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PIPETTE TIP TRAY AND RACK ASSEMBLY

Abstract

Various implementations of a pipette tip system are disclosed having a number of innovative features. In one implementation, a pipette tip tray includes a support plate and one or more sleeves extending downward from the bottom of the support plate. The sleeves can be configured to increase the stability of pipette tips stored in the tray. In another implementation, a pipette tip rack includes a rack base having one or more support walls extending underneath a pipette tip tray having downward extending sleeves. The thickness of the sidewalls of the sleeves can be reduced in the area of the support walls so that the support walls can reach the bottom of the support plate. In another implementation, a pipette tip rack includes a cover having a cushioning layer on the bottom of the cover that contacts the top of the pipette tips and stabilizes them during handling and transport.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATION [0001] This Application claims the benefit of priority under 35 U.S.C § 120 of U.S. Provisional Application Ser. No. 62/772,269 filed on Nov. 28, 2018, the content of which is relied upon and incorporated herein by reference in its entirety.

TECHNICAL FIELD

[0002] This relates to pipette tip trays and/or pipette tip rack assemblies used in connection with liquid handling and dispensing systems.

BACKGROUND

[0003] Liquid handling and dispensing systems use pipette tips to accurately and reproducibly handle a range of liquid volumes. The pipette tips can be used for a variety of purposes such as processing samples, adding reagents to samples, and the like. Liquid handling and dispensing systems are used in a variety of industries and facilities including, for example, medical laboratories, research facilities, and the like.

[0004] Pipette tips have an opening at one end that is configured to be coupled to a dispensing device and a smaller hole at the other end through which liquid can be drawn and dispensed. Pipette tips are often placed in a pipette trip rack assembly for shipping, storage, and use. Rack assemblies vary in size with some racks being configured to hold dozens, hundreds, or even a thousand or more pipette tips.

[0005] One problem with conventional tray and rack combinations is that the pipette tips can become statically charged due to movement between the pipette tips and the tray or rack assembly during shipping, humidity changes, sterilization processes, and the like. The static charge can cause a number of problems. One problem is that the static charge can interfere with liquid pickup and dispensing operations, especially those involving small liquid volumes. The static charge can also affect the chemical characteristics of solutions due to interactions with charged molecules. This can affect the results of experiments in which these factors are important.

[0006] The static charge can cause the pipette tips to become misaligned on the rack assembly. The desired alignment is typically straight up and down and/or perpendicular to the rack face. If the pipette tips are not correctly positioned on the rack assembly, then they can become misaligned on the dispensing device, fall off the dispensing device, or be crushed by the dispensing device. This can lead to situations where the dispensing device is unable to accurately draw and dispense liquid. In some situations, it can even lead to contamination of the pipette tip system and/or corresponding well plate samples. The ultimate result is significant and costly down time.

[0007] These problems are especially severe for high density rack assemblies. The pipette tips in such assemblies are generally smaller and more susceptible to misalignment from static charges. They also involve small liquid volumes that are more susceptible to being affected by static charges.

SUMMARY

[0008] A pipette tip tray and a pipette tip rack assembly can be used to hold and support one or more pipette tips during shipping, handling, and/or use in a liquid handling and dispensing system. The tray can include a support plate and one or more sleeves extending outward from a surface of the support plate. The sleeves each define a hole configured to receive and support a pipette tip. The sleeves support the pipette tips and prevent them from becoming misaligned.

[0009] The rack assembly can include a rack base and a cover. The base is configured to receive and support the tray. The cover can be configured to prevent the pipette tips from moving in the tray and becoming misaligned. This can be accomplished by positioning the cover close to or in contact with the top of the pipette tips when the cover is closed.
[0010] The tray and rack assembly can be implemented in various ways to realize one or more of the following potential advantages. One advantage is that the pipette tip tray and rack assembly reduce the generation of static electricity that causes misalignment of the pipette tips and disrupts liquid handling operations. They can do this by being structured in such a way as to reduce or prevent movement of the pipette tips in the rack assembly.
[0011] Another advantage is that the sleeves strengthen the tray and rack assembly making it better able to withstand the load placed on it during the process of coupling the pipette tips to the automated dispensing device. Yet another advantage is that the pipette tips are the same height in the tray and rack assembly as convention tip systems so that there is no need to reprogram the automation system to use the new tip system.
[0012] Although these advantages apply to any pipette tip tray and rack, they can be especially applicable to high-density pipette tip trays and racks such as those that are configured to hold at least 96 pipette tips.
[0013] One innovative aspect of the tray can be implemented by increasing the amount of contact or engagement between the pipette tips and the tray. Increasing the amount of contact can reduce or prevent movement between the pipette tips and the tray. The amount of contact that is sufficient to reduce and/or prevent relative movement of the pipette tips can vary based on the specific design of the pipette tips and the tray and rack assembly.
[0014] In one implementation, the tray can include one or more sleeves extending downward from a bottom surface of the support plate. The holes in the sleeves can be shaped to increase the amount of contact with the pipette tips. For example, at least 50% of the total surface area defining the holes can be configured to contact the pipette tip. In some cases, the holes can have a tapered shape that corresponds to the tapered shape of the pipette tips.
[0015] Another innovative aspect of the tray can be implemented by reducing the thickness of the sleeves in the area next to upward extending support walls in the base. In this way, the sleeves can contact and prevent movement of the pipette tips while also accommodating the underlying support walls.
[0016] One innovative aspect of the rack assembly can be implemented by reducing or eliminating the gap between the bottom of the cover and the pipette tips. This serves to further reduce movement of the pipette tips during shipping, handling, and use. In one implementation, the bottom of the cover can be coated with or include a layer of a cushioning material that contacts the top of the pipette tips and holds them in place.
[0017] The systems, methods, and devices of this disclosure each have several innovative aspects, no single one of which is solely responsible for the described desirable attributes. The summary is provided to introduce a selection of concepts in a simplified form that are further described below in the detailed description. The summary and the background are not intended to identify key concepts or essential aspects of the disclosed subject matter, nor should they be used to constrict or limit the scope of the claims. For example, the scope of the claims should not be limited based on whether the recited subject matter includes any or all aspects noted in the summary and/or addresses any of the issues noted in the background.

