above. The fingers include at least one set of fingers extending to a first depth and a second set of fingers extending to a second depth. Each of the fingers preferentially extend centrally toward the center axis of the ring from which they extend. The fingers are free at their lower ends so that the fingers in one set can grasp the test tube in a first horizontal plane and the fingers in the other set can grasp the test tube in a second horizontal plane spaced vertically from the first horizontal plane.

[**0019**] **FIG. 3** is a fragmentary view showing exemplary clamp **30** mounted in circular opening **14** of top plate **12**. **FIG. 4** is a top view of the clamp, and **FIG. 5** is a view taken on line **5-5** of **FIG. 4**. Each circular opening **14** of top plate **12** includes an annular inwardly extending and upwardly facing shoulder **32** on which rests a complementary annular outwardly extending and downwardly facing shoulder **34** of an annular ring **28** of clamp **30**. Annular ring **28** is sized to be tightly secured when pressed into in circular opening **14** of top plate **12**.

[**0020**] As shown in **FIG. 3**, ring **28** defines a substantially flat plane **28**A, which is parallel to the flat planes defined by the top and bottom plates of the rack. Clamp **30** is adapted receive a test tube therein. Annular ring **28** forms the top portion of clamp **30** and includes inner face **35** of annular ring **28** which tapers upwardly and outwardly at the upper end of the ring to facilitate insertion of a test tube (not shown) into clamp **30**. Clamp **30** includes a first set of three downwardly extending long fingers **36** spaced at equal intervals around the clamp ring, and a second set of three downwardly extending short fingers **38** spaced at equal intervals around the ring and spaced equidistant between adjacent long fingers. According to other exemplary embodiments, other configurations and numbers of fingers may be used. Long fingers **36** comprise one set of fingers which extend to a first depth and short fingers **38** comprise a second set of fingers which extend to a second depth less than the first depth.

[**0021**] As shown clearly in **FIGS. 2, 3** and **4**, short fingers **38** extend downwardly and inwardly toward each other, and are about one half the length of long fingers **36**, which also extend downwardly toward each other. The distal or free ends of the long fingers in the first are more closely spaced to each other than are the short finger in the second set. Short fingers **38** may have a flat or inwardly facing convex surface according to various exemplary embodiments. Long fingers **36** extend downwardly and inwardly and each presents an inwardly facing convex surface. Each of the set of short fingers and the set of long figures include portions internal to the periphery of circular opening **14**. In the preferred embodiment, each of the fingers extend downwardly inward and toward the center axis of circular opening **14** and annular ring **28**. The fingers of each set of fingers may take on various shapes as they extend downwardly inward. The fingers of each of the respective sets of fingers preferably have the same shape.

[**0022**] When each circular opening **14** of top plate **12** is fitted with a clamp as shown in **FIG. 3**, test tubes can easily be inserted in, and removed from, rack **10** with great precision, even though the test tubes may not be of the same size, and may not be located with the bottom of the test tubes resting in corresponding cavity **20** underlying a respective circular opening **14**. Test tubes of various sizes (for example ranging from 8 to 16 mm in diameter) are firmly and precisely grasped so that the longitudinal axis of each test tube is coaxial with the axis passing through the center of circular opening **14** and respective underlying cavity **20** because the grasped test tube is secured at contact points (the points at which the test tube contacts each of the respective sets of fingers) in two different horizontal planes. The particular contact point for each of the sets of fingers depends upon the curvature, degree of inward extension and length of the fingers. The contact point for the fingers of each set of fingers lie essentially in a horizontal plane. The horizontal plane defined by contact points of one set of fingers is vertically spaced from the horizontal plane defined by the other set of fingers.