Description

DRAWINGS
[0018] The preferred and other embodiments are disclosed in association with the accompanying

drawings in which:
[0019] FIG. **1** is a perspective view of a pipette tip rack assembly including a pipette tip tray holding pipette tips in accordance with embodiments of the present disclosure.
[0020] FIG. **2** is a top perspective view of the tray in FIG. **1** in accordance with embodiments of the present disclosure.
[0021] FIG. **3** is a bottom perspective view of the tray in FIG. **1** in accordance with embodiments of the present disclosure.
[0022] FIG. **4** is a cross-sectional, perspective view of the rack assembly in FIG. **1** showing the tray supported by support walls extending upward from the rack base in accordance with embodiments of the present disclosure.
[0023] FIG. **5** is a cross-sectional view of the rack assembly in FIG. **1** showing the pipette tips in the tray in accordance with embodiments of the present disclosure.
[0024] FIG. **6** is a bottom perspective view of the pipette tip tray in FIG. **2** holding pipette tips in accordance with embodiments of the present disclosure.
[0025] FIG. **7** is a front view of one implementation of the rack assembly in FIG. **1** having a gap between the bottom of the cover and the tops of the pipette tips in accordance with embodiments of the present disclosure.
[0026] FIG. **8** is a front view of another implementation of the rack assembly in FIG. **1** having a cushioning layer on the bottom of the cover that contacts the tops of the pipette tips in accordance with embodiments of the present disclosure.

DETAILED DESCRIPTION

Pipette Tip Rack Assembly

[0027] FIG. **1** is a perspective view of one implementation of a pipette tip rack assembly **10** (alternatively referred to as a pipette tip rack, pipette tip box, pipette tip assembly) including a rack base **12** (alternatively referred to as a support base or rack support base), a cover **14** (alternatively referred to as a rack cover, lid, or rack lid), and a pipette tip tray **16** (alternatively referred to as a pipette tip insert, pipette tip rack insert, pipette tip plate, pipette tip deck,) supporting pipette tips **18**. The base **12** supports the tray **16**, and the cover **14** fits over and is coupled to the base **12** to protect and enclose the pipette tips **18**.
[0028] The rack assembly **10** can be used with any suitable liquid handling and dispensing system such as a manual or automated pipetting system. In general, the rack assembly **10** is used to hold and provide the pipette tips **18** to a dispensing device, which uses the pipette tips **18** to transfer liquid to and from microwell plates (microplates). The combination of the rack assembly **10** and the dispensing device can be referred to as a pipette tip system.
[0029] The liquid handling and dispensing system uses the pipette tips **18** to transfer liquid as follows. The pipette tips **18** are coupled to the dispensing device by placing the lower or distal portion of the dispensing device (commonly referred to as the barrel or nozzle) in contact with the top of the pipette tips **18** and applying compressive force.
[0030] The dispensing device with the pipette tips **18** attached is moved into contact with the liquid, and a negative pressure is applied to the pipette tips **18** to acquire the liquid. The dispensing device is moved to the dispensing location, and a positive pressure is applied to the pipette tips **18** to dispense the liquid.
[0031] This basic procedure can be used to transfer liquid from one location to another. For example, this procedure can be used to transfer liquid from a source to a microplate, from one microplate to another microplate, and the like.
[0032] In some implementations, the rack assembly **10** can be used in conjunction with a pipetting head that is part of a manual or automated pipetting system. The pipetting head can be operated using a peristaltic pump system or other suitable system configured to provide negative and positive pressure to the pipette tips **18**. The pipetting head can be a multichannel or a single-channel pipetting head. The position and operation of the pipetting head can also be controlled

using servo motors or stepper motors. It should be appreciated that the rack assembly **10** can be used with any liquid handling and dispensing system and/or any pipetting head.

[0033] The cover **14** moves between an open position where the rack assembly **10** is open and the tray **16** is uncovered and a closed position where the rack assembly **10** is closed and the tray **16** is covered. The cover **14** can be coupled to the base **12** in a variety of ways and allow the cover **14** to move between the open and closed positions. In one implementation, the cover **14** is pivotably coupled to one side of the base **12**. The cover **14** rotates between the open position where it is upright and roughly vertical and the closed position where it is down and roughly horizontal.

[0034] The rack assembly **10** can have a variety of features depending on a given implementation. For example, in some implementations, the rack assembly **10** can be configured to be disposable or reusable. In some implementations, the rack assembly **10** can be configured to be autoclavable. In some implementations, the rack assembly **10** can be configured to be modular and/or stackable.

[0035] It should be appreciated that the components of the rack assembly **10** can be made of any suitable materials. In some implementations, these components can be made of plastic such as polyolefins, for example, polyethylene, polypropylene, and the like. In some other implementations, these components can be made of metal, composites, ceramics, glass, wood, and the like. The components can be made of the same materials or a combination of different materials.

[0036] It should be appreciated that numerous changes can be made to the rack assembly **10** shown in FIG. **1**. For example, in some implementations, the rack assembly **10** can be provided without the cover **14**. The tray **16** can be permanently uncovered. In other implementations, the rack assembly **10** can be a different size. For example, the rack assembly **10** can be configured to hold more or fewer pipette tips **18**, can be configured to be shorter or taller, and the like.

Pipette Tip Tray

[0037] FIGS. **2-3** are top and bottom perspective views of the pipette tip tray **16** in FIG. **1**. The tray **16** includes a support plate **20** (alternatively referred to as a tray face) having a top surface **22** and a bottom surface **24** and sleeves **26** (alternatively referred to as cylinders) extending downward from the bottom surface **24**.

[0038] The tray **16** shown in FIGS. **2-3** is configured to hold 384 pipette tips **18**. It should be appreciated, however, that the tray **16** can be configured to hold more or fewer pipette tips **18**. The number of pipette tips **18** the tray **16** is configured to hold can range from one to thousands. In some implementations, the tray **16** can be considered a high-density pipette tip tray, which is a term used to refer to trays having at least 96 pipette tips **18**.

[0039] The following are some examples of suitable configurations for the tray **16**. In some implementations, the tray **16** is configured to hold at least 48 pipette tips, at least 96 pipette tips, at least 192 pipette tips, at least 384 pipette tips, at least 768 pipette tips, or at least 1536 pipette tips. In some implementations, the tray 16 is configured to hold 48 to 1536 pipette tips or 96 to 384 pipette tips.

[0040] The tray **16** includes holes **28** (alternatively referred to as bores or tray holes), which are configured to receive and support or hold the pipette tips **18**. Conceptually, each hole **28** can be viewed as the combination of separate, concentric holes **30**, **32** (FIG. **5**) through the support plate **20** and the sleeve **26**, respectively.

[0041] The hole **30** through the support plate **20** can be referred to as a plate hole **30**, and the hole **32** through the sleeve **26** can be referred to as a sleeve hole **32**. Also, it should be appreciated that any description of the hole **28** in the tray **16** can apply equally and separately to each hole **30**, **32** in the support plate **20** and the sleeve **26**, respectively. This means, for example, that a description of the hole **28** as being tapered applies equally and separately to the hole **30** in the support plate **20** and the hole **32** in the sleeve **26**.

[0042] The pipette tips **18** fit in the holes **28** in the manner shown in FIGS. **4-5**, which are cross-sectional views of the rack assembly **10**. Each pipette tip **18** has an elongated, tapered shape and includes a top **34** (alternatively referred to as a top portion or top end), a bottom **36** (alternatively referred to as a bottom portion or bottom end), and a flange portion **38** (alternatively referred to as a flange or enlarged portion).

[0043] The hole **28** in the tray **16** is sized to receive the bottom **36** of the pipette tip **18**. The pipette tip **18** can be inserted into the hole **28** until the flange portion **38** reaches the top surface **22** of the support plate **20**. The flange portion **38** is larger than the hole **28** and prevents further movement of the pipette tip **18** through the hole **28**. The pipette tip **18** is supported on the top surface **22** of the support plate **20** by the flange portion **38**.

[0044] Referring back to FIGS. **2-3**, the holes **28** are uniformly spaced apart from each other on the support plate **20**. Likewise, the pipette tips **18** are also uniformly spaced apart from each other on the tray **16** as shown in FIGS. **4-5**. Spacing the pipette tips **18** in this manner makes it easier to couple them to the dispensing device compared to unevenly spaced pipette tips **18**. It should be appreciated, however, that the pipette tips **18** can be spaced apart in any suitable fashion whether it be evenly or unevenly.

[0045] The holes **28** in the tray **16** have a tapered, annular shape such as the truncated cone shape shown in FIG. **5**. The pipette tips **18** can also have a corresponding tapered, annular shape that fits inside the holes **28**. The holes **28** and the pipette tips **18** are configured so that the entire interior surface of the holes **28** contacts the exterior surface of the pipette tips **18** in the manner shown in FIG. **5**. The amount of contact between the one or more surfaces defining the holes **28** and the exterior surface of the pipette tips **18** helps prevent the pipette tips **18** from moving and generating static charges and/or keeps the pipette tips **18** in a true perpendicular position relative to the tray **16**.

[0046] It should be appreciated that the holes **28** and the pipette tips **18** can have any suitable shape and/or amount of contact with each other as long as it is sufficient to prevent undue movement of the pipette tips **18** and the resulting undesirable static charges. The following are some examples of alternative configurations of the holes **28** and the pipette tips **18**. It should be appreciated that those configurations that produce a significant amount of contact between the holes **28** and pipette tips **18** are typically preferred—e.g., the length of the holes **28** is 1.5 to 2.0 times the diameter.

[0047] In some implementations, at least a portion of the holes **28** and the pipette tips **18** have corresponding cross-sectional shapes, or, in other words, matching or at least substantially matching cross-sectional shapes. For example, both the holes **28** (or the one or more surfaces that define the holes **28**) and the pipette tips **18** can be: cylindrical, polygonal (triangular, rectangular, square, pentagonal, hexagonal, octagonal, and the like), oblong, irregular shaped, and the like. The holes **28** and the pipette tips **18** can also have different cross-sectional shapes.

[0048] The shape of the holes **28** and the pipette tips **18** can be the same over the length of the holes **28** or they can vary. For example, in some implementations, the holes **28** and the pipette tips **18** can be larger near the top of the holes **28** and taper downward to the bottom of the holes **28**. In other implementations, the holes **28** and the pipette tips **18** can be the same size at the top and the bottom. In other implementations, the holes **28** and the pipette tips **18** can have the same shape for at least 50% of the length of the holes **28**, at least 75% of the length of the holes **28**, at least 90% of the length of the holes **28**, or at least 95% of the length of the holes **28**.

[0049] In some implementations, at least 50% of the total surface area defining each hole **28** (the surface area of one or more interior surfaces forming the boundary of the hole **28**) is configured to contact the exterior surface of each pipette tip **18**. The amount of the total surface area defining each hole **28** configured to contact the exterior surface of the pipette tip **18** can also be at least 60%, at least 70%, at least 80%, at least 90%, at least 95%, or at least 98%.

[0050] In some implementations, the length of the hole **28** can be at least as large as the width of the hole **28** where the width is measured at either the top or bottom surface **22**, **24** of the support plate **20**. It should be noted that the width of the hole **28** refers to the largest cross-sectional dimension of the hole **28** at the top or bottom surface **22**, **24**. If the hole **28** is circular, then the width is the diameter of the hole **28**.

[0051] The ratio of the length of the hole **28** to the width of the hole **28** measured at the top surface **22** of the support plate **20** in FIG. **5** is approximately 2 (2:1). It should be appreciated, however, that the ratio of the length of the hole **28** to the width of the hole **28** (measured at either surface **22**, **24**) can vary substantially. In general, larger ratios make the pipette tip **18** more stable and less prone to undesirable movement. In some implementations, the ratio of length/width of each hole **28** is at least 1 (1:1), at least 1.25, at least 1.5, at least 1.75, or at least 1.9. In other implementations, the ratio of length/width of each hole **28** is 1-3, 1.25-2:75, 1.5-2.5, 1.75-2.25, 1.9-2.1, or 2.

[0052] The pipette tips **18** can be configured to hold any suitable volume of liquid. In general, the volume of the pipette tips **18** decreases as the density of the tray **16** increases. In some implementations, the volume of the pipette tips **18** can be no more than 200 μl, no more than 100 μl, no more than 50 μl, or no more than 30 μl. As the density of the tray **16** increases, there is a greater need to keep the pipette tips **18** in a true perpendicular position for pipette head pickup.