[**0023**] **FIGS. 6 and 7** show another exemplary embodiment of the clamp of the present invention. A clamp **40** is constructed to make a pressed fit into an opening formed in a top shelf of an exemplary rack and includes features as previously described in conjunction with exemplary clamp **30**. Clamp **40** includes annular ring **48**, downwardly facing shoulder **44**, inner face **45**, long fingers **56** and short fingers **58**. Clamp **40** additionally includes a third set of fingers—peripheral fingers **50**. Peripheral fingers **50** extend essentially straight down and are essentially the same length as long fingers **56** in the illustrated exemplary embodiment although they may have different lengths in alternative embodiments. As described in conjunction with short fingers **38** and long fingers **36** of clamp **30**, long fingers **56** and short fingers **58** of clamp **40** each extend downwardly inward. In the exemplary embodiment, long fingers **56** and short fingers **58** each include an arcuate shape although other shapes may be used in other embodiments. Also in the exemplary embodiment, long fingers **56** and short fingers **58** extend

centrally inward toward the center axis of annular ring **48** from which they extend. Clamp **40** includes peripheral fingers **50** peripherally spaced about annular ring **48** and having a short finger **58** or a long finger **56** alternately interposed between each neighboring set of peripheral fingers **50**. Each of the three long fingers **46** and the three short fingers **48** are spaced at equal intervals around the ring and interposed equidistant between adjacent peripheral fingers **50**. Different numbers of fingers and various other arrangements may be used in other exemplary embodiments.

1. A test tube clamp comprising:

a ring defining a substantially flat plane;

a first set of flexible fingers secured to the ring to extend away from the flat plane and toward each other; and

a second set of flexible fingers secured to the ring to extend toward each other and away from the ring in the same direction as the fingers of the first set, the fingers in the first set being longer than those in the second set.

2. A test tube clamp according to claim 1 in which the fingers in each set are about the same length.

3. A test tube clamp according to claim 1 or **2** in which the fingers in each set terminate in a separate respective common plane substantially parallel to the flat plane defined by the ring.

4. A test tube clamp according to claim 1 or **2** in which the flexible fingers in the first set are about twice as long as the flexible fingers in the second set.

5. A test tube clamp according to claim 1 or **2** in which the distal ends of the longer fingers are more closely spaced than those of the shorter fingers.

6. A test tube clamp according to claim 1 or **2** in which the fingers in each set are spaced at substantially equal intervals around the ring.

7. A test tube clamp according to claim 6 in which each finger in one set is disposed between adjacent fingers in the other set.

8. A test tube clamp according to claim 1 or **2** in which the longer fingers in the first set are curved so that each finger presents a convex surface facing toward the other fingers in the first set.

9. A test tube rack including a generally rectangular top shelf superimposed over a corresponding generally rectangular bottom shelf, said top shelf having an array of openings and said bottom shelf having an array of cavities corresponding to and vertically aligned with said array of openings, each cavity capable of receiving an end of a test tube having a maximum diameter and including an aperture of a lesser diameter extending vertically therethrough,

a flange formed along a side of said rack and including an alignment marker formed therein,

a plurality of inserts inserted into openings of said array of openings, each insert including an upper annular ring releasably secured within said corresponding opening and including a first set of fingers extending downwardly and centrally from said annular ring and having free lower ends terminating at a first depth and a second set of fingers extending downwardly and centrally from said annular ring and having free lower ends terminating at a second depth, said first depth being different from said second depth,

wherein each insert is capable of retaining a test tube having an outer diameter being less than or equal to said maximum diameter, such that the longitudinal axis of said test tube is coincident with the center axis of said opening.

10. A test tube rack including a generally rectangular top shelf superimposed over a corresponding generally rectangular bottom shelf, said top shelf having an array of openings and said bottom shelf having an array of cavities corresponding to and vertically aligned with said array of openings, each cavity capable of receiving an end of a test tube having a maximum diameter and including an aperture of a lesser diameter extending vertically therethrough, and

a flange formed along a side of said rack and including an alignment marker formed thereon.

11. A test tube rack according to claim 9 or **10** which includes a plurality legs formed integrally with the top shelf, and a dowel pin in each leg and extending into the and bottom shelves.

12. A test tube rack according to claim 11 in which the top shelf and legs are formed integrally of plastic, and each dowel pin is made of metal.

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