Support Plate

[0053] Referring to FIGS. **2-3**, the support plate **20** and the sleeves **26** are described in greater detail. The support plate **20** is depicted in FIGS. **2-3** as a flat or planar, rectangular component supported by the base **12**. It should be appreciated, however, that the support plate **20** can have any suitable shape. The support plate **20** can also be made of any suitable material including any of those described above in connection with the rack assembly **10**.

[0054] Other than the holes **28**, the support plate **20** is entirely solid or almost entirely solid. The support plate **20** doesn't include any other holes extending to the open space under the support plate **20**. The support plate **20** includes holes **40** and other miscellaneous holes at the edges, but they do not extend through to the open space under the support plate **20**. The holes **40** receive corresponding projections **42** extending upward from the base **12** to hold the support plate **20** in place.

[0055] It should be appreciated that the support plate **20** can have numerous other configurations. In some implementations, the percentage of the support plate **20** that is solid, excluding the holes **28** for the pipette tips **18**, is at least 75%, at least 80%, at least 85%, at least 90%, at least 95%, or at least 98%.

Sleeves

[0056] The sleeves **26** include one or more sidewalls **48** extending downward from the bottom surface **24** of the support plate **20**. The sleeves **26** define central axes extending vertically and at least approximately parallel to each other. The central axes pass through the center of the holes **32** in the sleeves **26** and the holes **28** in the tray **16**.

[0057] The sleeves **26** have a cylindrical shaped exterior and a tapered, annular shaped interior (e.g., truncated cone shape) as shown in FIGS. **3-5**. The sleeves **26** are also separate, discrete components spaced apart from each other on the bottom surface **24** of the support plate **20**.

[0058] It should be appreciated, that the sleeves **26** can have numerous other configurations. For example, in some implementations, the sleeves **26** can have interior or exterior surfaces shaped in any of the ways described above in connection with the holes **28** and the pipette tips **18**. Likewise, instead of being separate components, the sleeves **26** can be integrally formed together with adjacent sleeves **26** or interconnected with adjacent sleeves **26** by way of ribs or other connecting structures.

[0059] The holes **32** extend through the sleeves **26** and form the lower part of the holes **28** extending through the tray **16**. The holes **32** can have any of the properties, characteristics, or dimensions of the holes **28** described above. For example, the holes **32** can have a tapered, annular shape such as a truncated cone shape. The holes **32** can also correspond to the shape of the pipette tips **18**. The amount of contact between the one or more surfaces defining the holes **32** can be the same as that described above for the holes **28**.

[0060] The shape of the holes **32** and the pipette tips **18** can be the same over the length of the holes **32** or they can vary. For example, in some implementations, the holes **32** and the pipette tips

18 can be larger near the top of the holes **32** and taper downward to the bottom of the holes **32**. In other implementations, the holes **32** and the pipette tips **18** can be the same size at the top and the bottom. In other implementations, the holes **32** and the pipette tips **18** can have the same shape for at least 50% of the length of the holes **32**, at least 75% of the length of the holes **32**, at least 90% of the length of the holes **32**, or at least 95% of the length of the holes **32**.

[0061] In some implementations, at least 50% of the total surface area defining each hole **32** is configured to contact the exterior surface of each pipette tip **18**. The amount of the total surface area defining each hole **32** configured to contact the exterior surface of the pipette tip **18** can also be at least 60%, at least 70%, at least 80%, at least 90%, at least 95%, or at least 98%.

[0062] In some implementations, the length of the hole **32** can be at least as large as the width of the hole **32** where the width is measured at the bottom surface **24** of the support plate **20** or, in other words, the top of the hole **32**. It should be noted that the width of the hole **32** refers to the largest cross-sectional dimension of the hole **32** at the bottom surface **24**. If the hole **32** is circular, then the width is the diameter of the hole **32**.

[0063] The ratio of the length of the hole **32** to the width of the hole **32** measured at the bottom surface **24** of the support plate **20** in FIG. **5** is approximately 1 (1:1). It should be appreciated, however, that the ratio of the length of the hole **32** to the width of the hole **32** (measured at the bottom surface **24**) can vary substantially. In general, larger ratios make the pipette tip **18** more stable and less prone to undesirable movement. In some implementations, the ratio of length/width of each hole **32** is at least 0.5 (1:2), at least 0.75, or at least 0.9. In other implementations, the ratio of length/width of each hole **32** is 0.5-2.5, 0.75-2.25, 1-2.1, or 1.5-2.

[0064] It should be noted that the holes **30** through the support plate **20** can have any of the properties, characteristics, or dimensions described for the holes **32**. This includes, for example, the shape of the holes **30**, the amount of total surface area defining the holes **30** that contacts the pipette tips **18**, and the ratio of the length of the holes **32** to the width of the holes **32**, although the width of the holes **32** can be measured at either the top or bottom surface **22**, **24** of the support plate **20**.

[0065] Positioning the sleeves **26** on the bottom surface **24** of the support plate **20** provides a number of advantages. One advantage is that it strengthens the tray **16** to withstand the load incurred when the pipette tips **18** are picked up by the dispensing device. The process of attaching the pipette tips **18** to the dispensing device can result in a significant amount of force being placed on the tray **16**. The sleeves **26** add additional structural support to the tray **16** and make it more resilient and capable of handling the force.

[0066] Another advantage of positioning the sleeves **26** on the bottom surface **24** is that it does not change the height of the pipette tips **18** (the height being the Z axis) relative to the dispensing device. This means the tray **16** can be substituted for a conventional tray and the pipette tips **18** will be the same height. There is no need to reprogram or reconfigure the dispensing device to account for height differences of the pipette tips **18**.

[0067] It should be appreciated that some implementations of the tray **16** can include sleeves extending upward from the top surface **22** of the support plate **20**. The upward extending slaves can have any of the properties, characteristics, or dimensions described above in connection with the sleeves **26**. In such implementations, the bottom surface **24** can include the sleeves **26** or can be flat. Although upward sleeves are possible, it is generally less desirable for at least the following reasons.

[0068] First, the upward extending sleeves will need to absorb much of the load applied by the automation head as it picks up the pipette tips **18**, which can cause the sleeves to deform. Second, assuming the other components of the rack assembly **10** remain the same, the top **34** of the pipette tips **18** will be higher, which means the liquid handling and dispensing system will need to be reprogrammed or otherwise reconfigured to compensate for the change.

Rack Base

[0069] Referring to FIGS. **4-5**, the rack base **12** can include sidewalls **44** located on the perimeter or sides of the base **12** and support walls **46** (alternatively referred to as ribs or support ribs) extending between the sidewalls **44** underneath the tray **16**. The support walls **46** form a grid pattern underneath the tray **16** where one group of support walls **46** is positioned perpendicular to another group of support walls **46**.
[0070] The support walls **46** extend upward from the bottom of the base **12** and contact the bottom surface **24** of the support plate **20**. The support walls **46** provide additional support for the tray **16** so it can withstand the forces associated with picking up the pipette tips **18**.
[0071] The base **12** shown in FIGS. **3-5** includes three support walls **46** extending in a lengthwise direction of the rack assembly **10** and five support walls **46** extending in a cross-wise direction. It should be appreciated that the base **12** can include more or fewer support walls **46** and the support walls **46** can have different spatial configurations. For example, the support walls **46** can be configured to extend diagonally underneath the tray **16**. Also, the support walls **46** can be configured parallel to each other without any perpendicular extending support walls **46**. Numerous variations are possible.
[0072] The sleeves **26** are modified to allow the support walls **46** to contact the bottom surface **24** of the support plate **20**. This is done by truncating one or more sides of the sidewalls **48** of the sleeves **26** in the area adjacent to the support walls **46**. As shown in FIG. **3**, some of the sleeves **26** are truncated on one side while some of the sleeves **26** are truncated on two sides. The sleeves **26** that are truncated on two sides are adjacent to locations where two perpendicular support walls **46** intersect. The sleeves **26** having truncated sidewalls **48** can be referred to as truncated sleeves.
[0073] Although the sidewalls **48** of the truncated sleeves **26** are thinner, they still surround and define the holes **32** in the sleeves **26**. Thinning the sidewalls **48** in this manner creates channels **50** between the sleeves **26** that are sized and shaped to receive the support walls **46**. The channels **50** are shown in FIG. **3**.
[0074] As shown in FIG. **3**, the channels **50** define square shapes on the bottom surface **24** of the support plate **20** each of which contains sixteen sleeves **26**. It should be appreciated that in other implementations the channels **50** can define any polygonal shape on the bottom surface **24** containing any number of the sleeves **26**. For example, the channels **50** can define a polygonal shape containing 8-32 of the sleeves **26**.
[0075] It should also be appreciated that numerous modifications can be made to way the support walls **46** support the tray **16**. For example, in some implementations, the sidewalls **48** of the sleeves **26** can be completely removed in the area adjacent to the support walls **46**. In these implementations, the holes **32** can be left open in those areas or the support walls **46** can be configured to define the missing portion of the holes **32**.
Cover
[0076] Referring to FIGS. **1** and **4-5**, the cover **14** includes a top **52** and a bottom **54**. The top **52** includes upward extending projections **56** configured to be received by corresponding recesses **58** in the bottom of the base **12**. The projections **56** and the recesses **58** make it possible to stack multiple rack assemblies **10** on top of each other in a stable fashion.
[0077] FIG. **7** is a front view of one implementation of the rack assembly **10** having a gap between the bottom **54** of the cover **14** and the tops **34** of the pipette tips **18**. The size of the gap can be reduced to further reduce movement of the pipette tips **18** during shipping, handling, and use. For example, in some implementations, the distance between the bottom **54** and the tops **34** of the pipette tips **18** can be no more than 50 mils (aprx. 1.25 mm), no more than 40 mils (aprx. 1 mm), no more than 35 mils (apprx. 0.9 mm), or no more than 30 mils (apprx. 0.75 mm). In other implementations, the distance between the bottom **54** and the tops **34** of the pipette tips **18** can be 5-45 mils, 10-40 mils, 15-35 mils, or 20-30 mils.
[0078] FIG. **8** is a front view of another implementation of the rack assembly **10** having a cushioning layer **60** (alternatively referred to as a cushioning film) on the bottom **54** of the cover **14**

that contacts the tops **34** of the pipette tips **18**. The cushioning layer **60** biases the pipette tips **18** against the top of the tray **16**. This helps to further reduce and/or prevent movement of the pipette tips **18** during shipping, handling, and use.
[0079] The cushioning layer **60** is softer than the material to which it is applied, which is typically the material used to make the rest of the cover **14**. In some implementations, the cushioning layer **60** can be at least 50% softer, at least 100% softer, or at least 150% softer than the substrate to which it is applied (alternatively referred to as a support layer or structural layer). The softness of the cushioning layer **60** and the substrate can be measured using an appropriate hardness scale such as the Rockwell hardness scale or the Shore hardness scale.
[0080] The cushioning layer **60** can be any suitable thickness and can be made of any suitable material. In some implementations the cushioning layer **60** is 5-50 mils (127-1270 microns) thick, 7-30 mils (178-762 microns) thick, or 10-20 mils (254-508 microns) thick. In some implementations, the cushioning layer **60** can be a polymer material such as a polyester material. In some implementations, the cushioning layer **60** can be made of a non-conductive or electrically insulating material. In some implementations, the cushioning layer **60** can hold a negative charge to help reduce static charges produced by transporting the pipette tips **18**.
Illustrative Implementations
[0081] The following is a description of various implementations of the disclosed subject matter. Each implementation may include one or more of the various features, characteristics, or advantages of the disclosed subject matter. The implementations are intended to illustrate a few aspects of the disclosed subject matter and should not be considered a comprehensive or exhaustive description of all possible implementations.
[0082] P1. A pipette tip tray comprising: a support plate; and a sleeve extending downward from a bottom surface of the support plate; wherein the sleeve defines a hole configured to receive and support a pipette tip; and wherein the hole has a tapered shape.
[0083] P2. The pipette tip tray of paragraph P1 wherein the hole has a conical shape.
[0084] P3. The pipette tip tray of any one of paragraphs P1-P2 wherein the sleeve has an annular shape.
[0085] P4. The pipette tip tray of any one of paragraphs P1-P3 wherein the hole has a tapered annular shape.
[0086] P5. The pipette tip tray of any one of paragraphs P1-P4 wherein the sleeve includes one or more interior surfaces defining the hole, and wherein at least 50% of the total surface area of the one or more interior surfaces is configured to contact the pipette tip.
[0087] P6. The pipette tip tray of any one of paragraphs P1-P5 comprising a hole extending through the pipette tip tray and including the hole in the sleeve, wherein a ratio of the length of the hole through the pipette tip tray to the width (e.g., diameter) of the hole at the bottom surface of the support plate is at least 1.
[0088] P7. The pipette tip tray of any one of paragraphs P1-P6 wherein a ratio of the length of the hole through the pipette tip tray to the width (e.g., diameter) of the hole at the bottom surface of the support plate is at least 1.5.
[0089] P8. The pipette tip tray of any one of paragraphs P1-P7 wherein the hole is a sleeve hole, the pipette tray comprising a tray hole extending through the tray and including the sleeve hole, wherein the tray hole has a tapered shape.
[0090] P9. The pipette tip tray of paragraph P8 wherein the tray hole has a conical shape.
[0091] P10. The pipette tip tray of any one of paragraphs P8-P9 wherein a ratio of the length of the tray hole to the width (e.g., diameter) of the tray hole at the bottom surface of the support plate is at least 1.
[0092] P11. The pipette tip tray of any one of paragraphs P8-P10 wherein a ratio of the length of the tray hole to the width (e.g., diameter) of the tray hole at the bottom surface of the support plate is at least 1.5.

[0093] P12. The pipette tip tray of any one of paragraphs P1-P11 comprising at least 48 sleeves.

[0094] P13. The pipette tip tray of any one of paragraphs P1-P12 comprising at least two of the sleeves, wherein each of the sleeves includes a central axis extending through the center of the hole, and wherein the central axes of the holes are parallel to each other.

[0095] P14. The pipette tip tray of any one of paragraphs P1-P13 comprising the pipette tip positioned in the hole, wherein the shape of the hole and the shape of the pipette tip correspond to each other.

[0096] P15. The pipette tip tray of any one of paragraphs P1-P14 comprising the pipette tip positioned in the hole, wherein the sleeve includes one or more interior surfaces defining the hole, and wherein at least 50% of the total surface area of the one or more interior surfaces contacts the pipette tip.

[0097] P16. The pipette tip tray of any one of paragraphs P1-P15 comprising the pipette tip positioned in the hole, wherein the hole and pipette tip have corresponding conical shapes.

[0098] P17. A pipette tip tray comprising: a support plate; and a sleeve extending downward from a bottom surface of the support plate; wherein the sleeve includes one or more surfaces defining a hole configured to receive and support a pipette tip; and wherein at least 50% of the total surface area of the one or more interior surfaces is configured to contact the pipette tip.

[0099] P18. The pipette tip tray of paragraph P17 wherein the hole has a conical shape.

[0100] P19. The pipette tip tray of any one of paragraphs P17-P18 wherein the sleeve has an annular shape.

[0101] P20. The pipette tip tray of any one of paragraphs P17-P19 wherein the hole has a tapered annular shape.

[0102] P21. The pipette tip tray of any one of paragraphs P17-P20 comprising a hole extending through the pipette tip tray and including the hole in the sleeve, wherein a ratio of the length of the hole through the pipette tip tray to the width (e.g., diameter) of the hole at the bottom surface of the support plate is at least 1.

[0103] P22. The pipette tip tray of any one of paragraphs P17-P21 wherein a ratio of the length of the hole through the pipette tip tray to the width (e.g., diameter) of the hole at the bottom surface of the support plate is at least 1.5.

[0104] P23. The pipette tip tray of any one of paragraphs P17-P22 wherein the hole is a sleeve hole, the pipette tray comprising a tray hole extending through the tray and including the sleeve hole, wherein the tray hole has a tapered shape.

[0105] P24. The pipette tip tray of paragraph P23 wherein the tray hole has a conical shape.

[0106] P25. The pipette tip tray of any one of paragraphs P23-P24 wherein a ratio of the length of the tray hole to the width (e.g., diameter) of the tray hole at the bottom surface of the support plate is at least 1.

[0107] P26. The pipette tip tray of any one of paragraphs P23-P25 wherein a ratio of the length of the tray hole to the width (e.g., diameter) of the tray hole at the bottom surface of the support plate is at least 1.5.

[0108] P27. The pipette tip tray of any one of paragraphs P17-P26 comprising at least 48 sleeves.

[0109] P28. The pipette tip tray of any one of paragraphs P17-P27 comprising at least two of the sleeves, wherein each of the sleeves includes a central axis extending through the center of the hole, and wherein the central axes of the holes are parallel to each other.

[0110] P29. The pipette tip tray of any one of paragraphs P17-P28 comprising the pipette tip positioned in the hole, wherein the shape of the hole and the shape of the pipette tip correspond to each other.

[0111] P30. The pipette tip tray of any one of paragraphs P17-P29 comprising the pipette tip positioned in the hole, wherein the sleeve includes one or more interior surfaces defining the hole, and wherein at least 50% of the total surface area of the one or more interior surfaces contacts the pipette tip.

[0112] P31. The pipette tip tray of any one of paragraphs P17-P30 comprising the pipette tip positioned in the hole, wherein the hole and pipette tip have corresponding conical shapes.
[0113] P32. A pipette tip rack assembly comprising: a rack base including a support wall; and a pipette tip tray positioned on and supported by the rack base, the pipette tip tray including a sleeve extending downward and defining a hole configured to receive and support a pipette tip; wherein the support wall contacts the underside of the pipette tip tray; and wherein the thickness of the sleeve next to the support wall is reduced compared to the thickness of the sleeve that is not next to the support wall.
[0114] P33. The pipette tip rack assembly of paragraph P32 wherein the sleeve is a truncated sleeve, the pipette tip tray comprising at least 48 sleeves, which include the truncated sleeve, and wherein the holes defined by the 48 sleeves are uniformly spaced apart from each other on the pipette tip tray.
[0115] P34. The pipette tip rack assembly of any one of paragraphs P32-P33 wherein the rack base includes opposing sidewalls and the support wall extends from one of the opposing sidewalls to the other one of the opposing sidewalls.
[0116] P35. The pipette tip rack assembly of any one of paragraphs P32-P34 wherein the rack base includes at least two support walls contacting the underside of the pipette tip tray.
[0117] P36. The pipette tip rack assembly of paragraph P35 wherein the at least two support walls are positioned perpendicular to each other.
[0118] P37. The pipette tip rack assembly of any one of paragraphs P32-P36 wherein the pipette tip tray is any one of the pipette tip trays recited in paragraphs P1-P31.
[0119] P38. A pipette tip rack assembly comprising: a rack base; a pipette tip tray positioned on and supported by the rack base, the pipette tip tray including a hole; a pipette tip positioned in the hole in the pipette tip tray; and a cover coupled to the rack base, the cover being movable between an open position and a closed position; wherein the bottom of the cover includes a cushioning layer; and wherein the top of the pipette tip contacts the cushioning layer on the bottom of the cover.
[0120] P39. The pipette tip rack assembly of paragraph P38 wherein the cushioning layer is coupled to a structural layer, and wherein the cushioning layer is softer than the structural layer.
[0121] P40. The pipette tip rack assembly of any one of paragraphs P38-P39 wherein the cushioning layer is non-conductive.
[0122] P41. The pipette tip rack assembly of any one of paragraphs P38-P40 wherein the cushioning layer includes polyester.
[0123] P42. The pipette tip rack assembly of any one of paragraphs P38-P41 wherein the cushioning layer is approximately 5 mils (127 microns) to approximately 50 mils (1270 microns) thick.
[0124] P43. The pipette tip rack assembly of any one of paragraphs P38-P42 wherein the cushioning layer is approximately 7 mils (178 microns) to approximately 30 mils (762 microns) thick.
[0125] P44. The pipette tip rack assembly of any one of paragraphs P38-P43 wherein the cushioning layer is approximately 10 mils (254 microns) to approximately 20 mils (508 microns) thick.
[0126] P45. The pipette tip rack assembly of any one of paragraphs P38-P44 wherein the pipette tip tray is any one of the pipette tip trays recited in paragraphs P1-P31.
[0127] P46. The pipette tip rack assembly of any one of paragraphs P38-P45 wherein the rack base is any one of the rack bases recited in paragraphs P32-P37.
General Terminology and Interpretative Conventions
[0128] Any methods described in the claims or specification should not be interpreted to require the steps to be performed in a specific order unless expressly stated otherwise. Also, the methods should be interpreted to provide support to perform the recited steps in any order unless expressly stated otherwise.

[0129] Certain features described in the context of separate implementations can also be implemented in combination in a single implementation. Conversely, various features that are described in the context of a single implementation can also be implemented in multiple implementations separately or in any suitable subcombination. Moreover, although features may be described above as acting in certain combinations and even initially claimed as such, one or more features from a claimed combination can in some cases be excised from the combination, and the claimed combination may be directed to a subcombination or variation of a subcombination.
[0130] Articles such as “the,” “a,” and “an” can connote the singular or plural. Also, the word “or” when used without a preceding “either” (or other similar language indicating that “or” is unequivocally meant to be exclusive—e.g., only one of x or y, etc.) shall be interpreted to be inclusive (e.g., “x or y” means one or both x or y).
[0131] The term “and/or” shall also be interpreted to be inclusive (e.g., “x and/or y” means one or both x or y). In situations where “and/or” or “or” are used as a conjunction for a group of three or more items, the group should be interpreted to include one item alone, all the items together, or any combination or number of the items.
[0132] The terms have, having, include, and including should be interpreted to be synonymous with the terms comprise and comprising. The use of these terms should also be understood as disclosing and providing support for narrower alternative implementations where these terms are replaced by “consisting” or “consisting essentially of.”
[0133] Unless otherwise indicated, all numbers or expressions, such as those expressing dimensions, physical characteristics, and the like, used in the specification (other than the claims) are understood to be modified in all instances by the term “approximately.” At the very least, and not as an attempt to limit the application of the doctrine of equivalents to the claims, each numerical parameter recited in the specification or claims which is modified by the term “approximately” should be construed in light of the number of recited significant digits and by applying ordinary rounding techniques.
[0134] All disclosed ranges are to be understood to encompass and provide support for claims that recite any subranges or any and all individual values subsumed by each range. For example, a stated range of 1 to 10 should be considered to include and provide support for claims that recite any and all subranges or individual values that are between and/or inclusive of the minimum value of 1 and the maximum value of 10; that is, all subranges beginning with a minimum value of 1 or more and ending with a maximum value of 10 or less (e.g., 5.5 to 10, 2.34 to 3.56, and so forth) or any values from 1 to 10 (e.g., 3, 5.8, 9.9994, and so forth), which values can be expressed alone or as a minimum value (e.g., at least 5.8) or a maximum value (e.g., no more than 9.9994).
[0135] All disclosed numerical values are to be understood as being variable from 0-100% in either direction and thus provide support for claims that recite such values (either alone or as a minimum or a maximum—e.g., at least <value>or no more than <value>) or any ranges or subranges that can be formed by such values. For example, a stated numerical value of 8 should be understood to vary from 0 to 16 (100% in either direction) and provide support for claims that recite the range itself (e.g., 0 to 16), any subrange within the range (e.g., 2 to 12.5) or any individual value within that range expressed individually (e.g., 15.2), as a minimum value (e.g., at least 4.3), or as a maximum value (e.g., no more than 12.4).
[0136] The terms recited in the claims should be given their ordinary and customary meaning as determined by reference to relevant entries in widely used general dictionaries and/or relevant technical dictionaries, commonly understood meanings by those in the art, etc., with the understanding that the broadest meaning imparted by any one or combination of these sources should be given to the claim terms (e.g., two or more relevant dictionary entries should be combined to provide the broadest meaning of the combination of entries, etc.) subject only to the following exceptions: (a) if a term is used in a manner that is more expansive than its ordinary and customary meaning, the term should be given its ordinary and customary meaning plus the

additional expansive meaning, or (b) if a term has been explicitly defined to have a different meaning by reciting the term followed by the phrase “as used in this document shall mean” or similar language (e.g., “this term means,” “this term is defined as,” “for the purposes of this disclosure this term shall mean,” etc.). References to specific examples, use of “i.e.,” use of the word “invention,” etc., are not meant to invoke exception (b) or otherwise restrict the scope of the recited claim terms. Other than situations where exception (b) applies, nothing contained in this document should be considered a disclaimer or disavowal of claim scope.

[0137] The subject matter recited in the claims is not coextensive with and should not be interpreted to be coextensive with any implementation, feature, or combination of features described or illustrated in this document. This is true even if only a single implementation of the feature or combination of features is illustrated and described.

Joining or Fastening Terminology and Interpretative Conventions

[0138] The term “coupled” means the joining of two members directly or indirectly to one another. Such joining may be stationary in nature or movable in nature. Such joining may be achieved with the two members or the two members and any additional intermediate members being integrally formed as a single unitary body with one another or with the two members or the two members and any additional intermediate member being attached to one another. Such joining may be permanent in nature or alternatively may be removable or releasable in nature.

[0139] The term “coupled” includes joining that is permanent in nature or releasable and/or removable in nature. Permanent joining refers to joining the components together in a manner that is not capable of being reversed or returned to the original condition. Releasable joining refers to joining the components together in a manner that is capable of being reversed or returned to the original condition.

[0140] Releasable joining can be further categorized based on the difficulty of releasing the components and/or whether the components are released as part of their ordinary operation and/or use. Readily or easily releasable joining refers to joining that can be readily, easily, and/or promptly released with little or no difficulty or effort. Difficult or hard to release joining refers to joining that is difficult, hard, or arduous to release and/or requires substantial effort to release. The joining can be released or intended to be released as part of the ordinary operation and/or use of the components or only in extraordinary situations and/or circumstances. In the latter case, the joining can be intended to remain joined for a long, indefinite period until the extraordinary circumstances arise.

[0141] It should be appreciated that the components can be joined together using any type of fastening method and/or fastener. The fastening method refers to the way the components are joined. A fastener is generally a separate component used in a mechanical fastening method to mechanically join the components together. A list of examples of fastening methods and/or fasteners are given below. The list is divided according to whether the fastening method and/or fastener is generally permanent, readily released, or difficult to release.

[0142] Examples of permanent fastening methods include welding, soldering, brazing, crimping, riveting, stapling, stitching, some types of nailing, some types of adhering, and some types of cementing. Examples of permanent fasteners include some types of nails, some types of dowel pins, most types of rivets, most types of staples, stitches, most types of structural ties, and toggle bolts.

[0143] Examples of readily releasable fastening methods include clamping, pinning, clipping, latching, clasping, buttoning, zipping, buckling, and tying. Examples of readily releasable fasteners include snap fasteners, retainer rings, circlips, split pin, linchpins, R-pins, clevis fasteners, cotter pins, latches, hook and loop fasteners (VELCRO), hook and eye fasteners, push pins, clips, clasps, clamps, zip ties, zippers, buttons, buckles, split pin fasteners, and/or conformat fasteners.

[0144] Examples of difficult to release fastening methods include bolting, screwing, most types of threaded fastening, and some types of nailing. Examples of difficult to release fasteners include bolts, screws, most types of threaded fasteners, some types of nails, some types of dowel pins, a few types of rivets, a few types of structural ties.

[0145] It should be appreciated that the fastening methods and fasteners are categorized above based on their most common configurations and/or applications. The fastening methods and fasteners can fall into other categories or multiple categories depending on their specific configurations and/or applications. For example, rope, string, wire, cable, chain, and the like can be permanent, readily releasable, or difficult to release depending on the application.

Drawing Related Terminology and Interpretative Conventions

[0146] The drawings are intended to illustrate implementations that are both drawn to scale and/or not drawn to scale. This means the drawings can be interpreted, for example, as showing: (a) everything drawn to scale, (b) nothing drawn to scale, or (c) one or more features drawn to scale and one or more features not drawn to scale. Accordingly, the drawings can serve to provide support to recite the sizes, proportions, and/or other dimensions of any of the illustrated features either alone or relative to each other. Furthermore, all such sizes, proportions, and/or other dimensions are to be understood as being variable from 0-100% in either direction and thus provide support for claims that recite such values or any and all ranges or subranges that can be formed by such values.

[0147] Spatial or directional terms, such as “left,” “right,” “front,” “back,” and the like, relate to the subject matter as it is shown in the drawings and/or how it is commonly oriented during manufacture, use, or the like. However, it is to be understood that the described subject matter may assume various alternative orientations and, accordingly, such terms are not to be considered as limiting.

Claims

1. A pipette tip tray comprising: a support plate: and a first sleeve and a second sleeve, wherein each sleeve extends downward from a bottom surface of the support plate and defines a hole configured to receive and support a pipette tip; wherein the first sleeve has a sidewall that is adjacent to a channel across the support plate and no sidewall of the second sleeve is adjacent to the channel; and wherein the sidewall of the first sleeve that is adjacent to the channel is thinner than any sidewall of the second sleeve.

2. The pipette tip tray of claim 1, wherein each hole has a conical shape.

3. The pipette tip tray of claim 1, wherein each hole has a tapered annular shape.

4. The pipette tip tray of claim 1, wherein each sleeve includes one or more interior surfaces defining its respective hole, and wherein at least 50% of the total surface area of the one or more interior surfaces of each sleeve is configured to contact the pipette tip for the respective sleeve.

5. The pipette tip tray of claim 1, wherein a ratio of the length of each hole through the pipette tip tray to the width of each hole at the bottom surface of the support plate is at least 1.

6. (canceled)

7. The pipette tip tray of claim 1, comprising at least 48 sleeves.

8. The pipette tip tray of claim 1, comprising at least two of the sleeves, wherein each of the sleeves includes a central axis extending through the center of its respective hole, and wherein the central axes of the holes are parallel to each other.

9. The pipette tip tray of claim 1, comprising a pipette tip positioned in each hole, wherein the shape of each hole and the shape of each pipette tip correspond to each other.

10. The pipette tip tray of claim 1, comprising a pipette tip positioned in each hole, wherein each hole and pipette tip have corresponding conical shapes.

11-23. (canceled)

24. The pipette tip tray of claim 1, wherein the length of each hole is 1.5 to 2.0 times its diameter.

25. The pipette tip tray of claim 1, wherein at least 85% of the support plate is solid, excluding any holes defined by sleeves.